An Alternative Proposal for a Revolution in Hypersonics and Space

By Mike Snead

Part 1 (As published on July 16, 2018)

Former Speaker of the House Newt Gingrich recently penned an op-ed "How to Seize Revolution in Hypersonics and Space." (Aviation Week Network, June 22, 2018.) I respect Mr. Gingrich's political instincts and his general support for advancing America's space enterprise. My critique explains where and why I respectively disagree with some parts of his proposal.

For those unable to access his op-ed article, Mr. Gingrich's proposal addresses these three areas: a programmatic imperative, a political imperative, and an economic imperative. In this first part of a two-part response, I address the programmatic imperative.

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A programmatic imperative

Gingrich proposes to establish a new "major spaceplane and hypersonics initiative" within the Office of the Secretary of Defense. "A key part of this initiative should include investment in both near- and far-term technologies as well as experimental vehicles (X-planes) that prove the potential for *aircraft-like access to space*," he wrote (emphasis added.) "The office should work closely with the military services, the Commerce Department, NASA, other agencies and industry to achieve its goals."

I strongly agree that the United States needs "aircraft-like access to space." I have written about this extensively in previous articles in this publication, Spacefaring America blog postings, and in technical papers. However, what the United States does *not* need is a major initiative within the Office of the Secretary of Defense focusing on technologies: it already has DARPA and the military laboratories for such efforts. Instead, what the United States needs is a government-led effort to develop national space operational capabilities that will support civil, commercial, and national security needs including, as a critical first step, "aircraft-like access to space."

A review of recent statements and discussions involving proposals for a Space Corps, Space Guard, and Space Force will find frequent mentions of the point that the United States needs "aircraft-like access to space." Clearly, the lack of aircraft-like access to space is the operational barrier that separates America's stagnant human space enterprise from its exciting human

spacefaring future. Without the ability for Americans, including members of the military and other federal agencies, to safely and routinely get to and return from Earth orbit, discussions of a "Space Something" are without any congressionally actionable substance. Thus, because the realistic future of such an entity depends on having "aircraft-like access to space," let's discuss what this really means to engineers.

What "aircraft-like access to space" really means

To open space to routine human activities, transporting people to and from Earth orbit must be acceptably safe to the public. Eventually, this means acceptably safe to politicians, reflecting public opinion; and the courts, reflecting common law and legal precedent. When Gingrich recognizes the need for "aircraft-like access to space," what I believe he is alluding to is the means to transport passengers to and from space in a safe and routine manner comparable to commercial aviation. Of course, Mr. Gingrich is not the first to use this description: it goes back to the 1950s.

From an aerospace engineer's perspective, "aircraft-like access to space" means human spaceflight on airworthiness-certified flight systems. Whether they have wings, takeoff on a runway, launch vertically, land vertically, and so on, does not matter. What will be needed are flight system designs type-certified for safety with each production operational system's safety being independently certified prior to entering service. Just as with all civil, commercial, and military aircraft, all civil, commercial, and military human spaceflight systems to and from Earth orbit will have to first earn an airworthiness certificate. The engineering challenge is developing a system design that can routinely achieve orbital flight while also being able to be airworthiness-certified. Such a system will be fully-reusable and will not, in my view, rely of abnormal modes of operation such as the use of parachutes.

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I raise this point about airworthiness certification because some take a different view—an unethical view in my opinion—of commercial human spaceflight safety. They assert that space is inherently dangerous and that, consequently, we must simply take significant risks to get things going. Fifty years of human spaceflight has shown that space is not inherently dangerous. Just like on the Earth, harm can arise from the operation of any system not properly designed, analyzed, tested, inspected, and maintained for the operational environment. We saw this twice with the two Space Shuttle losses.

From my discussions of this topic, I find that the public generally does not understand that the Department of Defense requires that all operational crewed military flight systems be airworthiness certified. Despite the use of these systems in combat, there is no "damn the

torpedoes, full speed ahead" mentality when it comes to ensuring the flight safety of these systems. The DOD undertakes careful, significant efforts to establish and maintain the integrity of its aircraft to ensure airworthiness. These efforts begin when the initial requests for information are made to industry beginning a new system development program.

Of course, accidents will happen and unforeseen imperfections will cause failures that can bring harm and, possibly, death. This is a simple fact of life for all modes of transportation. Yet, from our experience with aviation we know that the rate of such accidents can be, through good engineering and design validation, made acceptably low using military integrity and civil airworthiness regulations.

Airworthiness is the legal means that the American aviation industry uses to meet its common law "duty to care" obligation for building and operating systems that carry crew and passengers or, in the case of the DOD, military personnel. This obligation has existed for hundreds of years. (It is my understanding that using the term "passenger" in commerce creates a duty to care obligation.) The federal government implemented the airworthiness system in the 1920s to enable aircraft to receive an independent assessment of the aircraft's safety and be issued an airworthiness certificate. The airworthiness certificate, issued for each operational aircraft, meets the duty to care legal obligation. To ethically protect the safety of its personnel and the safety of the public, the Department of Defense has a comparable process. I have not found a mode of public transport that does not require safety certification.

The alternative, advocated by some, is using the "human spaceflight participant" approach that Congress has adopted in lieu of airworthiness certification. This approach places the legal burden of determining the safety of the system upon the person using the system. The law requires the customer to provide "informed consent," thus relieving the operator of the duty to care obligation (absent gross negligence.) Such advocates, in my view, sold Congress a "bill of goods" by arguing that space was dangerous, and companies needed freedom from regulation to try different ideas. This is, in my opinion, an unethical approach. No average person has the wherewithal to assess the safety of a human spaceflight system anymore than they have the ability to assess the safety of an aircraft. Courts have recognized this limitation for centuries, invoking the duty to care obligation placing the legal burden to assure safety on the owners and operators of systems placed in commercial service for transporting passengers.

I recently attended a public presentation by a company preparing a suborbital human spaceflight system. A chart of the company's approach to safety was presented. In the Q&A, I asked what means of certifying the safety of the system would be provided. The presenter declined to respond, citing, as I recall, on-going discussions with the government. In the presentation, that individual mentioned that they planned to start selling tickets in as little as a year. Yet, they were unwilling to explain how the safety of the system would be established to

enable a normal member of the public to make an informed decision as to the demonstrated safety of the system. This is *not* "aircraft-like"!

To advance America's human spacefaring enterprise, "aircraft-like access to space," with safety acceptable to the public, is essential. This will only be achieved through an airworthiness approach comparable to that done on commercial and military aircraft. This requirement must be baselined in any new government initiative and should be mandated by Congress.

(Note: NASA does not airworthiness-certify its human spaceflight systems. They use a human-rated approach primarily because their systems have not been fully reusable. The human-rated Space Shuttle suffered two losses in 135 missions despite significant mission costs and stated attention to safety.)

X-planes are unneeded

The United States built many experimental aircraft to gather airframe, engine, and flight dynamics test data at higher altitudes and speeds. This was needed due to limitations in ground test facilities, analytical methods, and, at times, simply unknown physical behavior (e.g., supersonic flight.) The pilots that flew these aircraft certainly had the "right stuff," many later becoming the first astronauts. Since that time, the need for experimental aircraft has diminished. Gingrich proposes to bring these back to facilitate developing aircraft-like access to space. I strongly disagree that this is needed.

If the United States wishes to build X-planes to establish new world records or to gather data in new flight regimes or while exploring new flight characteristics, I have no problem with doing that. The NASA's Quiet Supersonic Transport X-plane is a good example. It appears to be a low-risk program designed to verify the analytical predictions of an aircraft design that minimizes the ground-level noise of a sonic boom.

I was, enthusiastically, the first engineer assigned to the National Aerospace Plane program office. Three years later, when I left the program, it had become clear that the list of required breakthroughs was getting longer, not shorter.

For America to quickly achieve "aircraft-like access to space", baselining X-planes is unwise. A national program focusing on rapidly achieving an operational "aircraft-like access to space" capability should not choose an approach requiring that a high-risk X-plane program first be undertaken.

This is what happened with the National Aerospace Plane/X-30 in 1985. What started out as a paper sketch of a proposed 50,000-pound X-aircraft to test scramjets became a national program and grew into a more than one-million-pound single-stage-to-orbit (SSTO) behemoth before the program finally collapsed in the early 1990s. I know firsthand. I was, enthusiastically,

the first engineer assigned to the program office. Three years later, when I left the program, it had become clear that the list of required breakthroughs was getting longer, not shorter. While the scientists were smiling, due to the increased funding and attention for their research, especially scramjets and high-temperature materials, the design engineers had nothing concrete to work with. We cannot let this happen again!

If, for a particular approach, an X-plane is needed to reduce scientific risk, then the level of uncertainty is too high. What must not be created is a program approach where research scientists are given the opportunity to say "just give us a little time (and a lot of money) and we can make things a lot better" like achieving SSTO. Some scientists are very good at playing to the egos of the program decision makers by promising breakthroughs on their watch while downplaying the technical unknowns that must be overcome.

Focus on getting a near-term operational capability

Airworthiness-certified aircraft require testing both on the ground and in flight. Most of this integrity-related testing is done on the ground where the test conditions can be carefully controlled. Flight testing is used to verify loads, demonstrate adequate flight behavior (e.g., stall response), and test some conditions, such as flutter, that cannot be readily ground tested.

The primary purpose of the testing is to verify the analytically-predicted integrity of the aircraft. This is a very important and often misunderstood point that requires repeating. The integrity needed for airworthiness is first established analytically and, only then, verified through ground and flight testing. Integrity is not "tested into" the system. Simply flying a test vehicle some arbitrary number of times without incident does not establish integrity or prove adequate safety.

Achieving near-term "aircraft-like access to space," via airworthiness-certified human spaceflight systems, will require designs that can be readily ground tested to the critical design conditions and flight tested to verify loads. Hence, the appropriate starting point in seeking a near-term operational capability is to solicit designs capable of being airworthiness certified, using conventional, demonstrated integrity verification methods, within a typical five- to seven-year development period. This is the only way to move forward with confidence.

Does this mean that research into more advanced operational capabilities should not be supported? Of course not. We have excellent national, university, and commercial laboratories that are quite capable of planning and executing such research. But these efforts—both their planning and funding—should be

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kept apart from the organization focused on achieving a near-term operational capability. "Scientists on call, not dictating the design," would be a good program motto.

Conclusion

The pertinent part of Gingrich's programmatic proposal is to emphasize achieving "aircraft-like access to space" with a priority given to achieving a near-term operational capability. From my experience, America's primary aerospace industry has been able to achieve this since the mid-1980s—a surprising fact to most people. It will be a two-stage-to-orbit system. We could have done this instead of pursuing the NASP or the NASA X-33 SSTO approaches. Neither the presidential administrations nor the Congress at those times understood (or even asked) what could then have been done with good confidence. Instead, Congress grabbed, twice, for the shiny SSTO prize. Failing in both attempts, they gave up, leaving our industrial capabilities to languish and our human space access capabilities to collapse. We must be very careful to avoid repeating this history by flashing another shiny program in front of Congress to fund. What is needed is a solid system engineering development program focused prominently on a near-term capability, not a research program.

Bottom line: Find the government organization best experienced to manage the development of advanced, airworthiness-certified, crewed flight systems and give them the charter to get an airworthiness-certified crewed "aircraft-like access to space" capability operational promptly as a national priority. (Note: NASA has not managed the development of an operational airworthiness-certified crewed flight system. Their "human-rated" approach is not comparable.)

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An alternative proposal for a revolution in hypersonics and space

By Mike Snead

Part 2 (As published on July 23, 2018)

The Honorable Newt Gingrich recently penned an op-ed "How to Seize Revolution in Hypersonics and Space." (Aviation Week Network, June 22, 2018.) Gingrich's proposal addresses these three areas: a programmatic imperative, a political imperative, and an economic imperative. In this final part of a two-part response, I address the political and economic imperatives.

A political imperative

To boost the prospects of Congress supporting the proposed spaceplane and hypersonics initiative, Gingrich has searched for a way to increase congressional support. In this quest, he is reaching out to the Aerospace States Association to gain their support by inferring that the initiative will enable all states to build spaceports. I believe this inference is impractical to be realized while we are still using conventional chemical propulsion. The primary limitation is the safety of the non-involved public—the people on the ground.

The National Aerospace Plane (X-30) was to be a single-stage-to-orbit (SSTO) aircraft that would takeoff from a runway and use a combination of airbreathing and rocket power to achieve orbit. Had the X-30 been built, it would likely have had a takeoff weight of over 500 tonnes. Of this takeoff weight, around 90 percent would have been hydrogen and oxygen.

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Being a X-plane program, the X-30 would have undertaken a large number of flight tests. While these would have started within established flight test areas in the western states, as the speed increased, the flights would have necessarily covered longer distances where the overflight of populated areas was likely, perhaps unavoidable. (An aircraft flying at hypersonic speeds does not turn quickly.) Flight over land would be necessary to enable the aircraft to abort to airports along the flight path should something happen.

During the early planning of the X-30 flight test program, after the loss of the Challenger, the consequences of a crash were examined. Should the aircraft crash with a significant quantity of propellants onboard, a large explosion could result, especially if the aircraft was still at

supersonic or hypersonic speeds. The kinetic energy of the crash would cause an extremely rapid mixing of the fuel and the oxidizer enabling, at least, a deflagration and, quite possibly, an explosion. For the X-30, such a crash may involve hundreds of tons of propellants exploding. We all remember the loss of the Challenger. This was a deflagration, per my understanding, with [a] considerably ~~less~~ [lower] energy ~~being released~~ [release rate] than had the propellants exploded. {Author's correction.}

For space launches from the coast, launch safety requires that large areas of the ocean surface and adjacent airspace be cleared of vehicles to prevent possible harm to the non-involved public. We use coastal launch sites away from populated areas for this reason. Any operational spaceport will need comparable safety considerations. For existing coastal states, it is unlikely that a new spaceport for achieving orbit would be located close to populated areas. Even then, routine flights to and from space would likely disrupt other routine human activities and commerce in the local area.

For interior states, space launch will require overflight of populated areas within the host state as well as adjoining states. Permission to launch an orbital flight from such sites is, in my view, unlikely to be achieved due to the hazard of a crash. Therefore, for some time, space launch to Earth orbit will probably remain being undertaken from established coastal sites in Florida and California.

Another option for states is to build spaceports for suborbital human spaceflight. I am not a fan of commercial human suborbital spaceflight for the simple reason that, per my understanding, no airworthiness-certified system is being developed for this purpose (see part 1.)

Imagine someone has built the world's most amazing roller coaster in your state and has convinced the legislature to pass a law exempting the coaster from the otherwise mandatory independent safety inspections. Instead, the ticket purchaser would, by law, need to explicitly accept the risk in order to remove the operator's legal responsibility for safety, just as they do for whitewater rafting. This is what some states appear to be willing to do for commercial human suborbital spaceflight—what is essentially a giant, trackless roller coaster. Absent a mandate to use airworthiness-certified systems, I do not see a big push to build spaceports for this purpose either. Marketing is not a substitute for safety.

I agree with Gingrich on the need to strengthen congressional support for developing dramatically improved American human space access. The Aerospace States Association should be called upon to support this by the benefits of a strengthened American aerospace industrial base that this initiative will bring. This brings us to the third part of his proposal.

An economic imperative

President Trump has called for the creation of a US Space Force on par with the other branches of the military. On the same day that Gingrich's op-ed was published, Namrata Goswami published an excellent assessment of the formation of the Space Force in *The Diplomat*. While her article covered many facets of a creating a US Space Force, the following conclusion is significant:.

> Consequently, it is argued that the U.S. government, to include its military, is constitutionally obligated to protect not only military space assets but also commercial and U.S. private sector activities in the cislunar space (the volume within the Moon's orbit.) To ensure that this is the case, the ability to not only develop cislunar situational awareness but also presence and be fully capable of enforcing laws is viewed as part of U.S. national interest.

When the federal government obtained control over new western territories following the Revolutionary War, the Louisiana Purchase, and so on, it moved to establish federal government control by building forts for the Army and extending the lines of communication to and within the new American frontiers. This opened the door for settlement and commerce.

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It is unreasonable to expect that a US Space Force will be established with a mission to only sit on the ground monitoring activities in Earth-Moon space, expressing outrage at press conferences about threatening actions of belligerent nations. All the services have robust capabilities to operate crewed systems within their respective regimes and to project a US military presence globally to protect Americans engaged in commerce and travel. It is only reasonable to expect that the US Space Force will seek comparable crewed operational capabilities throughout Earth-Moon space—to become a real Space Force.

Immediately after World War II, the Air Force was formed as a separate service in 1947. Strategic bombing was its primary mission. For this, it needed new capabilities to offset the emergence of jet-powered fighters. It began a comprehensive program to develop jet-powered, swept-wing bombers—the B-47 and B-52—to gain the needed operational speed, altitude, and range capabilities. For an industry built on piston-powered, straight-wing transports, this was a gamechanger. Both military and commercial aircraft would be able to cruise over intercontinental distances at high altitudes above the weather and at speeds approaching Mach 1. Of course, the Air Force did not do this themselves. They hired airframe, engine, and avionics contractors to develop the systems. Essentially, they paid for the American aerospace industry to leap ahead in terms of its technological mastery, enabling a thriving commercial jet airline

industry to emerge only a decade later. This is the model to again use to nationally achieve "aircraft-like access to space."

The US Space Force will need "aircraft-like access to space" spaceflight systems to enable US spacefarers and materiel to access low Earth orbit (LEO). It will also need facilities in LEO to service these spaceflight systems; support personnel; undertake logistics, maintenance, and training; and, support spaceships providing access throughout Earth-Moon space. This is the equivalent of the Army forts and lines of communication built in the 1800s in new American frontiers to enable settlement and commerce. America's experience with opening its western frontiers and rapidly advancing its aeronautical industrial mastery after World War II should be highlighted when discussing America's spacefaring future with the Aerospace States Association.

The seeds of this important discussion have been planted by Gingrich's proposal. America needs a robust program to aggressively develop near-term "aircraft-like access to space" using airworthiness-certified spaceflight systems to meet emerging civil, commercial, and Space Force needs. Operational robustness demands developing several design- and manufacturing-independent spaceflight systems along with the development of LEO infrastructure and spaceships.

All states, perhaps through the Aerospace States Association, need to be thoroughly briefed on the exciting future that is just starting to unfold. Through the use of advanced nationwide communications and travel, the World War II/Cold War era need to cluster contractors in only a few areas of the country has disappeared. Research, design, and manufacturing can take place across the nation linked together by the rapidly emerging nationwide gigabit-speed Internet and cloud-based data management. This will enable America's spacefaring enterprise to be a real national program with spacefaring engineering and manufacturing centers opening in locations now devoid of such aerospace enterprises.

Federal priority must be placed on rapidly achieving an operational "aircraft-like access to space" using airworthiness-certified flight systems along with the establishment of the LEO spacefaring infrastructure to provide an initial American destination in space.

It is especially important that all Americans be made aware of the fact that the economic scope of the coming commercial spacefaring activities is staggering. America's transition, this century, to geosynchronous orbit space solar power to replace fossil fuels is inevitable. To accomplish this, America will need to build hundreds of space solar power systems, each generating more power than the Hoover Dam. This will involve establishing immense American space mining, space manufacturing, space power, and spacefaring logistics industries along with the US Space Force capabilities needed to protect and defend these national assets. All of the engineering and manufacturing needed to equip these industries and the US Space Force will be done here in

America, creating many new science, technology, engineering, and manufacturing businesses and jobs.

Closing thoughts

I applaud Gingrich's public advocacy for America to get serious about its spacefaring future. America's great power status demands an aggressive political, economic, and military strategy to protect the United States from threats from and within space while also facilitating America's transition to space-based sustainable energy to replace fossil fuels. Federal priority must be placed on rapidly achieving an operational "aircraft-like access to space" using airworthiness-certified flight systems along with the establishment of the LEO spacefaring infrastructure to provide an initial American destination in space. These efforts should support civil, commercial, and national security needs and be undertaken as a nationwide effort. With this, America will begin its transformation into a true human spacefaring nation capable of boldly going spaceward!

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