Creating a Sustainable Manned Space Flight Program

A New Vision for Space Exploration

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Overview

The purpose of this document is to outline the key strategies that the United States must undertake to remain a leader in the area of space exploration. This document defines a proposal that would allow America to leverage the knowledge, experience and infrastructure and provide for a more robust space capability and one that over several decades would prove to be more cost-effective and beneficial to the citizens of the United States.

This plan also suggests a new vision that would take America from "point and shoot systems" to a staged strategy that looks at cost-effective and reliable capabilities at all levels of space operations with a focus on development of sustainable capabilities and vehicle reuse. This high-level outline proposes an alternate approach that would move us closer to navigating among the moons, asteroids, and planets of our solar system.

Lessons Learned

Without question the United States is the nation with the greatest manned and unmanned space exploration capability. From humble beginnings with Explorer I to the manned lunar landings, Skylab, the Space Shuttle, the Hubble Telescope, the probes to the outer planets – Pioneer, Voyager, Galileo, Cassini, and New Horizons, our exploration of Mars with Mariner, Viking, Mars Global Surveyor, Mars Reconnaissance Orbiter, and the Mars Exploration Rovers; our journeys to comets, asteroids, the voyage to the inner planets, and many other satellites and observation capabilities too numerous to list America has led the world in exploring the reaches of outer space.

The American Manned Space Program though is at a critical crossroads, the same crossroads that presented itself in 1969. Critical strategic decisions made then have left us adrift now. During the late 70's we found ourselves without a manned launch capability and despite being the only nation to take man beyond Earth's gravitational pull we limited our manned journeys to low Earth orbit.

Today, we find ourselves at the same place – we are on the cusp of retiring one system and replacing it with an entirely new system that in many ways resembles the system we abandoned decades ago. In the interim a gap will exist in our manned launch capability brought on partially by a lack of funds and partially by a lack of strategic planning decades ago.

During the '60s and early '70s America perfected its heavy lift launch capability in the Saturn series. Developing and mastering the capability was an important step that launched us to the Moon. However, we failed to sustain that capability and as a result lost the production and refinements that only repeatable efforts produce.

A chief reason the former Soviet Union and now Russia has produced reliable rockets over a sustained period of time is that they have been producing nearly the same configuration and design for decades with only incremental improvements.

Repeatability has brought reliability and an enduring success rate.

The United States has made gargantuan leaps in technology, but as strategies changed we discarded that experience and learning for something new. We did that in Apollo, Skylab, and the Shuttle and now will proceed with the needed Constellation program that will reuse some Shuttle developed systems, but will abandon a component of the overall versatile capability we need. We are once again returning to a “point and shoot” model that is dependent on single multi-purpose vehicles which in the event of a failure grounds the entire program. A more effective approach is one that provides the highest level of reliability at the least cost for the operation required (Earth to low-orbit, lunar transit, Earth to lunar orbit, lunar landing) while providing a level of potential redundancy if required, but more importantly insulating the entire program from shutdown should a failure occur in a single system.

Had America continued production of the smaller Saturn 1-B for capsule/crew delivery and the Saturn V for heavy lift (Skylab-type) initiatives in addition to developing the capabilities unique to the Space Shuttle the savings and progress that were projected would have materialized over the long term, but only by increasing the program and allowing a versatile capability with each part of the total system fulfilling a specific function rather that one element required to perform multiple functions which increases costs, risk and support.

The overall path the space program has taken in its history has been a strategy of “develop and discard”. That strategy has caused unevenness in our capability at any given time and enormous costs as we are forced to periodically reinvent the system from scratch rather than incrementally improve and refine existing systems. It has also been a strategy where all problems are attempted to be solved by a single system. Failure of that “system” carries the risk that if the system encounters a failure the entire program goes offline (Apollo 1, Apollo 13, Challenger, and Columbia). The answer to consistent, cost-effective and reliable space travel is to focus on building expertise at each stage of an operation rather than a one-size fits all approach. It is the difference between achieving goals at a cost or sustaining goals over a long-term.

There are fundamental errors that key business leaders would agree ultimately lead to organizational and mission failure. These errors have plagued the space program and are continuing to do so in the form of a vague vision for future manned space exploration:

1. **Building a new strategy on the foundation of an existing flawed strategy** – The result will always be another flawed strategy. Perhaps an improvement, but nonetheless a flawed strategy. The space program since the late sixties has been hampered by this type of strategic planning. The manned space program started with an end goal in sight of reaching the moon. What followed was a clear and progressive strategy to achieve that goal. The Shuttle is not the result of what was needed or the next logical step in the evolution of the space program, but a step in a different direction one that could have laid a foundation for larger steps, but rather turned out to be a strategy of how a manned space capability be maintained at the lowest possible cost.

   The first strategic error occurred when the original Shuttle design was compromised by a requirement to reduce costs which in-turn delivered reduced capabilities. The decision to go forward with a less capable vehicle and no defined mission would hamper the Shuttle throughout its history. The resulting Shuttle while an amazing technical achievement became the most complex machine humans had ever built and the most dangerous that humans would ever use to venture into space.

The original primary customer of the new Shuttle was the Department of Defense, but as costs limited the Shuttle's design and capabilities and difficulty in keeping the Shuttle's very public launch complex and schedule of classified payloads a secret it forced some of the business away from the Shuttle to single-use launch vehicles. After the Challenger accident all Defense Department payloads were shifted away to unmanned rockets. The Shuttle was also designed to launch unmanned probes, but these probes carried limited amounts of nuclear fuel to provide power during long duration missions and while Galileo was successfully launched from the Shuttle, the Challenger accident and the possibility that another Shuttle accident with a nuclear payload on-board would cause an environmental disaster once again limited the Shuttle's mission.

In addition to losing its primary customer there were other impacts to the program – First, one could argue that the original space station (Freedom) was approved to create a mission for the Shuttle. Orbiting space laboratories like Skylab, Salyut and Mir were all launched and deployed at significantly reduced costs by single launch vehicles. The large International Space Station (changed from Space Station Freedom during the Clinton years) with a cost exceeding one-hundred billion dollars has to-date an operating crew that matches Skylab's capability of three decades ago. While the ISS was designed for a larger crew, the cancellation of the Crew Escape (Rescue) Vehicle that was to be carried to the ISS in the Space Shuttle cargo bay limited the number of on-board crew without a Shuttle docked to the capacity of the Soyuz escape vehicle (3). While this will change and the ISS on-board crew will eventually expand it will do so much later in the life of the ISS than originally planned. This has limited the capability of the ISS to maintaining the presence of humans in space not expanding it. The ISS was planned as a floating laboratory for science, but with a reduced crew the focus has been on operating the large complex. Keeping a heavy launch capability in the Saturn V could have led to a Skylab approach to an orbital space station freeing up funds to develop additional launch vehicles such as a Moon or Mars vehicle while still accomplishing low-Earth orbit missions.

The loss of the Columbia Shuttle on February 1, 2003 in another example. The aged Columbia which was older and heavier than other Shuttles in the fleet wasn't capable of reaching the International Space Station. Rather than retire that Shuttle it kept flying and performed a rare science-only mission created specifically around its limited performance capabilities. While the cause of the accident could have occurred on any Shuttle mission it occurred on a mission where there was no real objective other than to keep a Shuttle flying and no chance of rescue had the damage been detected while the Shuttle was in space. Both the Challenger accident and the Columbia accident made subsequent Shuttle flights safer, but also opened many eyes as to the "unknowns" surrounding the vehicle. All of these unknowns can be traced to the initial flawed strategy of "what can we do at the lowest cost" versus "what is the vision for what we want to achieve in manned spaceflight and what capabilities do we need to achieve and sustain that objective".

2. **Making Costs the primary driver -** Every organization strives to get the maximum return for every dollar it spends, but there is a difference between defining a mission or goal and trying to achieve at the lowest cost possible and defining a target budget and then resolving what can be done with the dollars.

   The Shuttle was born of a debate to cancel or keep the manned space program. When the decision was made to keep the space program the conversation turned to what could be done with significantly fewer dollars. A reusable multi-function spacecraft was the answer. Then President Richard Nixon had to be sold on keeping the manned space program alive and there were two arguments presented at the time - 1) America must continue to show its technical leadership and 2) The far-fetched potential that the Shuttle could be use as a military operations vehicle by retrieving Soviet satellites (It should be noted that this was never a consideration in the use of the Shuttle, but made the perfect argument to sell to the President who had his hands full with the Vietnam War and a high level of distrust with the Soviets). Ultimately, NASA had to get very creative with the dollars it was given and had to set operating budget goals for the Shuttle that could never be achieved. The costs that were to be realized by the Shuttle never materialized and while it performed for twenty-eight years its operational costs have not matched its predecessor the Apollo/Saturn V combination.

3. **"Every problem is a nail is the only tool is a hammer" and the "Jack of All Trades" conundrum –** America will never build a rocket taller that 363ft. Why? Is there a technical constraint to the size of a launch vehicle? No, the simple answer is that is the maximum height of the tall bays in the Vehicle Assembly Building. Another problem that plagues the space program is that it is forced to work within the confines of its existing infrastructure. Immediately solutions are designed around what can be done and not what needs to be done. America may never need a rocket taller that 363ft, but if it did it the structure wouldn't be modified, the strategy would, resulting in a compromise that would either reduce capabilities or increase operating costs.

   Let's look at a real world example: For decades The Boeing Company's passenger aircraft ruled the skies. It was the dominant provider of passenger planes to the world market with no single threat in sight. How did Airbus dethrone an established and entrenched powerhouse? The answer is simple. Boeing relied on World War II era factories and processes while Airbus had to design new factories and new processes to compete. The result was a more efficient production line that leveraged the latest technology and a global strategy that resembled the Dell Computers model. Build or fabricate components anywhere, transport, then assemble in modern facilities.

   America's space program is still operating under the Boeing model and will build or design what the current infrastructure will support. Russia is similar, but Russia always has relied on a simpler approach to manned spaceflight. An example is the ARES I launch vehicle. The ARES I is built using a five segment solid rocket booster leveraged from the Shuttle program (Shuttle boosters are four segments, but ARES design is the same). While this is a great "re-use" of technology it is the wrong use of existing technology. When deployed and launched with an Orion capsule on board the ARES I will already be at the margin of its safe operating limits. There will be no room from growth in the Orion capsule to accommodate more crew or equipment. The only option will be to reduce vehicle weight in other areas, reduce crew or increase risk. This will eventually lead to the design of a new vehicle to accommodate additional vehicle weight or a limit in mission capability based on the current design China however will have the advantage of building what it needs based on what goals it wants to achieve and not rely on decades old processes, factories or facilities to drive strategy. That will give China an advantage in developing a much broader set of space objectives.

The creation of multi-function vehicles and a “Jack of All Trades” approach is a direct result of costs constraints as both the space program and military tried to find ways to squeeze more capabilities into fewer assets. There is no more efficient or cost effective way to achieve an objective that to design a vehicle specifically around the requirements needed to successfully execute that objective. The greatest efficiency comes then from cross training support crew and ensuring the use of standard or common components across a diversity of assets. As deficits and reduced budgets limited options on finding the best way to do things America fell in love with multi-role vehicles. This became a mainstay in the military where the same aircraft is asked to perform a fighter role or an attack role and in some cases other roles such as electronic jamming or reconnaissance roles. It is the same aircraft with a slightly different configuration based on its role, but this approach carries a compromise. Performance, weight, mission capability, safety, maintenance, cost, and risk are all attributes that vary from one role to the next. Since performance, weight, safety, and mission capability are attributes unique to the role being asked of the vehicle then if mission capability becomes too broad then performance, weight, safety and cost don’t carry the appropriate strength level required for mission success which increases overall risk and the likelihood of loss or mission failure. An example is the Navy’s F/A 18 Hornet fighter which serves in both a fighter and attack (bombing) role. When the F-18 was first deployed as a replacement to the F-14 Tomcat it became readily apparent that the Hornet was underpowered as a direct result of asking a vehicle to perform more roles than it could reliably perform. Weight, and as a direct result fuel consumption limited the performance of the aircraft and increased risks to the pilots. The main driver to add more functions to the Hornet? Costs. This eventually lead to a redesign called the Super Hornet which was designed to carry more fuel and larger engines. The premise behind such a strategy became if a vehicle can do 75% of one role and 75% of another role then it can do 100% of both. The Shuttle became one of the the first highly visible examples of this trend. Designed in the early seventies under enormous costs and technical pressures it was the “one-shot” to get an Apollo replacement sold to the President and Congress and get it in production.

Shuttle designers threw everything they could into the vehicle. It was deemed a “space truck” that could haul and retrieve satellites, but was also a crew transport, crew habitat, and science platform. The cost of performing so many functions was vehicle weight and marginal if not substandard performance of its core revenue generating capability of delivering satellites to orbit. Conversely, the cost of delivering crew only to orbit became much expensive. To compound the problem the Shuttle had to operate at the extremes of machine performance. Routine access to space as it was promised would come riding in the world’s most complex machine and one that didn’t account for failure. For all its functions and complexities it lacked the common crew safety measures should an accident occur (abort, ejection, escape).

As long as the American Space Program continues to execute on a base strategy of multi-function vehicles, a reduced operating budget relative to the mission, and designing new vehicles around old strategies and infrastructure it will not realistically be able to maintain a best-in-class program. That is not to say that the program can't and won't achieve its objectives, but it will do so as greater costs and greater risk.

The New Drivers for Space Exploration

The first space race began with the launch of Sputnik I and culminated with the United States landing on the Moon. That era captured the imagination and spirit on the American people. It was a race in every sense of the word - it was country against country with both the former Soviet Union's and the United State's pride and technical prowess on the line and America rallied to win and watch the impossible become possible.

When the race was over the rush of excitement, enthusiasm and urgency waned. The general public became disinterested in space. Subsequently, unmanned missions to the outer planets, the Hubble telescope and rovers on Mars produced stunning photos and results, but renewed interest in manned programs failed to gain a foothold even with periodic Presidential support. The public seemed uninterested in mounting another race and seemed unimpressed by our space achievements especially given the losses we suffered with Challenger and Columbia.

America began to show fatigue with the space program shortly after Apollo 11. The goal had been achieved and the public saw it as routine. The same fatigue is present today even before a Mars launch. While initially exciting and certainly captivating when humans set foot on Mars the transit time it would take to reach Mars would disinterest the public. The occurrence of an in-flight accident would likely bring an end to space exploration beyond Earth orbit and could delay future exploration even to the moon for decades. It is hard to imagine how this could be overcome and public support be regained unless there were interim, tangible results from the program.

The initial stepping stones to Mars should take the program initially from exploration to operation. The public doesn't perceive the value of bases on the Moon largely because in their view space is space. The difference between being on the ISS or the lunar surface is a mere change in venue. The result is the same. Unless there is an initiative to use a lunar mission to provide a benefit to humans the perception will be that it is a replay of what was done in 1969. Lastly, and perhaps the overarching reason for public disinterest is that the rapid pace of technological change since the original Moon landing and the pervasiveness of technology in our everyday lives has changed the way American's view all technical achievements of which manned space flight is an example. American's have come to assume we can do anything and that going back to the Moon or off to Mars isn't the daring reach it was in the 60's. It is already assumed that it can be done so anything less than flawless execution is a failure.

There is though a driver that can rally support and strong interest from the public. We have watched as the world dynamics have changed and continue to head at a pace that is unsustainable. Here in the United States our infrastructure is vast, our economy large and our population growing (although not at the same pace as emerging countries) and we are reaching a point where the world's resources cannot support our needs and the growing demand from China, India and other developed and still emerging economies.

Today, our driver for manned space flight is exploration. Our platforms are costly and predominantly single use or limited reuse. The new drivers for manned space are resources and energy and the platform while still costly should focus on specific areas of performance and high reuse. The focus of manned exploration of Mars will be an eventual outcome of this path, but making it the core focus will not gain the program the required expertise or return that would allow it to gain public support. We must avoid the “moonshot mentality” of mounting a large effort with enormous costs only to not be able to sustain or repeat the capability. While nothing about space travel is or ever will be routine - a manned exploration of Mars must be as routine a mission as possible because we will have honed the skills, developed and practiced the effort in normal space operations to make it routine.

The new reality of our planet is that we need to do something radical to solve our future energy and resource needs and something equally daunting to keep our climate in balance. The answer may lie in transitioning America and eventually the world to a fully “Electric Economy” fueled by carbon-free or low-carbon resources. This undertaking will be a mountainous task that will take time, effort, innovation, risk, money, and during the transition a level of angst and pain as we migrate our vast infrastructure to this longer term solution. As overwhelming as this seems we must look at our current situation and ask ourselves “if not now then when?” There is no immediate answer and any solution will take time. The sooner we start the better chance we have. It is a task that will take decade after decade after decade to bring to fruition, but with small steps and incremental advances we can be ready for the eventual day when we must harness the resources beyond planet Earth.

The energy solutions today of oil, gas, coal, hydro, bio-fuels, solar, wind and to some extent nuclear are limited in scale and quantity. They are too diverse to be stable and are collectively as costly as a space-based solution. As we have seen with bio-fuels there is a give and take impact. More fuel equals less and more costly food. This is another possible solution and that has little or no impact, but has the by-product of honing our skills in space.

The answer to our long-term energy needs and in turn a benefit to our climate may lie in harnessing space-based solutions – these may be in the form in-orbit power stations or the Helium3 resources on the lunar surface. While this may seem a lofty and ambitious undertaking it only appears that way because we are thinking of the solutions in view of our limited strategies and defined capabilities.

Creating a space program that focuses on achieving this goal and reducing and ultimately eliminating foreign dependence on oil; eliminate or greatly reduce coal usage and provide for unlimited energy resources to power a fully electric economy while simultaneously building out a robust space presence and capability is an approach that would surely energize the population to support the space program. While the current generation may not realize the benefits it is an opportunity for the current generation to lay the groundwork for a better tomorrow for those that will inherit the future.

Since the ultimate goal is providing a steady energy source partial funding can be gained by auctioning off “rights” to the resources to global energy and oil companies as well as other industries that would have a vested interest in its success (reactor and heavy equipment manufacturers). A $5-10 billion dollar a year investment from a consortium of energy related companies could provide the added financial resources to achieve this ambitious goal.

These companies would pay now for access and rights that would be available later on the assumption that the rights to such an energy resource would become more valuable over time as demand and resource availability brings the cost to deliver the service to a large populous becomes more feasible and that they are securing the rights during a limited “ground floor” opportunity.

Getting There - Creating a Versatile Space Capability

It was the inspiring vision of science fiction writers that dared us to dream about what it would be like to journey through space. Many depicted fantastic ships traveling at light speed across the galaxy, others had us walking on the Moon or Martians ready to invade Earth. From the earliest days of the human race we gazed upon the heavens in wonder and amazement. Our manned steps in space have been small to date. Far we are from venturing outside our Solar System and even Mars is an effort that will stretch us technically and financially. However, it is often the case that the strategies we take today under the guise of progress and austerity will actually cost us more over the long term. We shouldn’t be as interested in achieving goals in space as we are in sustaining a presence and a versatile capability.

Achieving goals are costly; it is sustaining the capability to achieve those goals that makes it more effective over time. What does that mean? For starters, to launch an effort to Mars to arrive, explore and return is a significant effort, but what next? Wait another forty-years to return or longer to take the next step? What about the resources the Moon holds for helping solve our energy crisis? Can we wait twenty or thirty-years to build a Helium3 mining and refining capability? Can we leverage our experience with assembling and operating large structures in space to build in-orbit power stations? If not now, when?

The cost of space travel will never be economical, but we can make it more efficient today by making the right strategic choices and decisions about what we are going to do and how we are going to do it. Many scoff at building a facility on the Moon as too ambitious, but our thirst for growth here on planet Earth now requires us to solve our problems by looking to the stars. To one day achieve the vision of moving across the stars requires the building blocks that can’t be deferred to future generations.

We are explorers by nature and the human race has thrived on progress. Had man decided to not venture beyond his shores we would be crowded on the savannahs of Africa not knowing that a vast wonderful world awaited us – had man decided the horse was adequate transportation there wouldn’t have been the “iron horse”, cars, planes or rockets. While our nature makes us nostalgic at times for the past, we are always looking ahead for the next journey we can take.

The course we are taking with the Moon, Mars and Beyond strategy is the correct course, but the means to achieve the vision and the drivers for a return require a different approach. As outlined below, maintaining a versatile space capability and leveraging what we have done in the first fifty-years requires additional steps to sustain and expand our presence while using progress as a means to making the space program more cost effective.

The Space Shuttle has been an amazing machine. From its conception to launch, through triumph and tragedy we have learned so much about this winged vehicle. Admittedly, we were naïve to its capabilities and dangers, but we learned, adapted and refined. Now, as that program's life cycle reaches an end we are discarding the very knowledge we paid so dearly to develop and perfect.

Progress is about learning from the past and using it to build a better future.

The Capabilities and Components to Sustain and Deliver a Long Term Space Presence

By following a path to build out the capabilities below America will achieve the goal of a more capable and economical presence in space. Our past policies of "develop and discard" and of "point and shoot" has left us at several key junctures without a manned spaceflight capability as we transition between systems and ultimately end up recreating methods that were abandoned years ago. We are approaching the problem from the wrong perspective.

There are six core fundamental aspects of a robust space program:

1. Crew Transport (Orbital Space Plane) – prior its cancellation and the switch to the Crew Exploration Vehicle this was to be the successor to the Space Shuttle and provide routine low-cost transport of crew from Earth to low orbit. Minimal cargo and supplies, but routine access to the ISS.

2. Medium Lift Capability and Retrieval – the ability to deliver supplies, fuel, components to the ISS or low Earth orbit in an automated manner without crew. This capability would also be used to return components to Earth for repair for refurbishment. This predominantly is a method to economically transport smaller modules for assembly in Earth orbit.

3. Heavy Lift Capability – Reserved for large components. While this capability should always be available its use should be limited in lieu of more economical approaches. However, this should nonetheless be a capability.

4. In-Orbit Platform – The ISS is the ideal staging platform for crews and equipment from Earth to rendezvous and assemble components and vehicles and to transit from the Moon to Earth or beyond.

5. Assembly – The ability to build larger structures that will need to operate only in space. Structures that can transport crew, materials and supplies to the Moon and beyond without the need to limit function by how much can be lifted in a single effort.

6. Reuse – All of the components should be designed for reuse and elements that can be maintained and sustained over a long period of time. Today, we plan to

use and discard. While the Crew Exploration Vehicle unlike Apollo is designed for reuse the Lunar Lander is not. Designing a system where space-based components are designed for reuse will provide for a more cost-effective system.

Using the six fundamental principles above there are then five capabilities that should be developed. Of the five, three are interconnected and are easily achievable based on the knowledge and experience we have today. They would reduce expense over several decades while positioning us to achieve our greater space objectives.

They are:

1) Automated Cargo Delivery and Return Vehicle*

2) ISS Assembler Module

3) ISS Platform Expansion

4) Free Return Laboratory

5) Crew Transport Vehicle

*The 1) Cargo Delivery Vehicle would be an unmanned Shuttle-type vehicle mated to the existing Shuttle stack (boosters and external tank) that would deliver medium-lift components into low Earth orbit for 2) assembly at the ISS 3) Retrieval of modules and return them to Earth for repair or refurbishment – this would include station modules, satellites, equipment, samples, other cargo.

1. Automated Cargo Delivery and Return Vehicle

Description: An unmanned, reusable, lighter, winged Shuttle-type vehicle that leverages the Shuttle infrastructure (solid rocket boosters and external tank) and a new “flying” cargo bay design that could deliver to and return modules from the ISS for expanding the station or for in-orbit assembly of larger exploration vehicles.

The Space Shuttle is a unique capability. Full of promise, but a system that carries inherent risk for manned crews. This system has been perfected as much as possible over the past twenty-six years. Taking the Space Shuttle to the next level is a cost-effective decision for our long term space goals.

Leveraging the systems and infrastructure of the existing Shuttle including the Solid Rocket Boosters and External Fuel Tank combined with a new fleet of lighter, unmanned orbiters would extend the Shuttle’s capability, continue to perfect the system, achieve medium-lift capabilities while keeping in place the capability to return to a winged manned Shuttle in the future. These vehicles would be unmanned automated cargo delivery and return vehicles.

As envisioned, a winged Shuttle-like vehicle that could ferry medium-lift modules into space to continue building out the ISS or returning sections of the ISS back to Earth for refurbishment and life extension. Essentially, a flying Shuttle cargo bay without the equipment and weight of crew quarters, life support or redundant systems required to achieve a manned performance rating. Having this capability can greatly extend the utility of the ISS and ensure that it can service crews and provide additional capabilities well beyond its expected life span today.

This vehicle would launch using existing Shuttle infrastructure, knowledge and technologies on an updated, automated, unmanned orbiter-like vehicle. The new vehicle could be designed to carry the approximate load of the Shuttle. The elimination of crew quarters, life support and redundant systems would make the vehicle lighter and smaller in overall design, but similar in shape.

The vehicle would ferry new modules to the ISS or return modules back to Earth that needed repair. This vehicle would be a critical part of a long term sustainable space strategy.

This platform would also be used to assemble lunar-bound vehicles and equipment for exploration and initial mining of H3 resources as well as assembling a larger vehicle for a transit to Mars.

Why this is critical strategic element of a continued American space program

America needs to maintain a medium-lift capability. A winged unmanned cargo delivery and return vehicle based on the infrastructure and learning's from the Space Shuttle program leverages our experience and positions us to continue to build, remodel and extend the ISS capabilities. It also provides the capability to prolong the life of the ISS and recoup our investment rather than build a new space station in the future at even greater costs down the road. Unlike the European Space Agency's Jules Verne Module it would not just deliver cargo, but carry larger amounts and be able to return items to Earth for refurbishment and reuse.

The Cargo Delivery Vehicle could continue the service the Shuttle provides today ferrying new modules, returning modules for servicing.

Future design of ISS modules should take into account this strategy.

As important is the true capability this system would provide to our vision for space exploration. It would make the ISS a space dock for building ships that could return us to the Moon and Mars. The Cargo Delivery Vehicle would deliver large components of fuel and structure for assembly of a Mars or Moon Vehicle at the space station.

Why this is a cost-effective system

The ARES 5 is a great successor to the Saturn V legacy and is still a capability that the United States must possess. However, the same goal can be achieved more expeditiously by using the existing Shuttle stack and Shuttle main engines in the development of an unmanned orbiter. The unmanned orbiter would be built from a modified Shuttle design and would be the only “new” component.

We have significant experience with all of these systems and we have experience building and supporting Shuttles. The CDV could not lift a lunar lander and TLI booster, but if the strategy were modified and vehicles built in space were left in space and reused we could accomplish the goal our getting back to the moon on a faster pace with a better capability.

An effective use of the CDV would be to transport fuel, components and modules for a lunar landing. A transport vehicle built from components launched from Earth and assembled at the ISS would include a detachable lander (single stage). The transport vehicle (“ferry”) is a small module resembling more a miniature space station (since it would operate only in space without need for reentry) with docks to hold equipment and a lander. The transport would remain in space where it would be refueled on return dock at the ISS. The transport would ferry the lander, equipment and supplies to lunar orbit where it would deploy the assets. The ferry would remain in lunar orbit and redock with the lander and return to the ISS.

For example: The “ferry” as described above would transit from the ISS to lunar orbit. Since the vehicle remains in space it could be nothing more than a “module” with a dock for a lunar lander. Upon return to the ISS, the “ferry” could jettison its “engine and fuel tank”. A subsequent launch of a CDV could carry a replacement “engine and fuel” tank along with other supplies on a routine mission to the ISS. The replacement engine module could be configured to mate with the ferry and allow the craft to be reused numerous times in manner similar to the space station. By flying just an engine and fuel the ferry can be reused and the CDV could carry a “hazardous”, higher risk cargo without fear of a manned crew onboard.

To achieve our ambitious goals as outlined in the Vision for Space Exploration will require that we build large structures in space from components fabricated here on Earth as we have successfully done with the ISS and reuse those components. It seems impractical that the Orion capsule would be used or required on a Mars transit. Its only function would serve to bring the crew back to Earth after the mission. Transporting the craft to and from Mars would itself carry risk to the vehicle and systems. A far better approach would be to dock a vehicle to the Mars transit vehicle when it reached Earth orbit. For example, launching a Crew Transport Vehicle/Orbital Space Plane to retrieve the crew and return them to Earth would be a more logical approach or docking the Mars transit vehicle to the ISS after it has reached Earth orbit (while risky, would provide a reuse potential of the vehicle).

Whether a journey to Mars or to build bases on the Moon or to ferry resources from the surface of the Moon back to Earth we will need a system to achieve these goals. Singularly attacking the problem with point and shoot systems will prove too costly and too time consuming. This system would put us decades ahead of the course we are currently on and save us tens of billions of dollars while providing a real tangible system to harness the Moons resources sooner rather than later.

The CDV could deliver pre-fabricated modules that would be assembled at the ISS. The modules could contain a crew cabin, electronics, fuel, food and water for a journey to the Moon or Mars. If the vehicle were going to the Moon it could contain the components to build a base, mining equipment. How large it is only a factor of how many modules are assembled to it. The resulting structure would then “launch” to the Moon or Mars and subsequently re-dock with the ISS before the crew would return to Earth. If were for example to mine the Moon for Helium3 the structure would deliver the necessary equipment and supplies to the Moon and then stay in lunar orbit until it would return the Helium3 or other resources back to the ISS where a CDV would return the resources to Earth. It is a repeatable and sustainable system. The ship could be refueled at the ISS or from fuel derived from the lunar surface and used over and over on the lunar missions or to Mars. Once built, Astronauts would depart Earth for the ISS (using an OSP/crew transport) and use the vehicle assembled in orbit to move to and from the ISS to the Moon. If the goal were to explore Mars or a nearby asteroid the ship would be assembled at the ISS and then launched to the target. The system could be reused over and over with only fuel and consumables re-supplied.

Costs are reduced over current Shuttle flights by reducing the scope of the mission. The CDV is pure medium lift cargo delivery and return. No crew, no crew training, a smaller vehicle without necessary manned flight required components or manned safety ratings.

This also preserves the existing infrastructure, expertise and facilities used to produce Shuttle components today allowing us to preserve this capability and continue to refine our expertise in these systems. Building a new heavy lift rocket with a new design is costly and time consuming.

Using the existing stack would save development time and testing. Two-thirds of those systems exist today and the remaining component (unmanned orbiter) would initially be costly to build, but it would be reusable and built on an updated Shuttle design greatly reducing expenses. It would be a loss to abandon the booster and external tank production and configuration when it could be used for medium lift capability with an unmanned Shuttle-like cargo vehicle. It has been tested thoroughly and the entire infrastructure and maintenance support is intact.

2. ISS Assembler Module

Description: An addition to the ISS that would house a robotic arm, docking hatch and mechanism where cargo from a nearby docked Cargo Delivery Vehicle (CDV) could be retrieved and modules “assembled” to form a larger vehicle. The assembly module would hold a base module in place; attach a subsequent module using the robotic arm then move or “slide” the entire assembly one module to the left or right to allow for another module to be attached. The modules would be supplied by multiple CDV launches. The overall length and capability of the assembled vehicle would only be a factor of the number of launches required to complete the design.

The Space Station makes an ideal platform for assembling in space. It is reachable in low Earth orbit and has the necessary foundation to provide for a larger capability namely the assembling of larger objects in space.

To build Moon bases, venture to asteroids or Mars is going to require the construction of larger vehicles. The strategy of a large single launch vehicle is outdated and the Constellation program requires two vehicles for just a manned lunar landing. This does not take into account a larger vehicle that would be needed for Mars or for creating an economically sustainable presence on the Moon.

Why this is critical strategic element of a continued American space program

We will need to build larger vehicles in space. Unless a major breakthrough materializes in spacecraft propulsion we will be dependent on chemical fuels. Launching and assembling components in Earth orbit was the original vision of Dr. Werner Von Braun. Today we have the ISS that we can leverage to assemble them modules. This is not just about Mars, but about assembling and ferrying supplies and resources to and from the Moon. The key element to this is using the Cargo Delivery Vehicle to boost components to the ISS, using the ISS to assemble the components. Then the assembled craft after use or on return from the Moon or Mars would re-dock with the ISS. The cargo (sample, Helium3, other mined resources, modules) would be loaded on a CDV for return to Earth. The crew would return in a separate vehicle.

Why this is a cost-effective system

This builds a component onto the existing ISS that will leverage that platform first as an assembly platform and second as a way station for a journey to and from the Moon or Mars. We already have the experience and expertise to build in space. It is how the ISS itself was built.

To expand our capability to reach the Moon, Mars or asteroids will require larger equipment assembled in orbit. This could be done by several launches on an ARES 5. However, that does not solve the assembly problem. We don't want to limit how far we can go or what can be accomplished by how big our rocket is. Instead, we must build a system that meets our needs today and tomorrow.

The assembler module is part of a three part system that will get cargo and components from Earth to the ISS, get them assembled at the ISS and then be launched from the ISS. The ISS will also be used as a return point. The CDV will be used in an additional capacity to return resources and components back to earth. This is a reliable and reusable system that is cost effective and builds strength by developing mission specific capabilities.

3. ISS – International Space Station

Description: A transformation of the ISS platform. In addition to using the ISS as an orbiting science laboratory the ISS mission would expand to assembling components transported from Earth into vehicles that can move people and equipment to the Moon, Mars and beyond.

By some accounts the work done to construct the International Space Station will have taken one hundred billion dollars by the time it is complete. Yet, as the Space Shuttle nears retirement and the prospect that not all the work can be achieved what is to become of this orbiting platform? Today, unless a Shuttle is docked only three residents inhabit the massive facility due to the lack of rescue options for the managing crew should an onboard emergency occur. With the cancellation of the X-38 (Crew Return Vehicle) that would have been carried in the Shuttle cargo bay and left docked as a rescue vehicle the station's only escape in an emergency is a docked three-person Soyuz capsule. It would be a vast waste of capabilities and resources if we were to build this platform and then let it age and fall back to Earth.

What needs to be done –

- Commit to a program that will sustain and support the ISS until at least 2020 and possibly beyond. This will be done by implementing the vehicles (CDV) that will deliver replacement modules and technologies while returning some modules for upgrade and repair.

- Expand the mission of the ISS to include assembly in orbit of larger vehicles that deliver supplies to and from the Moon or carry a crew and adequate supplies on a mission to Mars or an asteroid.

Why this is critical strategic element of a continued American space program

Significant time and effort has gone into the development of the ISS. As in the past, we can't let this capability go underutilized or the skills, experience and knowledge that went into building the largest man-made object in the heavens go to waste. Long duration spaceflight like a trip to Mars will not be on a traditional spacecraft, but a space station. A craft which can house and support humans for long periods of time necessary for the trip to Mars.

Using the ISS as a destination to assemble modules is a logical solution to building large craft in an efficient manner. The station itself can serve a way station for travelers to and from the Moon and Mars. A key flaw in our strategy today is that we believe in re-use of selected components, but have the wrong delivery system. Building a vehicle in space and leaving it there to move large amounts of equipment and supplies while moving people to and from Earth is a significantly better approach. The vehicle left in space and docked at the ISS can be reused over and over. Under this model even the top half of a lunar lander could be returned to the ISS and refitted with a new descent stage and refueled.

This would save half the cost and weight of delivering a full lunar lander to the Moon.

Why this is a cost-effective system

Using the ISS in an extended capability is leveraging a large investment. It also is utilizing the skills we developed to build the station. The largest savings though it derived from thinking about how we do travel differently. Assembling a vehicle in orbit that will stay in space and once built will need only refueling will constitute a large savings. The vehicle must be refueled, but transporting fuel is less costly than transporting fuel and a vehicle. Once the craft is assembled the focus can be on delivering crew to the ISS where they will then board the lunar transport or Mars transport vehicle. This could be the same vehicle that could first be tested in a voyage to the Moon and then upgraded for a trip to Mars. This would accomplish a test in the close proximity of Earth before venturing out on a longer voyage.

Section Summary

Developing these three capabilities changes the thought process from an extremely expensive, nearly cost prohibitive method of reaching the Moon and Mars to a sustainable, more economical approach that will deliver a superior capability. Our ultimate goal for Mars is exploration; our goal for the Moon is eventually harnessing the resources of Helium3 and establishing a Moon presence where fuel can be produced to self-sustain a travel loop between the ISS and the Moon without refueling from Earth.

Additional Expanded Capabilities

The additional capabilities listed below extend and enhance the current program base and utilize the core components specified above.

4. Free Return Laboratory (FRL)

Description: Using the Cargo Delivery Vehicle and the ISS Assembly Module construct a small multi-module manned craft (mini space station) that would be launched from the ISS or from a heavy-lift launch vehicle into an Earth-Lunar orbit. The insertion would place the FRL on a course that would lock it into a perpetual "double" free-return orbit that would take the craft around the Earth and the Moon.

The vehicle would operate at a larger orbit than a typical "Apollo" type flight plan. The purpose of this vehicle would be to test long duration flight outside of Earth orbit, but within the relatively safer confines of the Earth-Moon system. Vehicles launched from Earth could be timed to dock with the craft as it passed by the Earth and use it to hitch a ride around the Moon depositing the vehicle on to the Moon or back into Earth on a subsequent pass. Vehicles could also be launched from the ISS to rendezvous and dock with the FRL.

A Free Return Laboratory would be an ideal approach to test a vehicle and system outside of Earth orbit, but not out of reach should a failure occur. This vehicle could be used in several configurations:

a. Orbiting test vehicle to shakedown systems and capabilities for long duration flight to include radiation shielding, communications, closed loop environment for water and food production.

b. Second Manned Space Station – This smaller station would be used to make observation and studies of the Moon on each passing orbit. Would also test shielding and environment.

c. Ferry – Using vehicles launched from Earth or the ISS dock with the FRL as it passes by Earth and uses it as a "free ride" to and from the Moon.

Why this is critical strategic element of a continued American space program

This capability allows us to test a vehicle that could be then used for deep space voyages (Mars, asteroids). It also provides a platform for testing equipment and components that would be necessary on a long duration without the risk of jeopardizing a crew. The vehicle would pass within the relative safety of Earth every 5-8 days. Where a crew could disengage and return to Earth or the ISS.

This is the next evolution in space travel. Journeying beyond Earth will be on a mini-space station not a confined craft. The vehicle will be capable of science, observation, navigation, and able to withstand the rigors of space.

Why this is a cost-effective system

The Free Return Laboratory (FRL) can be a small design that will house 2-3 crews that would be assembled or launched from or the ISS or from single heavy-lift rocket. The vehicle would then be inserted into a stable orbit that would take it on a free return orbit using the Moon's gravity to loop it back to Earth and the Earth's gravity to loop it back to the Moon. In addition to providing valuable science and serving as a conceptual model for a Mars journey, the vehicle could also provide a "free ride" to and from the Moon. The craft would be refueled and re-supplied periodically from Earth launched vehicles.

5. Crew Transport Vehicle/Orbital Space Plane

Description: Small reusable vehicle that would be launched atop a more economical stack (Ex: X-38/HL-20) and configuration. Leveraging the experience with the Space Shuttle and lifting bodies as well as partnering with Russian and European agencies to build a less complex Crew Transportation vehicle.

The vehicle's purpose would be solely to transport crews to and from Earth. The spacecraft would not need to be multi-functional or capable of long duration missions or extended flight capabilities. Additional vehicles required by the crew would be delivered and assembled at the ISS where the crew would transfer. Upon return the crew would re-dock at the ISS and use the Crew Transport Vehicle to return to Earth.

A challenge that has faced the space program in the past has been the requirement to develop a single spacecraft that serves multiple roles. Developing craft that perform so many functions including launch, mission, and return is costly. The Crew Transport Vehicle's only mission would be to transport crew to and from the ISS. This minimizes weight and mission function. All other mission or science objectives would be performed on a vehicle designed only for space that would be assembled at the ISS from components delivered in a separate system (Cargo Delivery Vehicle).

Several competing nations (Russia and European Consortium) have conceptualized such a vehicle. The Russian Clipper and the ESA Hermes are two such vehicles that could be used for this function.

Why this is critical strategic element of a continued American space program

To venture beyond Earth's orbit in a cost effective method requires using the simplest method to get a crew into space and returning them safely to Earth. The mission to be performed should be on a vehicle designed for the mission that would be built and re-used in space. Simpler is better. Building complex multi-role capsules adds to costs and risks.

Why this is a cost-effective system

Simpler is better. Simpler is more cost-effective. Simpler is safer.
The key to success is to build several simple systems that can be refined and repeated over and over with high degrees of effectiveness and safety. While all space travel carries risk. The highest margin for failure occurs at launch and reentry. A vehicle with less weight, less systems where the main purpose is safe delivery and return of crew is cost effective. This also simplifies training and objectives. The vehicle should be a small Shuttle-type vehicle in a winged or lifting body configuration that could be fitted atop an existing Delta stack or other easily available and reliable rocket.

Stages to Success

America's objectives in space can be achieved at a reasonable cost and risk level if it is done in stages and if it is done with the right strategy that focuses on each component performing a specific function and each component developed progressively over time.

America should focus on building out the necessary components to progressively move the program towards its long term goals. In order of priority:

- Earth to low-orbit transport of crew only via reusable winged vehicle.
- Earth to low-orbit transport and return of equipment to/from ISS using an unmanned Shuttle replacement.
- ISS expansion to support in-orbit module assembly of lunar transit vehicles.
- Design of reusable Earth-Moon Transit Vehicle that would depart and dock at the ISS.
- Small manned laboratory/station (same design as the Earth-Moon Transit Vehicle) that would operate in an Earth-Moon orbit for testing of long duration systems and components.
- Lunar lander that could be reused and ferried to and from lunar orbit back to the ISS for refueling/re-supply using the Earth-Moon Transit Vehicle.

Stages to Success – Asset Profile

Stages to Success – Asset Profile			
Asset	**Description**	**Crew**	**Capability**
Crew Transport Vehicle (CTV)/Orbital Space Plane (OSP)	Small reusable winged vehicle modeled on the X-39/HL-20 design. Crew transport to and from the ISS only. Launch and return to KSC	2 minimum 6 maximum	Delivery of crew only to and from the ISS. Launched atop a manned rated rocket, (would likely require modification and or certification of an Atlas or Delta Heavy Lift Rocket.
Cargo Delivery Vehicle (CDV)	Large reusable automated winged vehicle modeled on the Shuttle, but restricted to medium lift of components, fuel and cargo to the ISS and return of hardware, equipment and modules back to Earth.	Unmanned	Provide a capability to lift components, cargo and fuel to assemble larger vehicles in orbit for transit to the Moon or Mars. Vehicle would also return equipment and supplies to Earth for delivery and refurbishment.
ARES V	Heavy Lift Vehicle (Single Use) currently under design.	Unmanned	Limited use to lift heavy objects into orbit that could not be assembled in orbit.
ISS	International Space Station	Up to 6	Repurpose the ISS as an assembly platform, refueling station and way station for transit to and from Earth and to and from the Lunar Surface.
Lunar Transit Vehicle (LTV)	Reusable vehicle assembled at the ISS from components delivered by the CDV. Vehicle would operate from low-Earth orbit or the ISS to transport crew and the Lunar Lander to lunar orbit and back .	Up to 6	Module configured to launch from the ISS or low-Earth orbit to the Moon. LTV would carry docking elements to carry, deploy and retrieve a Lunar Lander or other surface components. Other surface components transported could include a habitat or equipment. LTV would transport lander, equipment and supplies back to the ISS. LTV and Lander would be refueled and reused.
Lunar Lander Vehicle (LLV)	Reusable Single stage transport to carry crew to and from the lunar surface. LLV would be transported	Up to 6	Vehicle that could carry crew to the lunar surface. Minimal surface operational capability. Additional surface habitats

	to the Moon by the LTV and dock with the LTV for transport back to the ISS.		would be transported and deployed via the LTV. The lander's function would be limited to descent and ascent operations.
Free Return Laboratory (FRL)	Small two module laboratory with engine and maneuvering capability that would operate in a double free return orbit between the Earth and Moon	2	Test platform for long duration operations in the relative safe confines of Earth-Lunar orbit. Crew exchange and refueling would come from Earth or ISS launch modules. Lab would be a test platform for a potential Mars transit vehicle.

Paying the Way – Financial Considerations

The projected costs to fund a single mission to Mars are projected at one-hundred billion dollars, an amount equal to the total projected costs of the International Space Station. By focusing the efforts on long-term sustainable strategies the projected Mars mission expense can be repurposed into developing systems, vehicles and operations that will provide a greater return and long-term benefit at a significantly reduced overall expense. Compared to the current Vision for Space Exploration this proposal contains numerous differences in the approach and execution of the manned space program:

1. Focus is on creating assets in space that can provide a long term solution to a pressing problem – Energy.

2. Leverages the investment we've made financially and in experience, knowledge, skills, components and infrastructure and prevents them from becoming "throwaway".

3. Builds an infrastructure where key elements are independent of each other. Relying on low cost methods where that is appropriate rather than building large scale systems that are overcapacity for some missions and underpowered for others.

4. Allows for refinement of skills local to Earth and Earth orbit while providing a tangible return and positioning the program for longer term missions once this capability has been established.

5. Focus on re-use of spacecraft throughout the system. Not "one ship" "one trip" to the Moon, but a recyclable system where vehicles require only fuel and consumables.

Costs are the key driver in the space program today. The Space Shuttle was born of an era where the focus was how to do it "cheaper". Constellation is an outcrop of returning to the Moon and Mars with the least amount of costs. Government supporters in Congress and the Executive Branch find the space program a symbol of American technology yet few are willing to fund the program at the level required to make significant leaps in progress. Currently, the manned space portion of NASA's budget is approximately $8.5 billion with $5.5 billion to operations (Shuttle, ISS, Training and Support) and $3 billion to development of Constellation. Incremental funding that would place the annual manned portion of the NASA budget at $10-12 billion per year could create a highly robust space capability that can provide the safety, repeatability and reusability that can reduce costs long term.

Our quest to explore space has yielded results and knowledge – our current task should be to take what we've learned and apply it to solve our problems on Earth by developing a method successfully harness Sun's resources or the Moon's resources to meet future energy demands. To fund this program there are several approaches:

1. Auction – The Federal Government can auction off rights to develop and utilize H3 resources that would be returned from the Moon or rights to purchase power from in-orbit power stations.

2. Energy Fund – Require Oil, Gas and Utilities to contribute to a fund that would pay for this exploration. In return, companies are able to share in the technology and knowledge when the system is proven.

3. Tax – an option of last resort, but with recent fuel prices at record highs the taxpayers might be willing to fund the program separately by a $.01 tax on each gallon of fuel. The $.01 would yield $1.5 billion dollars to fund this initiative. $.02 would yield $3 billion. This alone would not cover the additional costs, but combined with other options could make the program viable.

4. Private Entity – Setup a separate private entity that would purchase technology, development and systems from and under the direction of NASA. The private entity would be a combination of private funding from energy and industrial companies and well as some public funding. The goal would be to make the system eventually self-supporting with the new organization fully funding development and ongoing operations and NASA gaining the benefit of the developed technologies and expertise for use in a subsequent Mars mission.

Summary

America is the world's greatest space power. Over the past 35 years we have allowed other nations to challenge our superiority in space. Due largely to economic reasons we charted a different course in space that did not leverage the progress that led to the manned Moon landings, but instead charted a new path that while highly capable left us without a versatile and broad-based space capability. Now, the Space Transportation System is approaching the end of its lifecycle and once again we are charting a new path that partially leverages the systems and knowledge gained from the 30 plus years of development and utilization of the Space Shuttle.

We are embarking on a journey that will be long, far too long and expensive, and one that doesn't provide the United States Manned Space Program with long-term sustainable capabilities. We could make another giant leap towards solving our energy problems here on Earth, but getting back to the Moon again, much less mining its resources is proving to be a lengthy process. If we don't land on the Moon until 2018-2020 then harnessing its resources is many more decades away. We must while we are at this crossroads develop repeatable strategies and systems that will deliver our near-term objectives while positioning us for long term goals.

This document outlines the capabilities that we must build now to make living and working in space, venturing out to the Moon and Mars a reality. To make true progress in space and harness its resources means that we must build a sustainable system. We will need the ARES 5, but cannot afford to abandon the knowledge gained from the Shuttle and we must evolve it to the next level and build an unmanned Shuttle replacement vehicle (CDV) that would use existing, well-tested components. The unmanned orbiter design would be built using our original Shuttle design and leverage our operational experience with the vehicle. We designed the Shuttle in the early '70s it was built in the early '80s and we have twenty-five years of technology and knowledge that would be incorporated into an updated unmanned version.

This document advocates a group of systems that would each perform a key specific function in a much broader space vision. Developing expertise and reliability at each stage of the system is far safer and much more productive than building multi-purpose systems that must do it all. Once this foundation is in place how we use it is up to us, but the platform will be there to help us take small steps or giant leaps.

With the growing concern that manned space flight is too fraught with risk or too expensive or that the objective aren't clear we must establish an achievable plan and the means to position ourselves to move the needle and change the approach to how we think about space exploration. We must establish that plan now so that it can service us for decades to come.

The beauty of space exploration is that it has proven to be the one area where nations come together and work together to achieve a common purpose. This proposal need not be an America only venture. We have some of the necessary components, others need development, but this is our opportunity to be not just a space faring nation, but a space fairing planet. We want a successful American space program today, tomorrow and beyond.

About the Author

Mike O'Hara is a life-long follower of the space program and space enthusiast. His interests include all facets of manned and unmanned space exploration. Additional hobbies include astronomy and rocketry. Mike developed and maintains his website "The Conquest of Space" (www.theconquestofspace.com) that catalogs his interest in space exploration. He also writes a blog on current space issues. That blog can be found at http://theconquestofspace.blogspot.com or as a link on his website.

He currently is a Vice President at a large financial institution in Charlotte, North Carolina and had held Executive levels roles in two of America's largest banking institutions.

In Mike's professional career he is a recognized industry expert in technology and end-to-end supply chain management. He is a sought after speaker addressing national conferences and local industry specific chapters like NCMA (National Contract Management Association), NAPM/ISM (National Association of Purchasing Managers/Institute for Supply Management) and IACCM (International Association of Corporate Contract Managers) across the U.S. and Canada.

Mike's twenty-one year career in the financial services industry includes tenures with two of America's largest banking institutions. This includes 9 years as the technology leader and strategist in the supply chain organization. During his tenure in financial services he has designed and led many key initiatives and functions in including Information Management, Contract Management, Procurement Audit & Compliance, Customer Service, Contract Development, Supplier Analysis, Training, Purchasing and Accounts Payable.

Mike is an accomplished leader with a successful track record in process redesign and reengineering, development and deployment of innovative technology, expense management and e-business strategies. He is recognized as an innovator, thought-leader and visionary around the use of technology, supply chain tools and processes. Over his twenty-one year career, Mike has received 11 corporate awards and 1 national award covering Service, Quality, Professional Excellence, Innovation and Leadership.

Mike majored in business management at the Johns Hopkins University in Baltimore. He is also a certified Six Sigma and Design for Six Sigma Greenbelt.

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