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Request for Information
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Independent Space Transportation Operator Concept

A Breakthrough Acquisition Strategy Using Independent Space Transportation Operators

Making Affordable and Sustainable Space Transportation Possible

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*****S I N G L E S H E E T S UMMA R Y*****

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REQUEST FOR INFORMATION (RFI) FOCUS AREA: Program Management, Acquisition, and Interfaces

RESPONSE SUMMARY—Progress in achieving affordable space transportation (i.e., cost-per-flight *and* cost-per-pound) for space exploration, commercialization and defense has been stalled. While many promising technical strategies must be pursued, this Request for Information (RFI) response suggests that a new business strategy using *independent operators* could be the breakthrough means that allows innovative technical approaches to be embraced that focus on operability, supportability and dependability. Explored are the near- and long-term programmatic benefits of establishing independent operators for space transportation; i.e., business organizations that operate and maintain space transportation system assets independently from flight system manufacturers. These independent operators do not profit from production of flight hardware but rather profit from producing flights for paying customers (either on government contract or in the marketplace).

More importantly, the enclosed paper indicates that a unique (but rapidly fading) opportunity exists for independent operators to influence design requirements for the space exploration systems that NASA's Office of Exploration Systems (Code T) intends to acquire, operate, and sustain. *Code T must initiate action within weeks if it is to impact currently planned proposal activities. If acted upon too late, Code T loses a significant opportunity to instill discipline in space transportation design activity for deriving operationally effective solutions.* This would be due to the perpetuation of the current space launch system acquisition status quo, where entrenched manufacturing interests continually trumps operability and supportability.

New business models, with profit motives driven less by hardware consumption and more by space system utilization, can unleash free-market economic forces to help NASA achieve its ambitious program cost, schedule and risk goals, while staying tightly focused on the needs of the operator. The paper discusses the pros and cons of using independent operators as a breakthrough means for NASA's Exploration Enterprise to achieve these objectives. This concept promotes interdependent contracting arrangements between suppliers and operators with natural economic incentives to pursue innovative technology development, establish affordable and sustainable space architectures, and promote internationally competitive space commerce growth by providing greater investment choices and opportunities. To achieve this Code T should recognize and encourage on-going government-industry-academia partnerships for spaceport and range technical development and seriously consider the benefits of pursuing the Future Interagency Range and Spaceport Technology (FIRST) program currently being formulated. Finally, the paper points to changes in technology needs, as well as needed changes in system design strategies.

PROPOSAL—NASA's upcoming Office of Exploration Systems proposal activity—particularly with regard to space transportation systems RFPs, BAAs, and so forth—should partition a) flight element concept definition activity from b) concept of operations development and ground/surface support element concept definition activity. No bidder of part (a) should be allowed to bid or earn profits from the efforts of part (b) during the concept definition period. Further, NASA should follow through with this separation of the means of space transportation flight element production from the means of space transportation operation during each phase of acquisition in order to ensure that inherently operable, supportable, and dependable system solutions emerge from NASA investments.

INFORMATION CONTENT

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- Historical Examples
- Potential Programmatic Improvements
- Enabling Needed Technical Improvements
- Need for Variation from Past Attempts
- Recommended Influence on RFPs and BAAs
- Conclusions

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INTRODUCTION

Situation for Space Transportation Operators—Why are inherently operable, dependable, and supportable systems not emerging in anything other than marketing bullets for space transportation? Huge programmatic investments are made. Billion dollar sales of hardware and software products are made. Yet no system has proven to be inherently operable and logistically sustainable enough for anything more than monthly utilization at best of the resulting space assets (flight elements and their support assets).[1]

A Vertical Space Transportation Industry—Today's space launch providers (large and small the world over) currently design, manufacture, and operate launch vehicle flight hardware. They also design, manufacture, operate and maintain unique ground support equipment (GSE). They even design, construct, activate, as well as operate and maintain unique launch infrastructure, such as dedicated launch platforms, custom launch pads, dedicated control rooms, vehicle assembly facilities and so forth.

The Manufacturer's Business Motivation—Separating the manufacturing function from within this vertical business model, we can see that the motivation is ultimately focused on production sales of flight hardware and associated software products.[2] Sales and profits, from the manufacturer's point of view, is maximized by tying the sale of a flight directly to the sale of flight hardware—preferably expended after each flight. Manufacturing profits are compounded even more when multiple flight elements are assembled at the launch site for each flight (such as multiple rocket engines, solid strap-ons or multiple common elements such as seen in EELV and Falcon concepts) and thus consume even more hardware per flight. This then creates, from a near-term perspective only, even greater hardware demand and thus more hardware sales within a given market condition.

Past experience has also shown that ground support equipment (GSE) creep—a process by which servicing and support equipment accumulates during the design phase—represents an excellent opportunity for cost-plus profit on government contracts for not only unplanned equipment acquisition, but also for recurring upkeep and associated services, as well.

On balance, the manufacturer's incentives are to make money by holding down their manufacturing costs regardless of operations and support impacts that occur well after the business commitment. This may also partially explain the lack of Operational Readiness Demonstration (ORD) requirements (which are demanded by the customer in most military aircraft acquisitions and commercial airliner enterprises). This is due to the fact that manufacturing interests dominate space launch business decisions. There is little incentive for the manufacturer to be held accountable downstream with regard to perceived "lesser priority" operational outcomes, such as the total system responsiveness, total accumulated infrastructure and logistics support systems. As long as the customer gets a capability to deliver the "mission" hardware successfully to space, all else can be compromised from the manufacturing point of view.

The Operator's Business Motivation—The space transportation system operator, if we can envision that business function in isolation for a moment, is concerned with owning and operating space transportation system equipment (both flight and ground support) and producing profit from sales of space flights for a customer. Repeatedly purchasing equipment, and the cost to operate and support that equipment, is to be minimized. The number of paid flights by a customer base is to be maximized. Labor and equipment-intensive assembly of flight elements and launch vehicles are to be minimized, simplified, and preferably eliminated—i.e., "no assembly required." Complex flight systems, such as liquid propulsion and power management systems need to be simple to service and operate; even though it may be perceived by the vehicle manufacturer (and their traditional parts supply chain) as having less profit potential for flight and ground hardware production.

In other words, the business motives of the space flight system manufacturer are very different from the prime motives of the system operators within the same industry. Can these differences be reconciled?

A Compromise Solution or a Win-Win Solution?—The natural tendency in the current vertical business arrangement, since both the manufacturing elements and the operating elements are embodied under one industrial house, is to strike a balance and compromise. The compromise process, however, has not proven to be win-win. Today's business equation tends to favor increased profits for higher-margin manufacturing at the expense of higher downstream operating costs. Separating these functions into independent enterprises would bring economic forces to bear on both sides of the equation, allowing optimization of both classes of the enterprise. This would likely encourage business growth and, perhaps, international leadership.

Compromise in Requirements—In today's environment, the process of compromise usually begins with the conceptual requirements for new space transportation system architectures, with experience teaching us that the business needs of the manufacturer continually dominate and delay specification of operations and support requirements to the "next phase," since the particulars of a flight system solution are the center-of-attention.

Discipline and Accountability in Aircraft Acquisitions—This degree of flight system design and manufacturing dominance is not true, however, for aircraft. For commercial aircraft sales, for example, independent airlines must be brought into the conceptual design process and sold on the proposed product before major commitment to detailed design and production. The airline's requirements (that is, the independent operator's requirements) must be met, or there is no deal. Additionally, airworthiness requirements must be demonstrated before the system is fielded, offering further evidence to prospective purchasers of the operational compatibility of the product with business operations.

The same is largely true for military aircraft equipment buys, even for relatively new concepts like the V-22 Osprey tilt-rotor vertical/short takeoff or landing (V/STOL) vehicle. In the V-22 case the DoD was not satisfied with the fielded reliability and maintainability of the product and has since been sent back to pass more rigorously enforced Operational Readiness Demonstration requirements.[3]

Possible Win-Win Solution: Independent Operators—In order to deploy and grow an affordable and sustained capability in space, we must find a "win-win" business construct or our nation's space business is certain to wander in a desert of stagnation and decline while our international space launch competitors continue to make ground.

Whatever the detailed nature of the solution looks like, an enduring and successful solution is not likely to be as dependent on hardware consumption and will naturally manage and control key performance parameters that influence the operational effectiveness for the operator—one way or another.

HISTORICAL EXAMPLES

Air Mail Act of 1934—Aerospace history can provide us some inspiration on this subject. The air transportation world in the early 1930s ran into the ethical problems that can often occur in completely vertical business arrangements with a narrow set of players. The issue was finally resolved through anti-trust legislation in the Airmail Act of 1934.

By way of background, air transportation "holding companies," like United Airlines (formed from Boeing Air Transport and other airmail airlines, such as National Air Transport), were formed in the late 1920s and early 1930s on a vertical business model that was shaped around U. S. Air Mail contracts passed out to industry by the U. S. Postmaster General. These holding companies owned the means of aircraft production, the airlines that operated its aircraft, and even its own network of airports.

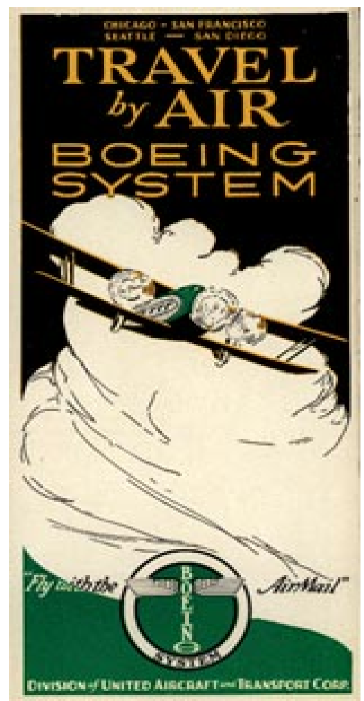

Figure 1*—Typical 1930 Air Transport Banner*

Contention grew when a nascent passenger air travel market was stifled because smaller operators couldn't get the manufacturers motivated to build inherently safer aircraft they needed to convince the public that it was safe to fly. This erupted into scandal when the Postmaster General consolidated airline routes to only three selected companies at what later became known as the "Spoils Conference" in May of 1930. Their smaller competitors were forced out. This became a presidential campaign issue in the election of 1932. After a change of administrations, and with the backdrop of the Great Depression, a Senate investigation called the process of giving contracts "spoils" and that the contracts had been issued to the friends of the previous administration. After a short period of time the existing airmail contracts were canceled and new contracts were let forbidding simultaneous ownership of both airlines companies and aircraft manufacturing companies.[4] After the Air Mail Act of 1934, United Airlines for example, was separated from its parent holding company.[5]

As a result of the Air Mail Act of 1934, the new United Airlines was free to purchase, own, and operate whatever aircraft it wished to purchase—not just Boeing products any longer. More significantly, it was free to move into whatever markets made sense to their operation and not what made sense to Boeing aircraft manufacturers. They drove technology needs for safer aircraft designs and features, so that technologists in general (and the National Advisory Council for Aeronautics, or NACA, in particular) emerged as important national economic assets in the late 1930s and beyond.

Telecommunications Revolution—Additional examples, some more recent, also offer historical insight. The technology revolution in the telecommunications industry that occurred in the latter decades of the twentieth century can arguably be traced to the end of the vertical industry structure that existed in that industry prior to legal actions.[6]

Satellite Industry Trends—It is also interesting to note that in the satellite operations arena we see a recent headline in *Space News* (April 26th, p. 16) that read "Separate Procurements Fueling Ground Systems Competition."[7] It's starting to happen where flight hardware procurements are intentionally separated from ground system procurements.

POTENTIAL PROGRAMMATIC IMPROVEMENTS

Acquisition Cost & Schedule—A major programmatic benefit that emerges from the separation of the means of space vehicle production from the means of space flight production is the purchasing power of the independent operator as it builds a portfolio of flight and ground equipment assets. The operator is now free to purchase flight and ground equipment from a supplier base focused on their particular needs (e.g., frequent heavy cargo for space infrastructure sustainment, or frequent-dependable passenger service, or infrequent-high value science expeditions—we will need them all!). A key issue NASA's Code T must eventually confront: who is to be the transportation system operator? Is it the same contractor that also sells the flight and ground hardware and various support services—as was traditionally done with the Cold War era industrial infrastructure?

The manufacturing community will benefit from independent operators by shedding a significant burden involved in designing, costing, building, and pricing non-flight element services, such as specialized, unique ground support equipment and infrastructure. The flight system manufacturer will no longer be required to envision the details of the "operations concept," and operational logistics plans and so forth (which are usually remote, secondary functions at best for a launch vehicle supplier). The independent operator would bear this burden.

The independent operators are free to go to a base of flight and ground system suppliers that match and economically optimize their envisioned portfolio of affordable, sustainable support assets (i.e., GSE, launch platforms, support services, logistics tail, etc.). This is not to say that new sister maintenance, repair and overhaul (MRO) businesses, perhaps owned or affiliated with reusable flight system suppliers could not emerge for all types of space vehicles, not just earth to orbit (ETO). This is the long-range vision: growing new markets for space vehicle manufacturing and manufacturing services.

The bottom line for space launch industry manufacturers: Infrequent, all-or-nothing large batch orders for launch vehicles turns into a steadily growing stream of smaller orders—from yearly orders to monthly orders, and eventually, to weekly orders from a widening market base of independent "space lines."

The bottom line for NASA's Space Exploration Enterprise: Large, drawn-out batch-order contracts turn into smaller, less-risky, pay-for-service contracts as needed and budgeted for independent operator contractors. Thus, independently contracting the operations (from conception of the operations) allows greater purchasing power for the U. S. Government throughout the acquisition cycle. At the same time, the approach promotes unleashing of free-market forces, in coordination with NASA's technology infrastructure, for advancing space commercialization and utilization.

Annual Operating Costs—Space systems operating costs have several major elements to consider. First, there are the direct operations costs. These are the highly visible costs associated with performing assembly, servicing, functional verification, and serving of the space flight elements.

A key issue NASA's Code T must eventually confront: who is to be the transportation system operator? …Is it the same contractor that also sells the flight and ground hardware and various support services—as was traditionally done with the Cold War era industrial infrastructure?

The labor and materials associated with these direct costs are often the only ones considered. Unfortunately, in the space transportation industry, these are not well tracked and made available to Government technologists by industry, even for the important function of operations modeling and technology prioritization.

Another set of costs that tend to overwhelm the direct operating costs is the fixed infrastructure support costs. These costs include the servicing, repair and upkeep of support equipment, facilities and other indirect logistical services. These support costs are required for safe, dependable and effective operation. For all other viable transportation market segments, the independent operator (whose economic existence depends on management and control of annual operations costs and infrastructure liabilities) is the means to achieve affordability and political sustainability.

Space Flight Demand and Growth—regardless of the business model followed, vertical or horizontal, healthy growth in the demand for space flights must exist alongside a capability to affordably meet demand for space flight growth.

Most current launch providers tie the payload with the sale of the vehicle, which for space exploration tends to favor heavy lift launchers, rather than highly operable, highly utilized reusable assets. Thus, the idea of "space freight" to build and sustain new outposts and infrastructure in space is considered to be outside the realm of business viability and is disfavored—usually through the claim that such approaches are inherently too expensive. One of the reasons this is the case is that the production or throughput capability of large-scale expendable launch vehicles (more than a couple metric tons per launch) has been limited to around no more than a dozen flights per year.

The Soviet Union's Soyuz launches did meet a high launch rate in the 1970s and 1980s, but only through the use of an expensive array of launch sites—about twelve simultaneously in operation, or about six to ten launches per year per string of ground processing facilities.

Since the fall of the Soviet Union, very few, if any, new Soyuz launch sites have been constructed. The notable exception is the one currently under construction on American soil at the European Space Agency's (ESA's) Kourou Space Center in Kourou, French Guiana in South America.

The emergence of independent operators focused on producing flights (and not just flight hardware) would be a move in the right direction for increased flight demand.

Consider how compatible this would be with NASA's current Space Flight Enterprise Strategy for development of innovative modular lunar bases.[8] Such approaches use simple, standardized families of dependable building blocks

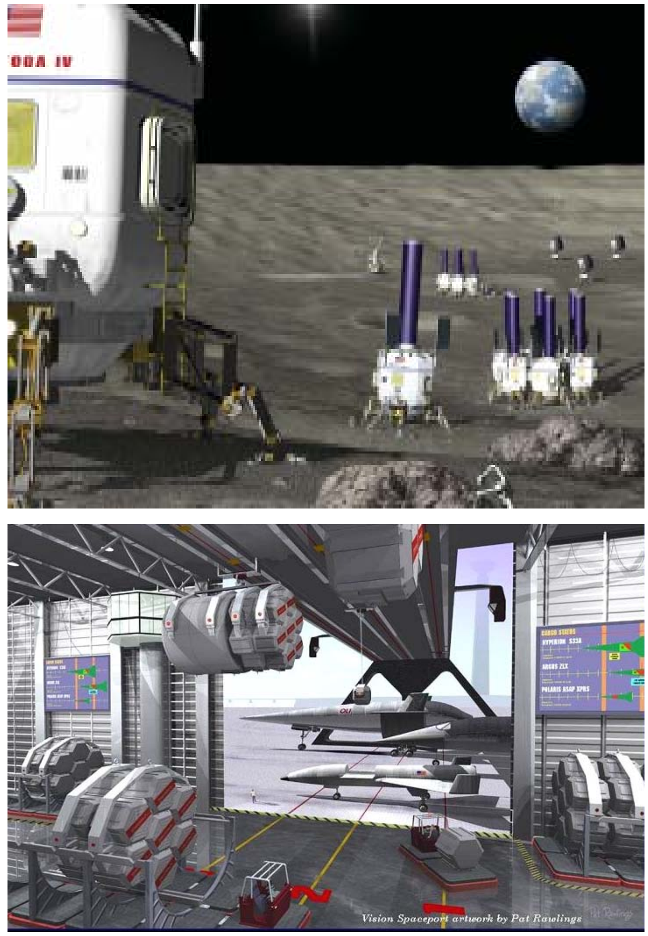

Figure 2*—Applying multi-function modular approaches for in-space operations will lead to steady flight rate growth*

to construct the infrastructure needed to occupy the space frontier (see Figure 2). Such approaches move the space transportation industry from "all-up" mission payloads towards the concept of a growing "space freight" industry.

ENABLING NEEDED TECHNICAL IMPROVEMENTS

Fundamentally Changing the Nature of Ground Ops—Motivated to produce flights affordably, independent operators would search in earnest for inherently *operable* space flight systems and technologies. *The operator is looking for a fundamental remake of space transportation systems from the inside out.*

Recent studies have begun identifying key functions and design needs associated with space transportation ground operations. How independent operators could impact the major high-level functions are addressed below.

Unplanned Troubleshooting & Repair Operations—Independent operators would strive to acquire dependable flight and ground hardware solutions. That in turn could initiate a sea-change in how space flight systems are certified and qualified for space flight, since there would be a high emphasis on removing sources of costly unplanned hardware change-outs. Inherently reliable parts and systems, demanded by the operator, would also influence the overall safety of the system. This would happen because operators would be continually searching for less complex systems with lower part counts, and focus on demonstrated reliability rather than relying on redundant parts with lesser reliability. Today, vehicle system and subsystem designs give rise to high part counts and this has not been adequately addressed to the operator's satisfaction.

With today's demonstrated reliability and dependability, engineering confidence in vehicle type certifications is inconceivable. Instead, each flight, with its numerous part change-outs (hundreds on the Shuttle Orbiter and an un-totaled number on domestic expendables per flight) and intrusive repair activities goes through a rigorous review. These flight readiness reviews (FRRs) conduct nationwide engineering examinations of the entire supply chain for material and process (M&P) variations and of the assembly, servicing and checkout activities, often requiring battalions of "sustaining engineers" at the design agencies and design centers, legions of "configuration managers," and regiments of safety, quality and reliability engineers, to name a few.

Independent operators would have no vested interest in hardware/part re-supply and manufacture. They would be motivated to invest in highly dependable parts and inherently reliable technologies. Over time, the operators would be motivated to move the industry to the point of demonstrating flights that had no part removals at the departure point. If this could be repeatedly demonstrated, then vehicle-type certification could become a reality and fundamentally change space transportation.

Specific Technology Opportunities Associated with Highly Dependable Systems—Several opportunities exist for the space technology community to help bring about vehicle type-certifications and help move the industry away from the burdensome flight-by-flight certification process.

First, independent operators would be shopping for basic improvements in vehicle functions (propulsion, airframes and mechanisms, power, communications, and so forth). Any areas of foot-dragging in addressing recurring hardware design problems would likely end very quickly, with the more technically challenging issues also surfacing quickly. Very specific technology needs would rapidly emerge.

Launch Vehicle Assembly and Integration Operations—Assembly of flight elements upon arrival at the launch area is a major work contributor. This includes more than just the lift and mate operations of major flight elements, such as mating the Orbiter onto its Solid Rocket Booster (SRB)/External Tank (ET) assembly; or the mating of a strap-on solid to a core expendable vehicle element. Flight element assembly operations have consistently required launch site assembly of ordnance devices and routing of electrical cables in systems tunnels that go across elements. Other assembly operations include application of thermal protection, (spray-on, curtain installation, etc.) range safety equipment among many other time-consuming and labor-intensive activities.

Specific Technology Opportunities Associated with Highly Integrated, Fully Assembled Transportation Systems—Much attention has been focused on automatic mechanisms for the mating of the elements, which may well be needed for designs with many flight elements to integrate into a launch vehicle. Mating operations and functional verification of the mate should be designed to be routinely performed in a matter of minutes. Today, however, such operations (including functional verification for cryogenic propellant flow, leak-free flow of other fluids, and electrical integrity) take hours and shifts, if not days, depending on the complexity of the vehicle design.

What needs more attention is a design focused on reducing the number of flight elements per launch. This will be highly desired by independent operators, bringing about a "no assembly required" policy at the spaceport.

The operators also need designs for reliable, dependable separation systems that eliminate archaic use of ordnance devices can greatly aid the independent operator by eliminating the need for area and facility clears involved with the installation and checks of such hazardous devices.

Research into alternative thermal protection devices, rather than complex, process-variant and time-consuming spray-on foam application techniques are also needed.

Servicing Operations—One of the greatest needs for independent operators is the reduction in ground servicing operations. These include simplified propellant loading operations with far fewer, simpler thermal conditioning tasks; far fewer dedicated power management fluid energy loading tasks, such as filling, draining, system pressurizations and purges. Numerous ground service ports require pre-flight hook-up operations. The Space Shuttle Orbiter, for example has 402 ground interfaces to its Orbiter Processing Facility (OPF), most of which relate to fluid and gas system servicing. While the expendable vehicles are less intensive than the decades-old Shuttle Orbiter, the number of hoses, ducts, and service arms for expendables can be improved upon. Independent operators, if given the opportunity, would search for elimination of liabilities, such as ground interfaces and dedicated umbilicals.

Specific Technology Opportunities Associated with Simple, Integrated Systems—Significant reductions in servicing operations would require wholesale elimination of dedicated subsystems, with their functions incorporated into other subsystems. The objective is to eliminate dedicated working fluids and dedicated systems of parts when a more robust and flexible set of parts in a similar system could perform the function.

Some of the solutions may be the result of simple design solutions while others may prove to be technologically challenging. For example, the general layout of a propulsive vehicle stage often elevates the liquid oxygen tank forward. When this is done dedicated anti-geyser hardware, ground support equipment and operations complicate the system architecture. Careful up-front systems location and vehicle balancing can eliminate entire subsystems on the vehicle and on the ground when operability is of the highest priority.

Other potential solutions require more technology development and demonstration. For example, the elimination of hydraulic and pneumatic equipment in favor of more-electric solutions offers tremendous potential to simplify the overall power management architecture of space transportation systems (see Figure 3).

Functional Verification Operations—Checkout and inspection operations, two of the more highly visible functions of the ground crew, are directly dependent not only on the flight criticality of a system or function, but also on the engineering confidence of the overall design.

If the degree of unplanned troubleshooting and repair is high enough (and it only takes a total of one or two items routinely per flight), then the overall system cannot be depended upon to function without conducting detailed system checks.

To overcome this, engineering practice over the years has instilled a significant amount of confidence-building test, checkout, and inspection operations, as the vehicle is built-up and serviced for flight.

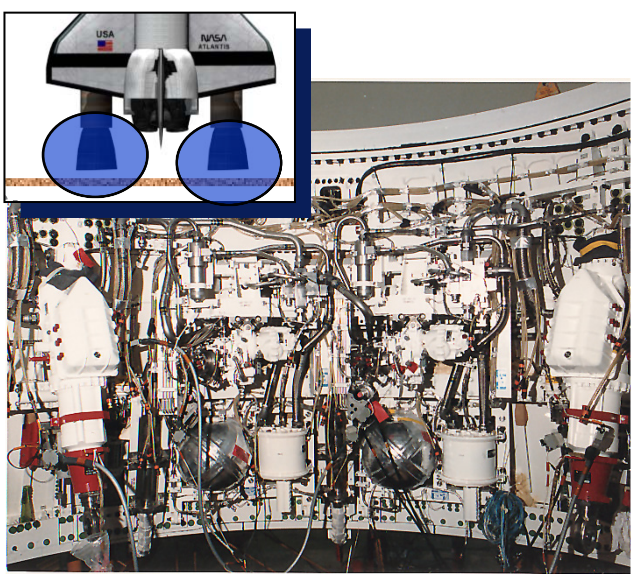

Figure 3—*Interior view of the current Space Shuttle Solid Rocket Booster (SRB) thrust vector control (TVC) hardware in the SRB aft skirt. Complex hydrazine and hydraulic system operations are ripe for technology improvement and significant operational benefit.*

If a system typically leaks, then routine, time-consuming and labor-intensive leak checks are required. If high-traffic internal compartment servicing is designed into the architecture, and many nicked wires, dented ducts and other collateral damage typically results, then pre-closeout "confidence runs" that power up the systems are often used as good practice to prevent major interruptions during the launch countdown.

Specific Technology Opportunities Associated with Smart, Autonomous Systems—The overall strategy likely to emerge from the use of independent operators is to: 1) strive to demonstrate vehicle processing without destroying the configuration of the flight vehicle that could occur from unplanned troubleshooting, replacement of limited-life items by design, or servicing by design; 2) inclusion of embedded component health monitoring and system-level health management technologies. The focus of the independent operator will be on validation of health management systems that provide confidence that the system is healthy and therefore does not need to destroy the structural or functional integrity of the vehicle to verify proper operation. On the other hand, premature deployment of "VHM" technologies can put the operator in a worse position by having to continually troubleshoot undependable instrumentation (i.e., the red light comes on often enough to lose engineering confidence in the total system design and technology).

Setting Up a Technology Pipeline—The technology focus for operationally effective systems needed by independent operators is going to be most challenging for NASA at the mid- to high-levels of readiness. While NASA has a wealth of capability in deriving new technology components and materials, its infrastructure for carrying out subsystem and system level technology integration, testing, and evaluation has deteriorated severely over recent decades.

Independent space transportation operators are likely to succeed today under one of two conditions:

1. Manufacturers have all the technology they need to succeed on the shelf, and therefore, independent operators are free to purchase highly operable, dependable, and supportable vehicles and ground equipment *(Considered unlikely).*
2. The technology integration gap is somehow closed for major subsystem and system design disciplines, such as structures and mechanisms, propulsion, power management, thermal management, communications, safety management and control systems, and so forth. *(Likely only with the proper forcing function).*

NEED FOR VARIATION FROM PAST ATTEMPTS

The Shuttle Processing Contract (SPC) and the Space Flight Operations Contract (SFOC)—The proposal for *independent* operators with purchasing power over manufacturers should be distinguished from past attempts to "privatize" the Space Shuttle. The United Space Alliance (USA) Space Flight Operations Contract (or SFOC) and its predecessor, the Lockheed Shuttle Processing Contract (SPC) were attempts to establish separate operators. In both cases, the "operations contractor" was not involved (or even in existence) during design requirements development. The SPC contract was not in existence during the acquisition phase of Shuttle, and, as with today's USA/SFOC contract, had no significant independent purchasing power to search, select and acquire its own vehicle or ground assets. The opportunity exists now to "do it right" for NASA's Space Exploration Enterprise (and perhaps for the Air Force's next generation Operationally Responsive Spacelift, or ORS, as well).

RECOMMENDED INFLUENCE ON RFPS AND BAAS

(1) Separate the means of transportation system production from the means of transportation system operation from the beginning, with this separation of function driving operability into the whole acquisition process.

(2) Immediately establish linkages between the H&RT themes and their technology break-outs and the infrastructure needed to mature these technologies at the mid-TRLs. This must be done in order to assure achievement of a proposed portfolio's operability, supportability and dependability; i.e., identify how these technology areas, particularly space transportation, are going to be demonstrated for ease of operation, simple and affordable support requirements, and reliability—not just flight reliability, but ground operations dependability, as well.

(3) Code T should work with and task the Advanced Range Technology Working Group (ARTWG) and its sister organization, the Advanced Spaceport Technology Working Group (ASTWG) to propose specific language for consideration in future proposals for space transportation acquisition and exploration vehicle operations. These government/industry/academia groups were formed several years ago under White House direction and have made significant progress in forming an alliance of technologists and managers to move the state-of-the-art in spaceports and ranges forward. However, a sponsor with meaningful resources is required to act on specific strategies that are emerging.

(4) Additionally, a collaborative program, such as the Future Interagency Range and Spaceport Technology (FIRST), with partnership of the Federal Aviation Administration (FAA), Office of the Secretary of Defense (OSD), and the Air Force Space Command should be pursued to bring forth the supporting ground system technologies needed to enable the whole industry to thrive. Government seed dollars are urgently needed due to the lack of current commercial interest and the stagnant state of the launch market. Further, a program such as FIRST allows for shared costs among several federal agencies, thus significantly reducing NASA's burden.

CONCLUSIONS

So important are the annual support costs, particularly for the accumulation of space systems as we move out beyond earth orbit, that Code T must find natural economic means to manage and control these costs. The non-existence of independent operators (whose economic survivability depends on management and control of annual operations costs and infrastructure liabilities) is the one key industrial distinction between space transportation and all other viable transportation market segments. For NASA to politically sustain a fresh new enterprise through old Cold War era, vertical business structures for space transportation would not be wise.

It is understood that what is being suggested represents a major sea change in space system acquisition culture. We need not fear the concept of independent operators, however, and become paralyzed by the suggestion. Unlike the downsizing of the 1990s, all hands need to be on deck in the manufacturing and operations arena if we are to unleash the nation's creative skills as it extends economic opportunity into the space frontier.

END NOTES

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