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Paper Session II-A - Helium Pipeline for Evolved Expendable Launch Vehicle (EELV) Program

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Transformation Space Gateway Support

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Technical Paper for Session

Commerce: Space Access in a Global Market

Helium Pipeline
For
Evolved Expendable Launch Vehicle (ELLV) Program

J. G. Jorgensen
Transformation
Space Gateway Support
Introduction

The Kennedy Space Center and Cape Canaveral Air Station (KSC/CCAS) location is the site of the largest helium consumption in the United States today at 80 million standard cubic feet (SCF) per year. The new Evolved Expendable Launch Vehicle (EELV) program will result in more than doubling that consumption. This paper documents the collaborative efforts of NASA Logistics Operations (LO) and EELV elements led and facilitated by Space Gateway Support (SGS), the Joint Base Operations and Support Contractor to best satisfy this new demand.

The background and historical development of helium supply and distribution at KSC and CCAS are reviewed. Also, the case is stated for an existing centralized compressor station near SLC 39 and a new underground pipeline to supply helium to the EELV launch complexes currently under construction on Complexes 37 and 41. The Concepts of Operation for the pipeline and a proposed Business Plan, which incorporates a unique partnership of commercial and NASA/AF interests provide cost effective and attractive services for the commercial launch program.

Background

The Converter Compressor Facility (CCF) is located midway between the Shuttle Vehicle Assembly Building (VAB) and Launch Pad 39A on the north side of the crawlerway road. Essentially all helium used at KSC and CCAS is delivered in some form to the CCF where it is pressurized to 6000 psig and presently distributed to users as follows:

- Above ground across country pipeline to the Shuttle Launch Pads 39A and 39B, VAB, and Orbiter Processing Facility (OPF) at nominally 6000 psig.
- Compressed gas rail cars to the Titan SLC 40 and 41 at nominally 3800 psig.
- Compressed gas trailers to the Delta and Atlas SLC 17 and 36, respectively, at nominally 6000 psig and 2400 psig.
- Compressed gas trailers and K-bottles to vehicle and payload processing facilities and institutional shops and laboratories throughout KSC and CCAS.

Until recently (since the late 1960s), gaseous helium was supplied by the Bureau of Land Management in high-pressure railcars. The railcars were positioned on a siding adjacent to the CCF and supplied helium to the compressor room presently consisting of 3 Henderson compressors at 350 SCFM each and 5 Joy compressors at 150 SCFM each for a combined capacity of 1800 SCFM at 6000 psig.

In 1994, the Titan Acceleration Program caused a renewal of interest in construction of an underground high-pressure helium pipeline originating at the CCF to accommodate the sharp increase in helium consumption due to processing and launching of the hydrogen fueled Centaur upper stage.

The Aerospace Corporation studied helium supply for Titan Centaur launch processing and concluded that the interests of the launch vehicle programs would be best served by sharing the cost of establishing a utility infrastructure capable of providing continuous helium supply to the facilities of major users.

Further, the most complete solution to the problems of providing helium supply would be to construct a gaseous helium pipeline from Converter Compressor Facility 39 to SLC-40 and SLC-41. The single drawback is the initial cost. The advantages would begin immediately.
Recharging the helium storage batteries at SLC-40 and SLC-41, would be continuous as required by demand, and virtually free of any conflicts with pad operations or weather constraints. Maintenance on the compressor fleet and the number of helium transfer operations would decrease dramatically.

The Air Force subsequently funded a design by Brown & Root for a pipeline from the CCF to the new Centaur Processing Facility (CPF), considerably south of the Titan launch complexes. The design was nearly completed but the funding for construction was denied in part due to the concerns developing regarding the CPF.

Scheduling and funding constraints precluded the pipeline construction at that time, as well as facility modifications to expand the high pressure battery capacity on the launch complexes. The Base Operations Contractor provided a temporary solution by installing a helium railcar offload station and buried high pressure tubing to feed the launch pad systems. The full BLM railcars at 3800 psig were transported to the Titan ITL where required and depressurized to approximately 2400 psig, the operating pressure of the pad systems. The partially filled railcars were then transported back to the CCF for emptying through the compressor station.

A dramatic transformation has occurred in the United States since the passage of the 1960 Helium Act. Gradually the helium market shifted from Government to commercial consumers. Production shifted from Government to commercial suppliers. Distribution shifted from predominately high-pressure government railcars to networks of commercial transfill stations supplied by large liquid helium semi trailers. In 1996 these factors ultimately led to the enactment of the Helium Privatization Act which mandated the shutdown of the Bureau of Land Management (BLM) Helium operations effective April 1, 1998. The impacts to KSC/CCAS were that helium must be procured commercially and, most significantly, helium would no longer be available in high-pressure railcars.

A NASA Headquarters led tiger team analyzed the impact of privatization on the Agency and found that all NASA centers could be supplied by the existing commercial capability from transfill stations. The KSC was an exception, however, due to the massive flow requirement for launch support activities. Ultimately, the decision was reached to modify the KSC Converter Compression Facility on Complex 39 to accommodate supply in liquid form. Those modifications to CCF 39 have been completed, helium is now purchased commercially by NASA and the shutdown of the Bureau of Land Management Helium operations was completed on April 1, 1998.

The CCF 39 helium plant is believed to be the largest of its type in the country. The preexisting compressor station with total capacity of 1800 SCFM at 6000 psig can be fed from either preexisting high pressure gas railcars or over-the-road compressed gas trailers systems. The recent modification installed a liquid helium conversion system that converts liquid to gas and compresses the gas to the induction pressure of the preexisting compressor station. The liquid helium supply and conversion subsystem is the primary mode of plant operation. Each liquid helium trailer carries approximately 1 million SCF of gas equivalent. The railcar or trailer feed systems are available for contingency in the event of outage of the liquid subsystem.

**EELV Impact**

The dual sourcing in 1997 for the Evolved Expandable Launch Vehicle program has resulted in the current plans for construction and/or modification and adaptation of vehicle processing and launch facilities which are in varying stages of maturity. The Boeing Delta IV vehicle will launch from Complex 37 and the Lockheed Martin Atlas II AR vehicle will launch from Complex 41. For the purpose of this discussion, it is assumed that the Delta IV vehicle with Liquid Hydrogen/Liquid Oxygen booster and second stage will require helium supply in flows and
durations. This would be similar to that required for Shuttle and the Atlas II AR vehicle with LH2/LO2 propulsion system. The second stage will only require helium supply similar to the Titan Centaur. This would drive significant capital investment in the launch complex infrastructure for helium supply, storage and distribution and in the incremental cost of operation and maintenance of permanently installed systems for both programs.

For Complex 37, the concept of operation would be to supply helium from over-the-road compressed gas trailers to an on-complex compressor station which would feed a high pressure storage battery and distribution system. For Complex 41, the concept of operation would be to supply helium using the railcars filled from CCF 39 as is currently done to an on-complex compressor station and expanded high-pressure gas storage battery feeding a distribution system. Estimation of the expected capital investment for the helium infrastructure on the two complexes is not available. To enable a comparison, some assumptions may be made. The current purchase price for 300 cuft water volume, 6000 psig operating pressure vessels is on the order of $250,000 each. If these launch complexes have stand-alone compressor and storage systems instead of the pipeline supply, a large number of vessels would be required, probably on the order of $10 million in purchase price alone. If the pipeline enabled the reduction of vessels by 50%, $5 million would be avoided plus the investment in compressors and remaining infrastructure.

These new requirements for helium raise, once again, the issue of a pipeline originating at the CCF 39. In this instance, there is a compelling argument both operationally and economically for the pipeline. The pivotal factor is that the economic aspects of previous studies attempted to compute the payback of the capital investment for installation of the pipeline solely by estimating the savings of incremental cost of operation and maintenance and payback periods varying from 10 to 20 years. If the avoidance of capital investment or reduction of capital investment on Complex 37 and 41 is considered, the installation cost for the pipeline is significantly more than covered by the avoided investment alone.

The following pipeline installation cost data is extracted from the 1993 Aerospace Studies. A 10% add on for contingency and new requirements, pressure control and metering at the user interface and annual 2.75% escalation are applied in the data below to derive a conservative estimate for planning purposes.

<table>
<thead>
<tr>
<th>Location</th>
<th>Distance, Feet</th>
<th>1993 Base Cost</th>
<th>1999 - 2000 Projection</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLC-39 to SLC-41</td>
<td>25,000</td>
<td>$1.9 M</td>
<td>$2.5 M</td>
</tr>
<tr>
<td>SLC-41 to CX-37</td>
<td>20,000</td>
<td>$1.5 M</td>
<td>$2.0 M</td>
</tr>
</tbody>
</table>
Operating Concept

Project Location

The 3-inch (nominal) 6000 psig pipeline will start downstream of the existing compressor system. The line will progress south under the crawlerway (directional bore) and then east to the Cape road south of Complex 39A. The line will essentially follow the existing 6000 psig GN2 line to Complex 41. The GHe line will continue south along the Cape road then follow the old A1A road terminating in a meter station at the perimeter fence of Complex 37.

Product Logistics

The NASA Logistics Operations Directorate has the responsibility for establishing helium supply contracts, as well as ordering, accounting and other logistics activities. Their role is also to see that user requirements are forecast and that appropriate support plans are formulated and coordinated. As a result of the BLM ceasing helium operations as previously discussed, KSC instituted a NASA-wide consolidated helium acquisition procurement strategy. The resulting contract utilizes four commercial vendors who supply 22 different NASA and NASA contractor locations throughout the United States. By using this consolidated contract approach, optimum competitive pricing was obtained as well as a reliable supply of helium.

O&M and Interfaces

SGS will be responsible for operating and maintaining the CCF and the pipeline distribution system up to the terminal meter stations.

Pipeline Management

The focal point in the overall management of the pipeline network would be at the CCF. The CCF has direct system status information. This includes real-time system flows, pressures and other data to assure user interface requirements are being met. Personnel at the CCF maintain communication with users, SGS Fluids Management and NASA/LO. This assures proper coordination in the supply of helium, contingency procedures, and operation of the converter and compressor equipment to maintain pipeline flows and pressures. This teaming arrangement also allows for the resolution of conflicts and supply priorities. During any launch countdown the CCF personnel provide around the clock surveillance of the helium systems and monitor the progress of the countdown.

Business Plan

The Business Plan for the pipeline is in two parts: the construction of the pipeline, and the ongoing operation of the helium system, including purchase of helium and operation/maintenance of the CCF and pipeline to supply EELV.

Pipeline Construction

At the time this paper was prepared, a number of options were being explored to implement the construction phase of the project. The recommended option was to construct the pipeline as a commercial enterprise with SGS as project manager including coordination for overall project implementation. SGS will be the liaison with NASA and AF to determine/define Government requirements and assure compliance. SGS will prepare the environmental assessment, obtain and coordinate necessary permits and easements, coordinate design reviews as necessary and perform construction monitoring. SGS will implement the construction using a design/build contract. The 1994 Brown and Root design drawings and Technical Specifications will be provided to the selected contractor for their use as appropriate. The
The pipeline will be co-owned by Boeing and Lockheed Martin according to an ownership agreement. It’s intended that the period of co-ownership be no longer than necessary for the principals to depreciate their investment. As soon as possible, the pipeline will revert to the government for the government’s use so long as the requirements of the EELV principals on Complex 41 and 37 are satisfied.

Ongoing Operation of the Helium System

Helium for all programs will continue to be procured by the NASA Logistic Operations Directorate for supply to the CCF. The Joint Base Operations and Support Contract under which SGS currently operates and maintains the CCF and existing pipelines will be modified to include the addition of the EELV helium flow requirements, maintenance of the new underground pipeline and meter stations and management/administration associated with a carrier account including price determinations and billing. The price of the delivered 6000 psi GHe to the end user will be established by adding the contract purchase price of the LHe to the shared costs of operation and maintenance of the CCF for conversion and compression of the helium. The volume will be determined by a calibrated meter station at each user location. The conversion and compression costs include electrical power, labor, equipment, facility maintenance, and other costs (conversion losses, etc.) necessary to supply the quality and quantity of GHe to the system users. These conversion and compression costs will be charged to the end users based on their consumption recorded at the meter stations. A formula will be developed to roll up all costs into a delivered unit price based on delivered volumes and billed monthly under a reimbursable agreement. The year 2000 unit price is currently projected to be $80 per MSCF.

The cost of helium supply system improvements benefiting all users would be shared by all users and reflected in the delivered unit price. Improvements, or expanded capability required by and beneficial to a particular user, would be paid for by that user in a separate funding arrangement. Such potential future costs are not included in the above.

Summary

Although the final determinations and agreements necessary for implementation have not been completed at the writing of this paper, all indications are positive that the pipeline project will be implemented as described. If so, it will be a success due to the collaboration of the Boeing and Lockheed Martin EELV elements, SGS, and NASA/AF to use the KSC and CCAS infrastructure in a way that is most beneficial toward the ultimate objectives of cost competitive and reliable access to space.