Abstract: 5th European Conference for Aeronautics and Space Sciences (EUCASS)

Munich, Germany

1-5 July 2013

TITLE OF PAPER: Liquid Rocket Hydrocarbon Booster Engines (LRHCBE's) for Launch Vehicles

Robert L. Sackheim

rlsack@me.com

Bob Sackheim—Consultant, Huntsville, U.S.A.

Abstract

There have been very few new rocket engines fully developed and flown in the United States (US) in the last five decades. Since the end of the Space Shuttle Program and flight certification of the Delta IV and Atlas V Evolved Expendable Launch Vehicles (EELVs), the US Government has not seen its way clear to directly fund any completely new liquid rocket engine (LRE) development programs. There have been, however, some elements of new LRE development efforts, including advanced modeling and analysis and some limited testing of newer prototype LRE hardware. These have been sponsored and supported to some degree by the National Aeronautics and Space Administration (NASA) and the United States Air Force (USAF) in what have been thus far, separate projects.

Recently, some interest has been shown from these agencies in taking their preliminary levels of early development into full blown flight applications. NASA is exploring the possibility of developing a new higher performance (than available in the United States today) liquid Rocket Hydrocarbon Booster Engine (LRHCBE) for their advanced, later generation Space Launch System (SLS). These engines could be candidates for high performance liquid strap-ons to replace the current baseline of Space Shuttle Solid Rocket Motor (SRM) derived strap-ons. Some preliminary estimates indicated that replacing these baseline Space Shuttle solids with high performance liquid booster strap-ons would help to increase the SLS heavy lift capability from its initial goal of 70 metric tons to almost double that capacity of 130 metric tons into LEO. One of the advanced LRE technologies being explored is a high thrust (on the order of 1 Mlb_f) oxidizer-rich staged combustion (ORSC) LRHCBE. The delivered Isp for this new ORSC engine is anticipated to be in the 330 to 340 vacuum Isp range.

In addition to these NASA exploratory LRHCBE development efforts, the USAF is also conducting some preliminary development activities for a similar high performance LRHCBE, but operating at somewhat lower thrust levels (on the order of 250 Klb_f). A potential application for this high performance LRHCBE would be a USAF fly back first stage which would be used for a re-usable booster system, currently identified as the RBS.

This RBS concept is still under preliminary investigation and evaluation in the US by both the Air Force Research Laboratory (AFRL) and the Air Force Space Command (AFSPC). The initial assessment of the economic benefits of such a reusable first stage based booster system appears quite promising in terms of

reducing costs for launching US national security payloads. However, more careful and detailed economic trade-off studies will be conducted before there will be any decision by the USAF to proceed into full scale development of such a RBS design concept.

Finally, another area experiencing some development success with LRHCBE's involves commercial applications. The leader in this commercial LRHCBE development activity is Space Exploration Technologies Corporation (SpaceX). Their engine design approach has emphasized low cost, very simple (to manufacture) and very high reliability attributes rather than concentrating on very high performance LRHCBE's. SpaceX has successfully developed and flown two relatively new LRHCBE's for the first and second stages of their Falcon launch vehicles known as the "Merlin" and "Kestrel" family of LRE's, respectively. In addition to SpaceX's new LRHCBE's**,** other commercial space companies have been reported to be developing new LRHCBE's as well for their commercial space business. One example is Virgin Galactic Corporation which is reportedly developing their new "Newton" low cost family of LRHCBE's for space tourism applications. Their emphasis is also initially on low cost, simplicity and high reliability, rather than very high performance.

So there are two trends now being seen in the US for developing some new LRHCBE's. One emphasizes open cycle, simple designs with high reliability for low cost commercial launchers. The other, under potential government sponsorship, is focused on very high performance, closed cycle LRHCBE's for very high performance, heavy lift vehicles. This heavy lift launcher could ultimately be used for both commercial and government applications to launch large spacecraft into Geostationary Earth Orbit (GEO) and potentially to send robotic scientific and human spaceflight further out into our solar system.

This paper will discuss some of these activities and briefly describe some of the technology development efforts for new LRHCBE's for both the US Government and some of the commercial low cost access to space, entrepreneurial organizations.