JOURNAL OF PROPULSION AND POWER
Vol. 19, No. 6, November–December 2003

# History of Liquid-Propellant Rocket Engines in Russia, Formerly the Soviet Union

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## I. Introduction

THE history of liquid propellant rocket engines (LPREs) in the former Soviet Union is remarkable because they have developed a larger variety and a larger number of LPREs than any other nation and the number of their LPREs that have been flown is considerably larger than that of any other country. When the Soviet Union split into several countries in 1990, the work was continued, and almost all of the LPRE development organizations, manufacturing plants, and test facilities ended up in Russia. Only a couple are located now in the Ukraine, but they seem to work well with the Russian establishments. The major progress in the technology of LPREs and, thus, most of the key historical events took place when the government of the Union of Soviet Socialist Republics (USSR) ran the country.

There is no single LPRE concept or type, but rather several that are related. All of them have one or more thrust chambers.[1,2] As in other countries, there are significant differences between large (high-thrust) and small (low-thrust) LPREs, between engines using cryogenic or storable propellants, monopropellants or bipropellants, with a single start or with multiple restarts during flight, those with pumps or gas pressure expulsion of propellants in their feed systems, and with a single flight or reusable for multiple flights. The history of all of these types is discussed.

Design bureaus, government laboratories, and vehicles will be identified by their names and in some cases also by the names of a few of their leading people. Unfortunately we cannot list all of the important Russian organizations or people who were leaders or strong voices in these LPRE teams. Soviet LPREs have usually more than one alphanumeric designation for a LPRE, such as those from the engine design bureau, the government, or the vehicle designer. In this paper, an LPRE will be identified by the vehicle application and/or the developer's designator.

In this paper a *successful LPRE* is defined to have been put into serial production and/or to have flown satisfactorily more than once. There have been many experimental and prototype LPREs and engine components that were conceived, designed, built, and tested, but for various reasons were never flown or produced in quantity, and most fell by the wayside. This article will concentrate on some of the successful Russian LPREs. However, a few other developments that may not fit this definition of success, but have interesting technology or some historic significance, will also be discussed.

It is not the purpose of this historical paper to present detailed information on specific LPREs or to include all of the Russian LPREs. There are far too many of them. Only a few have been selected, and for each of these only very limited data and/or a brief description is given. Some of the LPRE have never been reported in the literature, some have been briefly mentioned in publications with limited distribution and are unknown outside of Russia. Therefore, these cannot be included in any U.S. paper. For more detailed parameters and for other engines, the reader is referred to the references and to a future book on the history of LPREs by the author expected to be published by the AIAA late in 2004. Although some of the flight vehicles driven by a LPRE (airplanes, missiles, space launch vehicles, spacecraft, etc.) are mentioned here briefly by name or identification number, the emphasis in this work is on the rocket engines. This paper will not cover Soviet solid propellant rocket motors, nuclear or electrical propulsion, turbojets, and combination rocket–airbreathing engines.

## II. K. E. Tsiolkowsky and the Earliest LPRE Concepts

The first serious technical mention of a LPRE in world history has been credited to the Russian Konstantin Eduardovich Tsiolkowsky (1857–1935).[3–5] He was a self-made man, had a serious hearing impairment, read avidly, and studied by himself. Most of his life, he taught high school mathematics and physics in Kaluga, a provincial town. In his spare time he diligently pursued his analysis, his writing, and his research.

He had three main technical interests. He investigated airborne dirigibles with a metal skin and heated gas, but his ideas were never really supported. He studied metal airplanes and aerodynamics; he built an "aerodynamic pipe" or wind tunnel, the first in Russia, and with it, he determined the drag coefficients for a variety of simple aerodynamic shapes. His avocation and main interest, however, was spaceflight, and he wanted to do it with LPREs.

He started his deliberations about spaceflight and rocket vehicles in about 1883. After trying for several years to publish his

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Received 29 January 2003; revision received 8 September 2003; accepted for publication 9 September 2003. 