Expanding the global footprint of hybrid rocketry

by Joseph Majdalani

The ***Hybrid Rockets Technical Committee*** *studies techniques applied to the design and testing of rocket motors using hybrid rocket systems.*

The field of hybrid propulsion marked 2015 with several notable accomplishments, global collaborations and geographical expansions.

After six years of development, a group of German students from Technische Universität München brought hybrid rocketry to Brazil in May by launching a self-pressurizing 225 pound-force **WARR-EX 2 motor** to an altitude of 4.3 kilometers off the country's Natal coast. WARR, the German Scientific Workgroup for Rocketry and Space Flight, has been actively promoting hybrid propulsion across Europe.

Also in May, SystemsGo, the nonprofit STEM education program based in Fredericksburg, Texas, that specializes in promoting hybrid rocketry in high schools, finished testing nearly 100 Tsiolkovsky and Oberth rockets from sites in Texas. These vehicles aim to either lift one pound of payload one mile high, or break the sound barrier. **SystemsGo** so far has trained 85 new teachers to implement its sequenced, four-year aeroscience curriculum. The group has also launched all six Goddard-level vehicles, targeting an altitude of nearly 30 kilometers, from the White Sands Missile Range in New Mexico.

In July, Texas students traveled to White Sands Missile Range in New Mexico to test their rockets. Left: A rocker from Houston's Booker T. Washington High School; right: San Antonio's Alamo High School.

Researchers at JAXA, the Japan Aerospace Exploration Agency, simulated a hybrid design that utilizes an altering-intensity, swirl-oxidizer type flow. This design enhances performance through continuous, thrust-independent control of the oxidizer-fuel ratio. The concept featured both axial and tangential oxidizer injectors that permitted adjusting the oxidizer swirl intensity independently of the throttle setting. The demonstration indicated that the performance of such rockets could be improved by optimizing the oxidizer-fuel ratio over the course of the burn. The majority of this improvement manifested itself in the form of increased combustion efficiency and reduced unburned fuel slivers relative to a conventional swirl-oxidizer-flow-type rocket.

The Aerospace Systems Research Group at the University of KwaZulu-Natal in South Africa has developed a successor to the Phoenix-1A hybrid rocket, which was launched from the Denel Overberg Test Range in South Africa late in 2014. Phoenix-1B will employ the same ground support equipment deployed for the 1A launch, including the mobile launch platform. As the workhorse vehicle for the **South African Hybrid Sounding Rocket Program**, 1B features a revised silica phenolic/graphite nozzle. When Phoenix-1A was flown near the Western Cape, its nozzle failed, leading to off-design performance. Nonetheless, the vehicle still attained an apogee of 2,500 meters and a maximum speed of 250 meters per second during its 55-second flight. The first Phoenix-1B launch is planned for next July.

The Advanced Propulsion Research Group at Auburn University developed a working model of the **quadrupole vortex hybrid rocket engine**. The QpV motion leverages an innovative rotary concept that is capable of driving high regression rates in cylindrically-shaped grain configurations. Auburn's work builds upon previous research into the effectiveness of quadrupole vortex configurations in heat transfer applications and draws inspiration from its use as an efficient mechanical drill in the petroleum industry. The combination of these characteristics gives rise to regression rate improvements on par with other swirl-driven hybrids while at the same time offering the additional benefits of greatly increased mixing, heat transfer and combustion stability.