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# AEROSPACE AMERICA

## Budget battles, test flights, lawsuits...

# 2013 IN REVIEW

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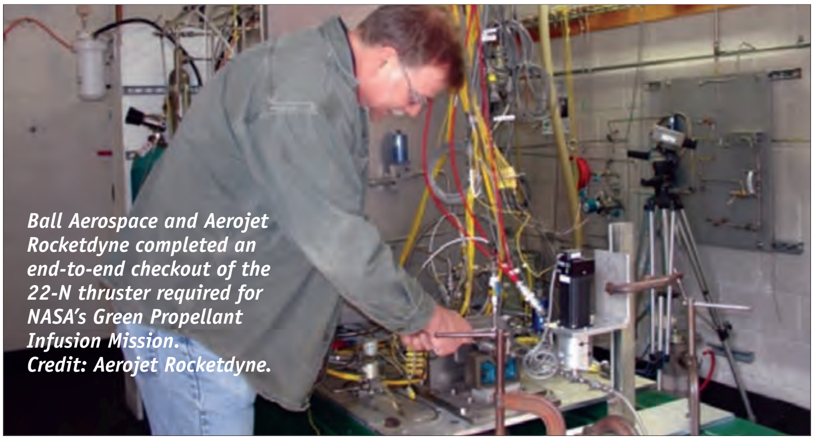
# Harnessing chemistry for propulsion

**by Joanna M. Austin and Yiguang Ju**

*The **Propellants and Combustion Technical Committee** works to advance the knowledge and effective use of propellants and combustion systems for military, civil and commercial aerospace systems.*

In July, Ball Aerospace and Aerojet Rocketdyne met the first milestone in demonstrating a more **environmentally friendly** spacecraft fuel, completing an end-to-end checkout of the 22-N thruster required for NASA's Green Propellant Infusion Mission, or GPIM. Ball is leading an industry and government team that will develop and fly the mission to demonstrate a high-performance, non-toxic fuel alternative to conventional hydrazine. This will bridge the gap between characterizing the functionality of an integrated propulsion system and the technology development needed for eventual use of green propellants in space.



***Ball Aerospace and Aerojet Rocketdyne completed an end-to-end checkout of the 22-N thruster required for NASA's Green Propellant Infusion Mission. Credit: Aerojet Rocketdyne.***

The milestone is significant because the 22-N thruster will fire simultaneously along with four smaller 1-N thrusters to initiate orbit inclination changes and altitude changes. It is also critical for de-orbit at the end of the mission. As the prime contractor and principal investigator, Ball is collaborating with Aerojet Rocketdyne, NASA Glenn, NASA Kennedy and the Air Force Research Laboratory, with additional mission support from the Air Force Space and Missile Systems Center. This will mark the first time the U.S. has used a spacecraft to test **green propellant** technology. The propellant, a hydroxyl ammonium nitrate fuel/oxidizer blend, or **AF-M315E**, offers nearly 50% better performance than traditional hydrazine. Green fuel alternatives also reduce environmental impact and operational hazards, improve launch processing capabilities, increase payload capacity, enhance spacecraft maneuverability and enable longer missions. The effort is a technology demonstration mission under the leadership of NASA's Space Technology Mission Directorate. The green propulsion system will fly aboard a Ball Configurable Platform 100 spacecraft bus.

*An Aerojet Rocketdyne researcher examines a container of AF-M315E fuel/oxidizer blend for flight testing. Credit: Aerojet Rocketdyne.*

The University of Illinois at Urbana-Champaign is the lead institution on **XPACC**, a new Center for Exascale Simulation of Plasma-Coupled Combustion. Funded by the Department of Energy and the National Nuclear Security Administration, it is part of the Predictive Science Academic Alliance Program. The center's goal is to leverage forthcoming heterogeneous computer architectures to enable truly **predictive simulations** of plasma-assisted ignition. Physics-targeted experiments at both Illinois and Ohio State University will be conducted in simple configurations to develop and evaluate models that will be integrated within a framework of uncertainty quantification, to enable ignition predictions in novel complex configurations.

**Plasmas** offer unique and untapped potential for controlling turbulent combustion. Radicals produced in plasmas accelerate burning by short-circuiting standard chemical pathways; electric fields affect flame stability by accelerating charged chemical species within thin flame fronts; and plasma Joule heating—the heating effect produced by the flow of current through a resistance—affects flow via thermal expansion and chemistry via temperature. Coupling them across all the important length and time scales to make quality predictions of plasma-coupled combustion requires the co-development of simulation models with tools to harness the heterogeneous architectures of anticipated exascale computing platforms. This is the goal of the new center.

Meeting this goal will require **tools** to access the power of forthcoming computer systems. Clock rates and power consumption limitations will lead to substantially slower, simpler, and heterogeneous processing elements. System scale will necessitate resiliency to faults, and heterogeneity will necessitate special approaches for efficient use. Researchers will develop tools to exploit heterogeneous processing elements in order to provide solutions. Different physical models generally lead to discretizations that will be better suited to different programming models and hardware sub-architectures. Recognizing this and building tools from this perspective will increase their utility, both for the proposed plasma-combustion application and more broadly.