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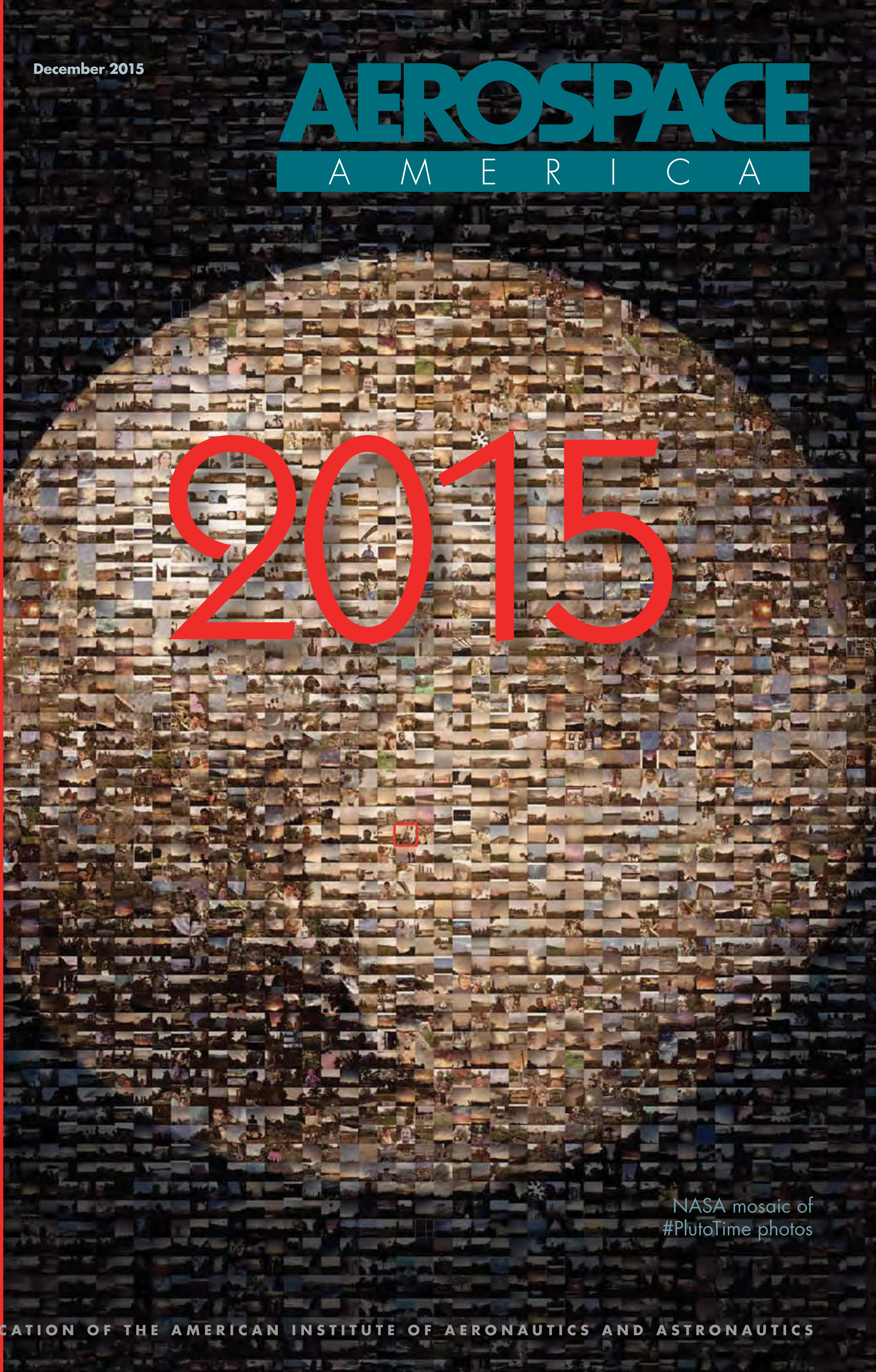

NASA mosaic of #PlutoTime photos

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Initial steps for nuclear thermal rocket design

by Bryan Palaszewski

*The **Nuclear and Future Flight Propulsion Technical Committee** works to advance the implementation and design of nonchemical, high-energy propulsion systems other than electric thruster systems.*

In 2015, the research in nuclear and future flight propulsion investigated nuclear propulsion in many forms and configurations. These nuclear propulsion systems are best suited for interplanetary travel. While there is always hope for breakthroughs, no practical ideas for fast interstellar flights within a human lifetime are showing promise. Studies point to nuclear fusion as one important option, but the power levels needed for such propulsion systems are far beyond our grasp with our current investments.

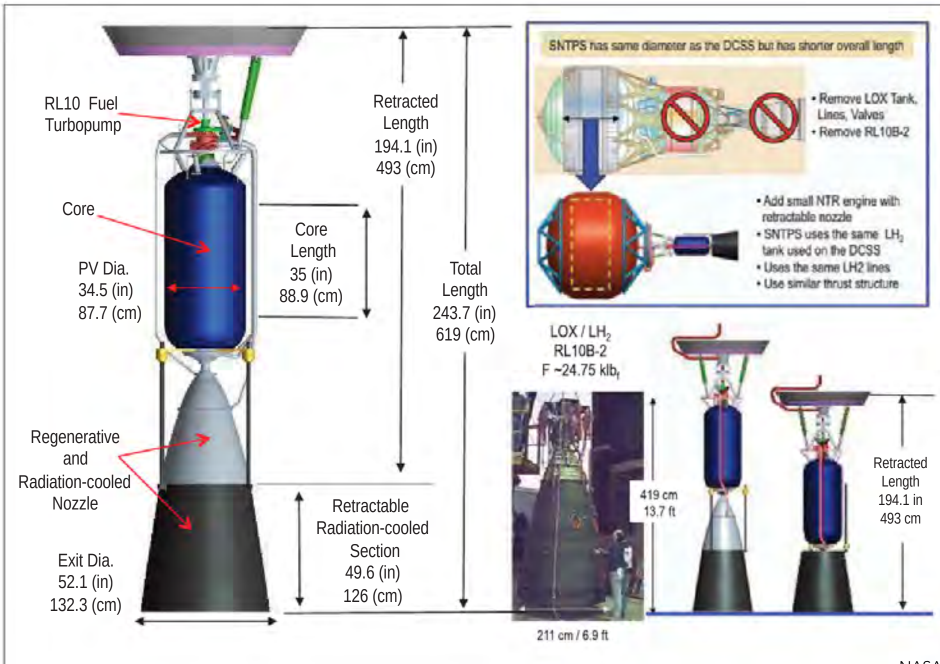
A team from the University of Connecticut, NASA Marshall Space Flight Center and the University of Michigan assessed **laser-heated pellet pulse propulsion**, LHPPP, which has the potential to compete with near-term deep space propulsion systems. LHPPP's ultimate potential, however, is in pulsed fusion propulsion. This evolutionary approach makes LHPPP very attractive for development today. Systems for attitude control and orbital correction of geosynchronous satellites would provide the experience necessary to begin the development.

NASA and Aerojet Rocketdyne are designing **nuclear thermal rockets**, NTR, for near-term applications. Nuclear testing options were assessed by NASA Stennis Space Center and Aerojet-Rocketdyne engineers. Testing of the simulated nuclear fuel elements is underway at the NASA Marshall Space Flight Center. Small NTR stages for in-space testing were assessed.

Previously, NASA's Glenn Research Center, the U.S. Department of Energy and industry partners outlined a preliminary plan for design, development, test, and engineering for NTR stages for NASA headquarters that involved significant system-level demonstration projects. Included were ground test demonstrations at the **Nevada National Security Site**, followed by a flight test demonstration mission. To reduce development costs, the demonstration tests use a small, low-thrust-level (7,500 pound or 16,500 pound) engine. Both engines use graphite composite fuel and a "common" fuel element design that is scalable to higher-thrust, 25,000-pound engines by increasing the number of elements in a larger diameter core that can produce greater thermal power output. To keep the FTD mission cost down, a simple "1-burn" lunar flyby mission was considered along with maximizing the use of existing and flight-proven liquid rocket and stage hardware (e.g., from the RL10-B2 engine and Delta Cryogenic Second Stage) to further ensure affordability. The planning would lead to the flight of a small NTR engine and stage within a 10-year time frame.

In July, NASA Glenn for the first time presented detailed analyses of elements of aerial transportation for **atmospheric mining in the outer solar system**. The paper also focused on an outer planet exploration with gas core and fusion propulsion applications, including interstellar missions.

Helium 3 and deuterium would be the fuels wrested from the planets' atmospheres with a closed cycle gas core nuclear rocket mining aerospacecraft. Subsequently, the fuels would be transported to an outer planet moon for processing. Sizing of several transportation vehicles and their related systems was presented: moon base propellant factories, moon base landers, and orbital transfer vehicles. Preliminary mission planning and optimizations for atmospheric mining were detailed and travel times for orbital transfer vehicles from Uranus and Neptune to their respective ISRU moon bases were presented. Preliminary optimization results of the transportation system pointed toward at 10 megawatt nuclear electric orbital transfer vehicle and a 200 metric ton propellant-payload, oxygen-hydrogen propulsion moon lander.



NASA is assessing a small nuclear thermal rocket engine and stage for in-space testing.