Studies of Fission Fragment Rocket Engine Propelled Spacecraft

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The NASA Office of Chief Technologist has funded from FY11 through FY14 successive studies of the physics, design, and spacecraft integration of a Fission Fragment Rocket Engine (FFRE) that directly converts the momentum of fission fragments continuously into spacecraft momentum at a theoretical specific impulse above one million seconds. While others have promised future propulsion advances if only you have the patience, the FFRE requires no waiting, no advances in physics and no advances in manufacturing processes. Such an engine unequivocally can create a new era of space exploration that can change spacecraft operation.

The NIAC Program Phase 1 study of FY11 first investigated how the revolutionary FFRE technology could be integrated into an advanced spacecraft. The FFRE combines existent technologies of low density fissioning dust trapped electrostatically and high field strength superconducting magnets for beam management. By organizing the nuclear core material to permit sufficient mean free path for escape of the fission fragments and by collimating the beam, this study showed the FFRE could convert nuclear power to thrust directly and efficiently at a delivered I_{SP} of 527,000 seconds. The FY13 study showed that, without increasing the reactor power, adding a neutral gas to the fission fragment beam significantly increased the FFRE thrust through in a manner analogous to a jet engine afterburner. This frictional interaction of gas and beam resulted in an engine that continuously produced 1000lb_f of thrust at a delivered impulse of 32,000 seconds, thereby reducing the currently studied DRM 5 round trip mission to Mars from 3 years to 260 days. By decreasing the gas addition, this same engine can be tailored for much lower thrust at much higher impulse to match missions to more distant destinations.

These studies created host spacecraft concepts configured for manned round trip journeys. While the vehicles are very large, they are primarily made up of a habitat payload on one end, the engine on the opposite end and a connecting spine containing radiator acreage needed to reject the heat of this powerful, but inefficient engine. These studies concluded that the engine and spacecraft are within today's technology, could be built, tested, launched on several SLS launchers, integrated, checked out, maintained at an in-space LEO base, and operated for decades just as Caribbean cruise ships operate today. The nuclear issues were found to be far less daunting that current nuclear engines. The FFRE produces very small amounts of radioactive efflux compared to their impulse, easily contained in an evacuated "bore-hole" test site. The engine poses no launch risk since it is simply a structure containing no fissionable material. The nuclear fuel is carried to orbit in containers highly crash-proofed for launch accidents from which it, in a liquid medium, is injected into the FFRE. The radioactive exhaust, with a velocity above 300km/s rapidly leaves the solar system.