Phase I Project Summary

PSI-6293

Firm: Physical Sciences Inc.
Contract Number: NNX11CE31P
Project Title: High Performance Monopropellants for Future Planetary Ascent Vehicles

Identification and Significance of Innovation: (Limit 200 words or 2,000 characters whichever is less)
Our high performance, green, non-cryogenic, low toxicity, non-carcinogenic relative to hydrazine and less corrosive monopropellants have the following advantages:

1. A tunable specific impulse from 237 sec to a maximum specific impulse of 374.6 sec - 309.6 sec. Exceeding the 240 sec mission requirement by 29% - 56%;
2. Superior improvement in I_{sp} (28% to 55%) and ρI_{sp} (71% - 112%) compared to hydrazine;
3. A tunable density from 1.11 to 1.38 g/cm^3. Exceeding hydrazine density by 11% to 38%;
4. A high ρI_{sp} comparable to NTO/hydrazine and superior to cryogenic LOX/LH_2 and LOX/LCH_4 (*Human Exploration of Mars Design Reference Architecture (DRA) 5.0*) bi-propellant systems;
5. Fine droplet dispersion with ignition delays less than 10ms at 1030psi
6. Safer, easier to handle, as well as better storability compared to fuming red or white nitric acid, liquid oxygen (LOX), liquid hydrogen (LH_2), liquid methane (LCH_4), concentrated hydrogen peroxide (H_2O_2), nitrogen tetroxide (NTO), dimethylhydrazine (MMH), and hydrazine.

Technical Objectives and Work Plan: (Limit 200 words or 2,000 characters whichever is less)

- Evaluated the physical and chemical properties of proposed monopropellants to ensure maximum I_{sp} and ρI_{sp}. Identified monopropellants thermal stability, storability, freezing point temperature, viscosity as a function of temperature, and material compatibility
- Demonstrate fine droplet dispersion, ignition and sustained combustion of the monopropellants up to chamber pressures of 1000psi
- Identified a Mars Ascent Vehicle design (using the Design Reference Architecture 5.0 as baseline) for sample return and manned mission that uses the proposed monopropellant, and demonstrated by analysis enhanced vehicle performance and its implementation for space borne mission

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)

- Successfully developed three monopropellant formulations including a safe mixing process using commercial available tools to facilitate processing scale-up at the production scale.
- Monopropellants showed good storability, material compatibility, freezing temperatures less than -60°C, thermal and chemical stability, and good flowability at room temperature and -15°C
- Demonstrated fine droplet dispersion, ignition tailorable burn rate, and sustained steady state combustion with ignition delays of < 200ms at 100psi and < 10ms at 1030psi
- A system level trade for the Mars ascent vehicle for the sample return and manned landing/return mission showing our proposed monopropellant was superior to alternative conventional monopropellants and competitive with or superior to, state of the art bipropellant.

NASA Application(s): (Limit 100 words or 1,000 characters whichever is less)
Multiple application within the NASA Exploration System and Planetary Science directorate:

- Advanced Capabilities Program
- Exploration Technology Development Program
- Mars Exploration program

Non-NASA Commercial Application(s): (Limit 200 words or 2,000 characters whichever is less)

- NetCentric Airborne Defense Element Proto-program
- Falcon force HTV-2 program
- Divert attitude control and upper-stage propulsion system for MDA missile programs

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