National Aeronautics and Space Administration

FY23 Innovative Spontaneous Concepts Research and Technology Development (ISC)

Additively-Manufactured Micro Gas Chromatography Columns for Harsh Planetary Environments

Principal Investigator: Richard Kidd (353)**; Co-Investigators:** Benjamin Kropff (353), Valeria Lopez (353), Samad Firdosy (357), Margie Homer (353), Marianne Gonzalez (353), Scott Roberts (357)

Objectives: This research focused on the development of first generation µGC columns using laser powder bed fusion 3D printing with titanium alloy (Ti6Al4V). The 3D printing process allowed for intentional porosity in the walls of the internal channels by adjusting laser parameters such as speed and spacing. Notably, three Ti µGC PLOT columns, each 1 meter in length and possessing internal channel diameters of 1 mm, 2 mm, and 3 mm, were successfully printed. These Ti µGC PLOT columns exhibit potential for enhanced performance in planetary exploration, especially in environments with high G-forces, shock, or corrosive conditions. While preliminary testing has shown limitations in the separation capabilities of the columns, this research demonstrated the feasibly of manufacturing Ti µGC PLOT columns through 3D printing. These findings suggest further optimization of the printing process and column conditions can lead to enhanced separation capabilities. The refinement of these factors could enable the implementation of microGC columns with varying applications in planetary exploration.

Background: Gas Chromatography (GC) is the workhorse analytical chemistry technology that has flown on numerous space missions including Pioneer-Venus, Apollo, Viking, Curiosity, Huygens, the ISS. GCs come in three designs: Wall-Coated Open Tubular (WCOT), Porous-Layer Open Tubular (PLOT), and packed capillary columns. WCOT GCs are used for complex, volatile organic compounds only found on Earth, Titan and in crewed spacecraft cabins. PLOT/packed columns are used for light gases at Venus, rocky/icy bodies such as Mars, asteroids, Europa, the moon.

Approach and Results: This research evaluates the performance of 3D printed PLOT-style GC columns with varying internal channel diameters, with emphasis on their suitability for harsh planetary environments. The evaluation encompassed pressure versus flow testing and integration with a thermal conductivity detector for robust sample injection analysis. Confocal microscopy and Scanning Electron Microscopy (SEM) were utilized to image the internal channel cross-sections of the columns, facilitating accurate assessment of surface roughness. Future endeavors involve comprehensive testing to optimize the separation capabilities of the 3D printed PLOT columns, focusing on fine-tuning the stationary phase and exploring the potential incorporation of a heating element.

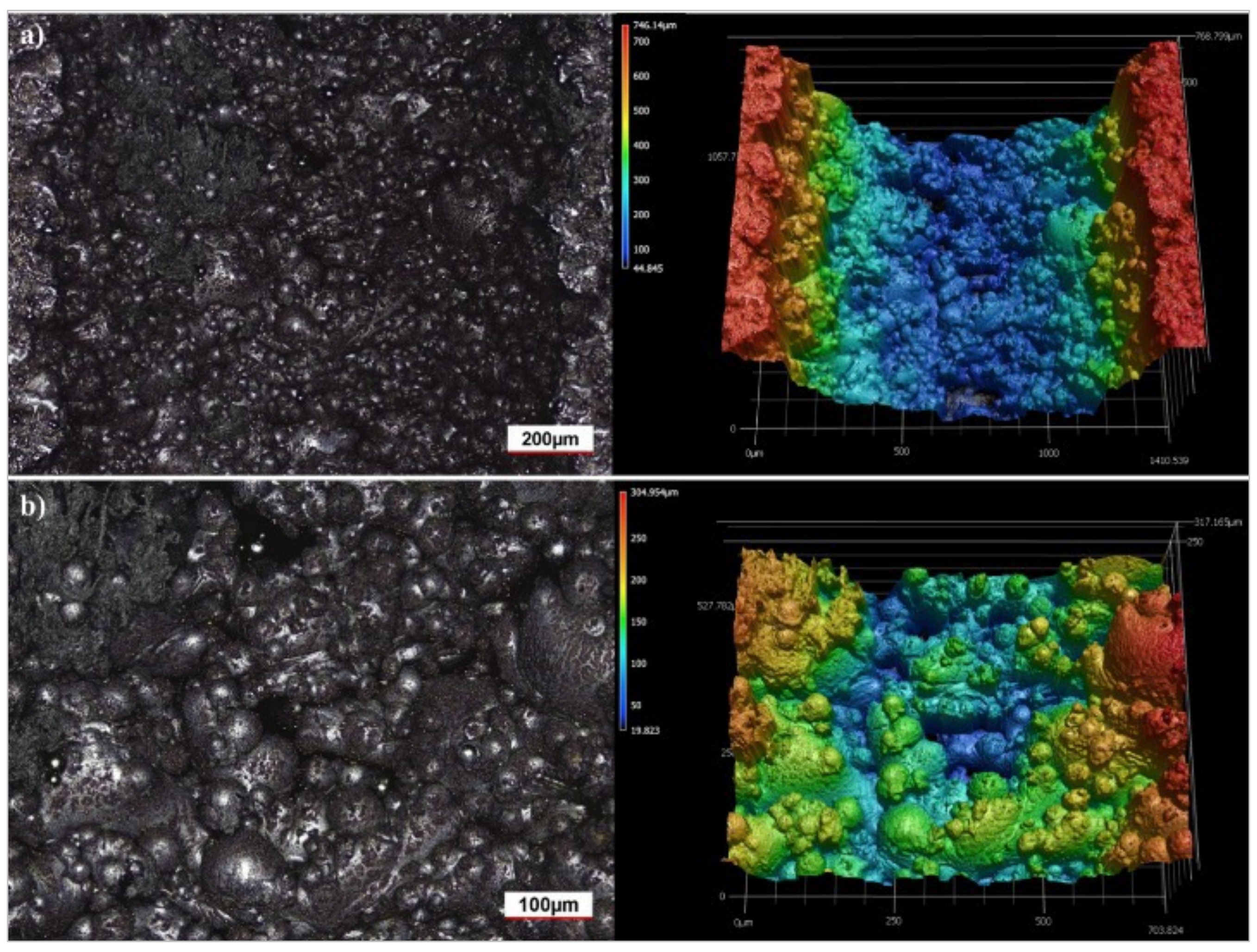

Figure 1. *Confocal microscope images of a channel cross section. a) 10 times magnification with 3D rendering of semicircular cross section of the channel. b) 20 times magnification within channel. Image correction included noise removal (medium).*

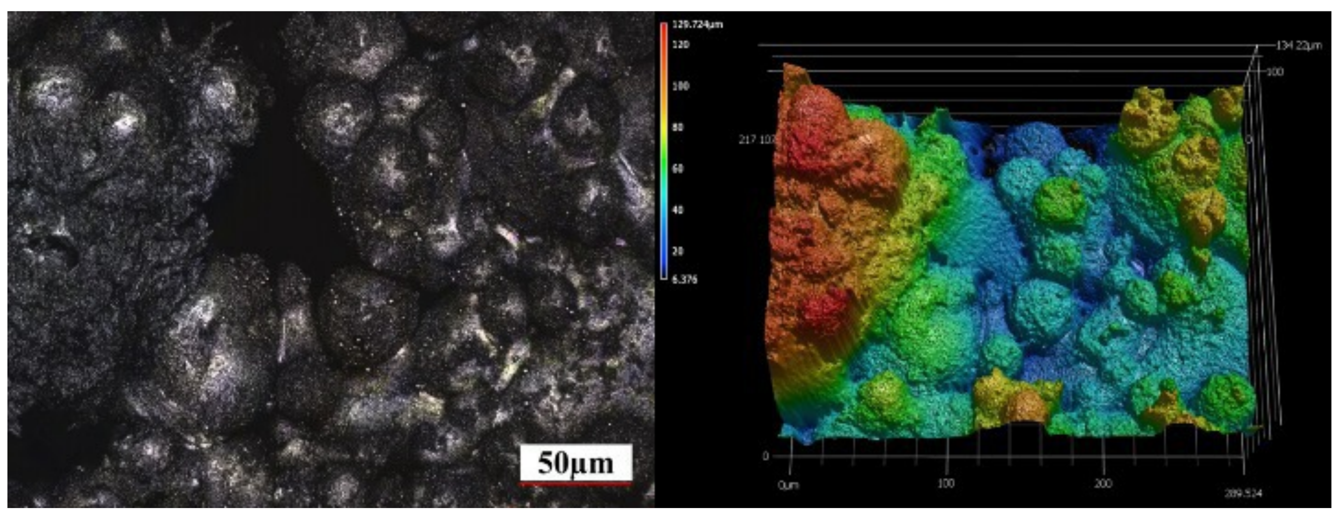

Figure 2. *Confocal microscope image at 50 times magnification. The reported SA value was 8.445 µm. Image correction included noise removal (medium) and surface shape correction (waveform removal).*

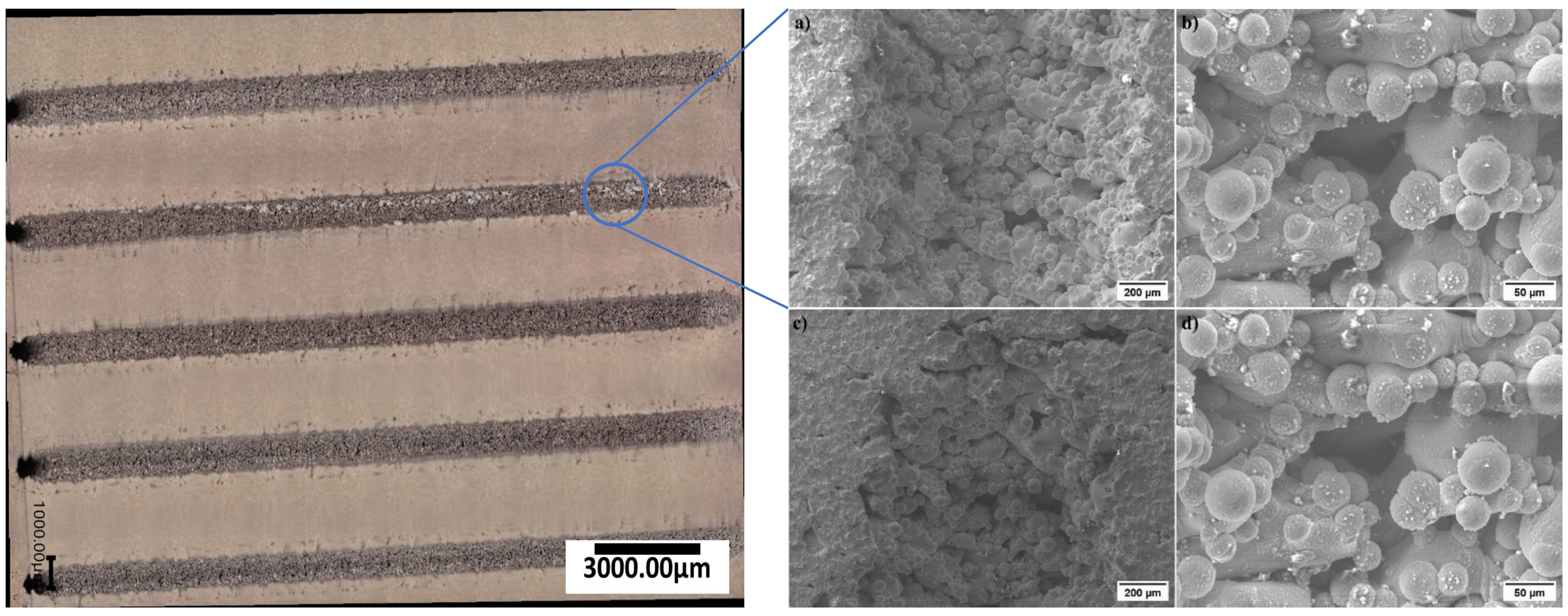

Figure 3. *Left, confocal microscope images of a channel cross section. Right, SEM images of the channel cross section. a) 69x magnification of the middle of a channel with an average diameter of 1.255 mm, b) 114x magnification, c) 69x magnification of the end of a channel, d) 286x magnification.*

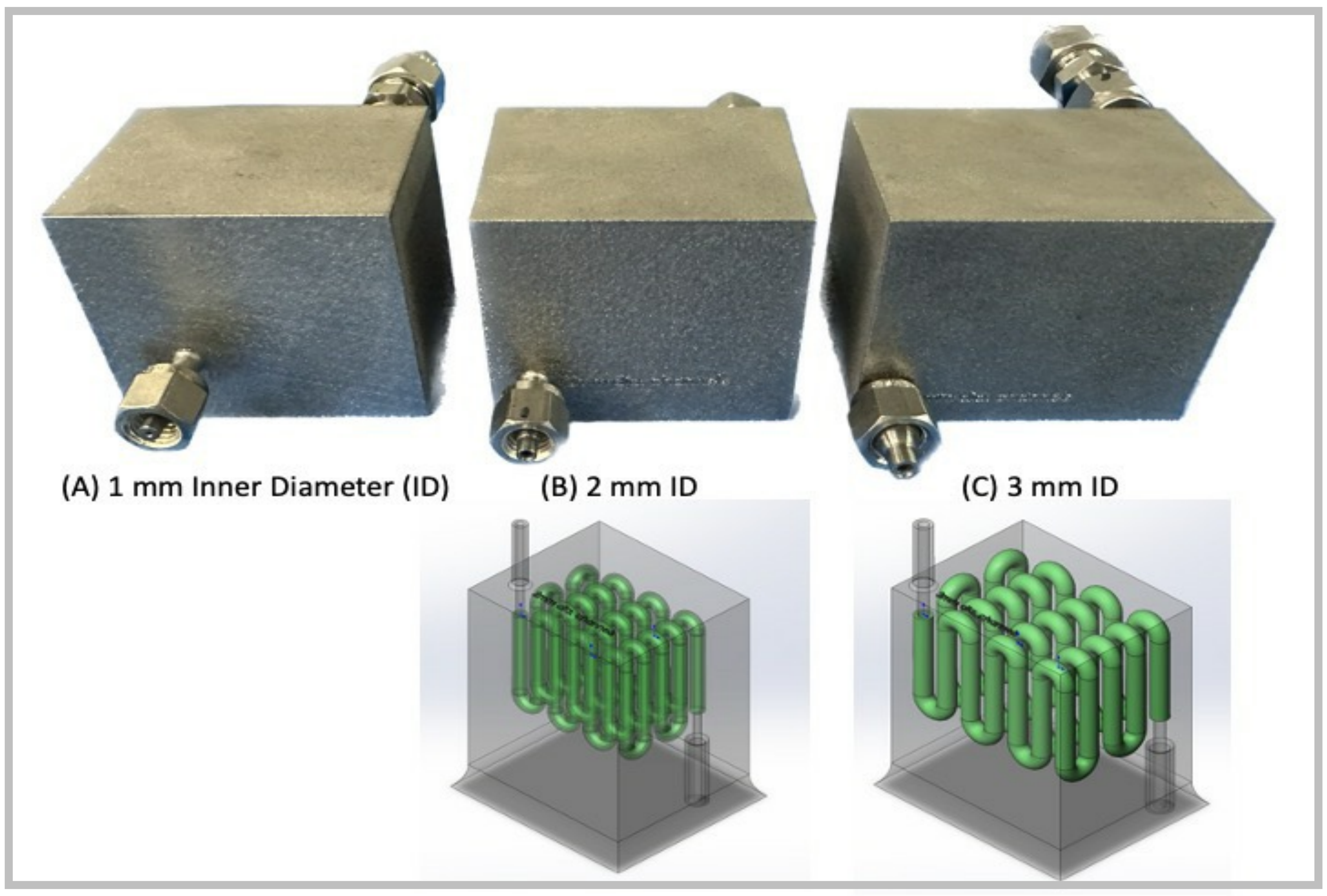

Figure 4. *Top, photographs of the 1, 2 and 3 mm inner diameter GC columns. Bottom, transparent CADs of the 2 and 3 mm GC columns. Note that the extra material shown in the CADs of the bottom of the blocks were machined away post-printing.*

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

Clearance Number: CL#00-0000
Poster Number: RPC#

PI/Task Mgr. Contact Information:
818-393-0409, richard.d.kidd@jpl.nasa.gov