MICROGRAVITY TESTING OF A SURFACE SAMPLING SYSTEM FOR SAMPLE RETURN FROM SMALL SOLAR SYSTEM BODIES. M. A. Franzen[1], J. Preble[2], M. Schoenoff[2], K. Halona[2], T. E. Long[3], T. Park[3], and D. W. G. Sears[1], [1]Arkansas-Oklahoma Space and Planetary Sciences, Department of Chemistry and Biochemistry, University of Arkansas, Fayetteville, AR 72701, [2]SpaceWorks, Inc., 7301 E. Sundance Trail, Carefree, AZ 85377, [3]Department of Chemistry, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0344, mfrazen@uark.edu.

Introduction: The return of samples from solar system bodies is becoming an essential element of solar system exploration. The recent National Research Council Solar System Exploration Decadal Survey identified six sample return missions as high priority missions: South–Aitken Basin Sample Return, Comet Surface Sample Return, Comet Surface Sample Return-sample from selected surface sites, Asteroid Lander/Rover/Sample Return, Comet Nucleus Sample Return-cold samples from depth, and Mars Sample Return [1] and the NASA Roadmap also includes sample return missions [2] . Sample collection methods that have been flown on robotic spacecraft to date return subgram quantities, but many scientific issues (like bulk composition, particle size distributions, petrology, chronology) require tens to hundreds of grams of sample. Many complex sample colletion devices have been proposed, however, small robotic missions require simplicity. We present here the results of experiments done with a simple but innovative collection system for sample return from small solar system bodies.

The surface sampling system: The sampling mechanism we are investigating involves an adhesive pad that makes contact with the planetary surface for just a few seconds, doing away with the need for the complexity, risk, and expense of landing. The experiments were designed to determine if microgravity conditions altered the amount of sample material that could be collected on the pad as well as determine if the sample collector was selective in the material it was able to collect. The intent was to minimize the disturbance to the surface and thus retrieve a sample ranging from small fine-grained particles to ~1 cm clasts. The collector consisted of different combinations of four substrate pads (7.6 cm x 7.6 cm) and 2 adhesives which were attached to a sampling shaft inside a test fixture that housed several types of regolith models (Fig. 1). Various forces and contact durations were investigated during flights on NASA's microgravity facility (a specially adapted KC-135 aircraft). The regolith models consisted of sand, small rocks, and pebbles. Data was logged with a laptop computer and the events were recorded on videotape.

Day 1: The sample material consisted of fine grained sand (78.5 % by mass) and ~1 cm sized pebbles (21.5 %). Force ranged from 5-20 N and contact durations ranged from 1-10 s. Only 4 of 12 sample pads were tested due to technical difficulties created by periods of "negative gravity".

Day 2: Flight paths were used that decreased the periods of negative gravity. The sample consisted of nearly all ~1 cm pebbles. The forces and contact periods were the same as in day 1.

Fig. 1. Schematic diagram of the test fixture used in the KC-135 tests. The sample pads were located on the sides of the fixture in sample boxes and were mounted manually onto the shaft. Once microgravity conditions were attained, the sample tray and box containing the sample pad were opened and the shaft was manually pushed down into the sample for a predetermined time and force. Once the sample was collected, the sample pad was removed from the tray and the sample pad box was closed and replaced with the next sample pad box.

Day 3: The sample consisted of small pebbles (34 %) and ~1 cm pebbles (64 %) and only one adhesive type was tested. All the other parameters were the same as in day 2.

Results: The two substrates were foam and steel wool wrapped around steel gauze (WGW) and two adhesives (TR and DH) were evaluated in the four sampling events (Fig. 2a.). The average weight of the three samples collected by the foam substrate and TR adhesive was 8.6 g with a range of 4.5 g to 11.3 g . The WGW substrate and DH adhesive collected an average of 16.2 g, ~37 % sand and 63 % pebbles. These collected proportions are unlike the original proportions (78.5 % sand and 21.5 % pebbles), but plane vibration and negative gravity may caused settling. Less material was collected by the foam subtrate coated with TR adhesive as force, contact duration and impulse (N-s) increased, but the data are meager.

Fig. 2. (a) Example of WGW substrate from day 1 flight. The sample was composed of sand and ~1 cm sized pebbles. (b) Foam substrate coated with TR from day 2 flight. Notice the bottom left corner displays the substrate/adhesive's ability to collect smaller particles among larger particles.

Table 1: Data collected from day 2 flight.

Substrate	Adhesive	Mass Collected (g)
F	DH	23.4
W	TR	21.1
F	TR	54.2
F	TR	41.2
W	DH	13.6
F	TR	47.8
WGW	TR	19.0
F	DH	19.3
F	TR	31.3

Day 2 was far more successful with 9 of 12 sampling events (Table 1). Substrates coated with the TR adhesive out-preformed substrates coated with the DH adhesive with an average mass collected of 35.8 g and 18.8 g, repectively. This was also consistent with ground tests. Pads made of the foam substrate collected the most sample, followed by pads made of the WGW substrate and then pads made of the steel wool (W) substrate, regardless of adhesive. (Fig. 2b.) In these prelimanry tests, it appears that there is no significant correlation between impulse, duration, or force to the amount of sample collected.

Seven of 12 sampling events were successful during day 3 (Table 2). The foam substrate once again preformed the best, collecting with an average of 34.3 g of sample per collection. The foam substrate with TR adhesive collected more sample on average (35.8 g) than the foam substrate with DH adhesive from day 3. The effect of force, time duration, and impulse was inconclusive due to the small data set. The sample tray consisted of 34.0% (by mass) small rocks and 66.0 % pebbles. The collected samples were 29.2 % small rocks and 70.3 % pebbles, on average, which are very close to the original values, despite airplane vibrations, settling, and negative gravity.

Table 2: Data collected for day 3 flight.

Sub.	Adh.	Mass (g)	Small Rocks (%)	% Pebbles
F	DH	27.4	20.8	75.9
W	DH	5.3	52.8	47.2
F	DH	34.3	13.4	86.6
F	DH	39.6	19.2	80.8
WGW	DH	5.3	28.3	71.7
F	DH	36.0	23.9	76.1
F	DH	20.4	46.1	53.9
Avg.			29.2	70.3

Conclusion: All substrates and adhesives used in these tests were able to collect particles as fine as sand and up to ~1 cm sized clasts. The foam substrate was able to collect more sample material than any of the other substrates and the TR adhesive proved to be better than DH. The adhesive pad sampling mechanism appears to be a viable concept for small body sample return missions.

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References: [1] Space Studies Board (2002). [2] National Research Council (2003).