IMPACT EXPERIMENTS ON THE NASA KC-135 REDUCED-GRAVITY AIRCRAFT: EARLY RESULTS.

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It is a strong possibility that planetary experimentation will be conducted on the proposed Space Station in order to study, among other things, the role of gravity in various planetary processes. A number of candidate experiments have been identified, and testing is underway to establish techniques that will permit experimentation in low-gravity environments. An impact facility is one of these candidates, a precursor to which has been flown on the principal testbed at present, the NASA KC-135 Reduced-Gravity Aircraft. This report describes the apparatus, the experimental environment on the KC-135, and some early results regarding cratering in sand targets.

The Low-Velocity Impact Facility: While it is desirable to accelerate a variety of projectiles over a wide range of velocities, the availability of funding for this initial facility dictated a modest approach. The accelerator is a Sheridan 5mm pellet pistol, modified to be mounted vertically and fired electronically; impact velocities of ~50-130 m/s are attained by varying the level of pressurization in the gun. Cylindrical lead pellets, averaging 0.961 grams, are used as projectiles. The impact chamber is a 51.8x51.8x45.8-cm box consisting of an aluminum framework with 1.25-cm thick tempered-glass walls to permit photography and viewing of the interior. As vacuum capability does not yet exist, all experiments have thus far occurred at aircraft-cabin pressure. Experiment data are collected through photography (high-speed motion-picture, still, and video cameras), while acceleration and pressure information are recorded digitally with a microcomputer. Projectile velocities are measured *via* interruption of infrared light sources separated by a fixed distance; an independent oscillator circuit is used for timing. Because it is often difficult to perform critical operations manually on a rapidly advancing timeline during variable-g flight, the computer is also utilized as an event sequencer — operating the cameras, firing the gun, measuring projectile velocities, and recording event times as well as the accelerometer and pressure-gauge data.

Experimental Environment on the KC-135: The KC-135 can support gravity levels ranging from -0.1 to ~2g's for tens of seconds; the flight profile is chosen by the investigators. Depending on a number of factors determined by the experimental program, up to 50 parabolas can be accommodated on a 2.5-hour flight. While aircraft vibrations are minimal during a typical parabolic maneuver, some low-frequency oscillations of varying amplitude around the targeted g-level are not unusual (Fig.1). Although the pressurized cabin provides a shirt-sleeve working environment, normally routine operations are occasionally made more difficult by the variable-g environment.

Some Early Experimental Results: The early developmental flights provided the opportunity to perform some limited cratering experiments. A coarse-grained, polymineralic sand (1.57 g/cm^3, 32.5° angle of internal friction) was utilized as the target; the sand, comprised predominantly of quartz and feldspar (see Table 1 for its grain-size distribution), filled the container to a depth of 15 cm. Comparison with earlier findings[1] leads to the conclusion that the volume of target material was sufficient to obviate edge effects during formation of the largest craters *at 1g*. (Although no anomalous phenomena were observed during flight, this parameter must still be examined in more detail before serious experimentation is undertaken at the lower g-levels, especially when higher projectile energies are employed.) A total of 27 shots performed over a range of 0.082 to 0.534g's yielded the results illustrated in Fig.2.

The variation of impact velocities in these experiments was small, providing an energy range of just over a factor of 6; corresponding crater diameters varied from 11.2 to 18.1 cm. Dimensionless units[2,3] were chosen to facilitate comparison with existing data at various g-levels; there was, however, no intention of duplicating extant data during these initial KC-135 experiments. Included among the factors that complicate any potential comparisons with the ground-based data is the high atmospheric pressure in these experiments relative to those commonly utilized in impact studies. In addition , the sand used here was a "target of opportunity", and its detailed properties relative to the more common media used in 1-g and high-g studies are not well documented. Furthermore, the velocities used in these experiments are below those of the hypervelocity scaling regime[1,2]. Thus, the larger scaled crater radii in these experiments could be due to any one or a combination of these factors, or to others that are not identified at present. Nevertheless, the figure illustrates that experimentation on the KC-135 is easily capable of producing data with the precision required for serious planetary investigations. Future activities will include a powder gun for higher projectile energies, as well as an impact chamber capable of supporting much lower atmospheric pressures and greater target volumes.

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References: (1)D.E. Gault and J.A. Wedekind, 1977, *Impact and Explosion Cratering* (Roddy, Pepin, and Merrill, eds.), Pergamon Press (New York), p.1231. (2)R.M. Schmidt, 1980, *PLPSC 11*, p.2099. (3)R.M. Schmidt and K.A. Holsapple, 1982, *GSA Spec. Paper 190* (Silver and Schultz, eds.), p.93.

Table 1. Grain-size distribution of target sand

Size(mm)	Mass Fraction
>0.500-1.000	0.264
>0.250-0.500	0.660
>0.125-0.250	0.075
<0.125	0.001

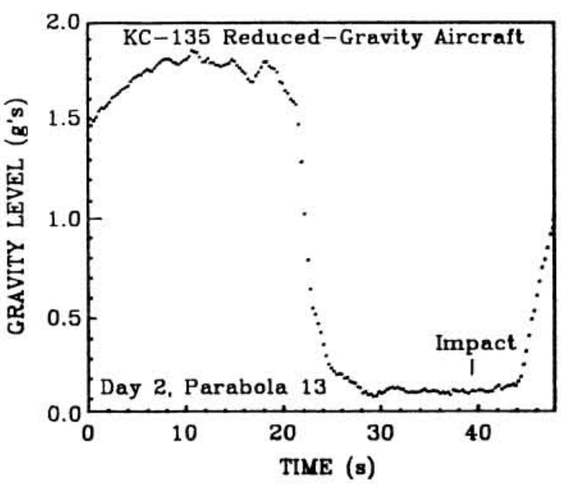

Figure 1. Example of the acceleration history during an impact experiment on the NASA KC-135 Reduced-Gravity Aircraft. The g-level on the vertical axis was sampled 4 times per second; the time of gun-firing and impact is indicated just after 39 seconds. Note the small oscillations around the targeted level of 0.16g.

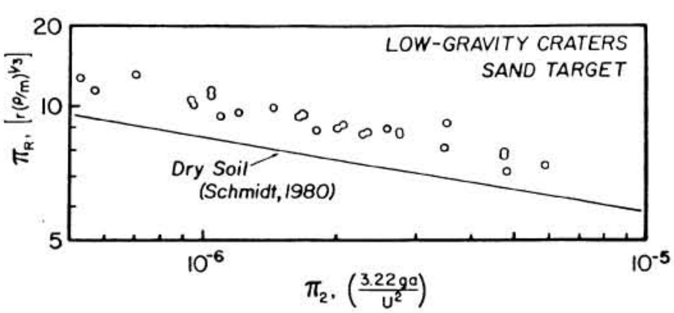

Figure 2. Dimensionless plot of the low-g crater data. The variables used are g, the gravitational acceleration, ρ, the target's density, m, the projectile mass, r, the crater radius, a, the effective projectile radius, g, the gravitational acceleration, and U, the impact velocity.