*GRMPY Surface Ground
Motion Measurements in Area 16*

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GRMPY Surface Ground Motion Measurements in Area 16

by

Robert G. Deupree

ABSTRACT

The GRMPY surface ground motion data collection system was fielded on two shallowly buried high explosive tests in Area 16 at the Nevada Test Site. Excellent data were collected on both tests and on two very small high explosive calibration tests conducted prior to the main tests. The data superficially resemble surface ground motion data for nuclear weapons tests, but there are differences. The most obvious is the rate of decline in peak vertical velocity with horizontal distance. Less obvious is the ratio of the surface ground zero peak vertical acceleration to the surface ground zero peak vertical velocity. The ramifications of these features as tools for on-site verification are explored.

I. INTRODUCTION

The GRMPY system for measuring strong surface ground motion was developed in the late 1980's to be fielded by a small cadre of people in a potentially hostile environment. Since the proof test of the system on the MISTY ECHO Event in December 1988, we have fielded the system on twelve LLNL and DNA events. The last of these, GALENA, was executed in the summer of 1992. The GRMPY system has been idle since then except for some development of the capability to communicate between the GRMPY Control Center and the individual units via radio as well as by hard wire.

The proposed execution of two high explosive events by the DNA in Area 16 offered us the opportunity to accomplish several goals with the GRMPY system. First, it would allow us to determine what time and effort would be required to prepare the system (and the remaining personnel) for fielding after such a long hiatus. One component of this is an examination of the adequacy of the checklists, since we will have forgotten many of the details required for the successful fielding of the system. Moreover, it would also give us an opportunity to field at least one of the GRMPY units with radio communication on an event, something we have not previously done. Finally, we could expect to gain some information about how shallowly buried high explosive events might be used to hide a more deeply buried clandestine nuclear test.

The GRMPY system is composed of the individual GRMPY units and

the GRMPY Control Center. Any GRMPY unit can be connected to the Control Center via either hard wire or radio. The Control Center can send each unit any of a number of commands which prepare the unit for data collection, provide diagnostic information, or send data stored in the units to the Control Center. The major components of the Control Center are a MicroVax, a signal box which contains the power supplies and radio communications equipment, generators to supply power to the whole system, and an UPS to carry through short power interruptions. The architecture of the GRMPY units is described by Khalsa (1989), the Control Center software by Watson (1991), and the steps required to field the GRMPY system by Deupree, et al. (1990).

The hard wire connections between the individual GRMPY units and the Control Center perform several functions. Not only are these cables used for communications, but there is also a special twisted pair to transmit to each unit a fiducial signal received by the Control Center from an external source, and another twisted pair to provide power to keep the individual unit batteries charged. The radio communication mode could not fulfill either of these two features. For those GRMPY units which use radio communications, we provide battery charging power from solar cells. These units also could not be activated by a fiducial signal, but can be activated by either a software signal sent from the Control Center or by a ground motion threshold being exceeded in the unit.

We found few problems in deploying the system, although we had to develop some new diagnostics in order to examine problems with the radio communication link. One particularly gratifying feature is that the checklists were very helpful in recalling how to set up the system. We present these checklists in Appendix A.

There were actually four explosions involved in the two tests in Area 16 because there was a small (approximately one pound of high explosive) calibration test two days prior to each primary test (about 500 pounds of high explosive). For the calibration shots, we allowed all the hardwire GRMPY units to be triggered by an external fiducial signal sent to the Control Center by SNLA. However, we had no way other than ground motion (unlikely to exceed any reasonable threshold) to trigger the one radio unit we deployed. Thus, the GRMPY unit communicating via radio was not activated for the calibration tests. Some GRMPY units actually obtained data above the background noise level on the two calibration shots. For the primary tests we allowed one unit which was expected to receive significant ground motion to trigger only on ground motion and then to trigger all other units. All other units except the radio unit were triggered by the fiducial signal. This ground motion trigger allowed us to trigger the radio unit as well as retrigger all other units. On-board clocks in the individual GRMPY units which store the times of all triggers allowed us to determine the time of all triggers relative to the fiducial signal.

All units obtained excellent data on the primary tests. The primary purpose of this report is to present this data. We also present the data for the calibration tests for those units which detected something above the background noise of the system. This background noise is determined by the bit resolution of the 12 bit analog to digital converter and is about 0.006 g.

Before presenting the data we provide some details of the station locations in Tables 1 and 2. We define the two tests as U16A_01 and U16A_02. The tables present the north and east Nevada Test Site (NTS) coordinates, the horizontal distance from surface ground zero (SGZ), and the azimuth (angle measured eastward from north) in degrees. Also indicated is which GRMPY units are connected by hard wire (cable) and which by radio communications. The relative locations of the stations are shown in Figure 1 for U16A_01 and in Figure 2 for U16A_02.

Although seven seconds of data were collected by each unit on each test, with only very few exceptions (which we shall present) were there any data above the noise level after about one second. We shall therefore focus on the first second after zero time interval in our presentation.

II. CALIBRATION SHOT FOR TEST U16A_01

All of the GRMPY stations are identical except for the one located at SGZ (GM1 for all tests). This station has three vertical accelerometers instead of the usual triaxial array. In all cases the vertical axis is positive upward. The x axis is positive toward SGZ and the y axis positive according to the left-hand rule. This unusual circumstance is produced because the triaxial mounting block is attached to the lid of the GRMPY unit with the vertical pointing downward (according to the right-hand rule). We have inverted the vertical to be positive upward in accordance with standard practice.

The three vertical acceleration records for the SGZ station are shown in Figure 3. In all records the bit noise is evident, but it is also clear that there is a small amplitude (approximately 0.03 g) signal imposed upon this noise.

Interestingly, a large amplitude signal is present on all axes of Station 2 in Figure 4. This station is about 40 feet less in elevation than Station 1, but is still farther from the explosion source. We also note that the transverse acceleration displays significant acceleration longer than the other axes (compare Figure 4b to Figures 4a and 4c).

This longer waveform duration is even more enhanced for the horizontal acceleration records for Station 3 (Figures 5a and 5b), but not obviously for the vertical acceleration (Figure 5c). Station 3 is another twenty feet downhill from Station 2 in

approximately the same direction (see Figure 1).

The asymmetry in the motion is indicated by the fact that there is no evidence of acceleration above the background noise level for Station 4, which is the same radial distance from SGZ as Station 3. As one would expect, there is no evidence for any acceleration above the noise for Station 7, which is farther from SGZ along the same azimuth as Station 4 (see Figure 1).

The data for Station 5 are shown in Figure 6. The motion is very close to the noise limit for the radial (Figure 6a) and vertical (Figure 6c) directions, but is more noticeable in the transverse direction (Figure 6b). However, the low frequency nature of the waveform between 200 msec and 400 msec in Figure 6a attests to the presence of physical acceleration. The situation for vertical motion is less clear cut.

There is no similar problem for Station 6, whose acceleration records are shown in Figure 7. While all three components show physical motion, the horizontal components (Figures 7a and 7b) are clearly more pronounced.

There are several interesting features which may be gleaned from this data. There is clearly an asymmetry in the motion as a function of azimuth about SGZ. Those stations which are north and east of SGZ show significantly higher acceleration amplitudes than those to the west and south. This correlates with the surface topology, as the stations north and east are downhill from SGZ. However, this difference cannot be explained by the downhill stations being closer to the working point because the elevation differences are not sufficiently large. The asymmetry is further highlighted by the relatively large amplitude of the transverse motion with respect to the radial. This probably does reflect to a certain extent the variation in surface topology.

Another feature of note is the relatively long lived nature of the horizontal motion in comparison with the vertical. This is particularly pronounced for Station 3 (Figure 5) and Station 6 (Figure 7). Many of these features will be present in the test data as well, to which we now turn.

III. TEST U16A_01

The three vertical acceleration records for the SGZ station are shown in Figure 8. The three records agree quite well, although there are some differences in the secondary peaks after the initial pulse passes. We also note that spall results from the initial approximately 2.85 g pulse.

The data for Station 2 are shown in Figure 9. We see that the peak radial acceleration (Figure 9a) is not much smaller than the peak vertical acceleration (Figure 9c). This is different from the

usual experience with nuclear explosions, mostly because the high explosive is buried much less deeply. With the shallow depth of burial the decrease in elevation is more significant and also plays a role in the enhanced radial component.

Figure 10 presents the data for Station 3. Again the relatively large radial component is evident, particularly if we note the much larger initial pulse width with respect to the vertical pulse (compare Figure 10a and Figure 10c). This also results from the continuing decrease in elevation in the eastward direction.

Station 4 shows significantly less motion than the previous stations in Figure 11. There is no hint of spall at this location.

Figure 12 presents the data for Station 5. Although this station is about the same distance from SGZ as Station 4, and like Station 4 is uphill from SGZ, the motion is significantly stronger.

The data for Station 6 are presented in Figure 13. The radial initial pulse here is quite strong (Figure 13a), but the vertical initial pulse is relatively weak because it is very narrow (Figure 13c). This station is also downhill from SGZ.

The results for Station 4 would imply that those for Station 7 be very weak. Figure 14 shows that this is the case.

The data for Station 8 (Figure 15) show stronger motion than for Station 7, although they are about the same distance from SGZ. Station 8 is somewhat downhill from SGZ, but not as much as Station 6. We also caution that the time of arrival is more uncertain for the radio Station 8, because of uncertainties in the radio transmission response times.

One other feature may be noted. The direction of the first pulse of the transverse motion is generally toward the north or east, in other words, generally downhill. This highlights the asymmetry which can be seen in the peak vertical velocity, shown as a function of horizontal distance in Figure 16. We shall return to this issue after the presentation of data for the second calibration shot and test.

IV. CALIBRATION SHOT FOR TEST U16A_02

The data for the calibration shot for the second test are presented in Figures 17-21. Again neither Station 4 nor Station 7 received any signal that could be perceived above the background bit noise of the packages. The vertical motion at SGZ is a little larger for the second calibration shot than for the first (compare Figure 17 to Figure 3) because of the shallower depth of burial for the second test. However, the amplitude at Station 2 is less in the second calibration test (compare Figure 18 to Figure 4). This

probably arises from the uphill nature of Station 2 on the second test compared to its downhill location on the first test. Also, one would expect that more shallowly buried explosions would leave a smaller horizontal surface expression (although other features may also affect this).

It is difficult to make quantitative comparisons for the other ground motion stations because the distances all differ between the two calibration shots and because the amplitudes are so low.

V. TEST U16A_02

The data for the second test in Area 16 are shown for the SGZ station in Figure 22. Again, all three data sets agree very well. We note that the peak vertical acceleration at SGZ is about twice as high as for the first test (compare with Figure 8). However, the peak velocity is only about 30% higher, so that the pulse is narrower on this second test. We shall return to this point in the discussion.

Unlike any data from the first test, this station shows some small signals well after the first second after the explosion. This is shown in Figure 23 for one of the accelerometers in this station. The most prominent signals are at about 3.8 and 4.3 seconds, but there are also others at about 1.3, 1.6, 2.2, and 2.6 seconds. The first two of these are also noticeable in the transverse motion of Station 2 (Figure 24), although the initial times are slightly later. There is also some evidence for a very weak signal at about 3.8 seconds in the transverse motion at Station 3 (Figure 25). Based on the films of the explosion, the most likely cause of these features is the return to the ground of rocks tossed into the air by the explosion.

The early time data for Station 2 are shown in Figure 26. We see that the vertical motion is larger than the horizontal motion for this station, in contrast with Station 2 on the first test (Figure 9). This suggests that the result derives from the downhill location of Station 2 from SGZ on the first test compared to its uphill location here.

Figure 27 shows the data for Station 3. The vertical motion more closely resembles the vertical data from nuclear events than most of the other data on these two tests. There is an initial pulse followed by a period of free fall and then slap down where the spall closure is communicated to the surface.

As one might expect from the first test, the motion at Station 4 is not large as seen in Figure 28. The asymmetry seen in the first test between Stations 4 and 5 is also present on this test. The data for Station 5 are shown in Figure 29.

The data for Station 6 are shown in Figure 30. The

characteristics appear to be about the same as for the first test (Figure 13), even though this station is about the same elevation as SGZ for the second test.

Again the expectations for Station 7 are for little motion, based on the results for Station 4. Figure 31 shows that this is the case.

The radio GRMPY data for Station 8 are shown in Figure 32. Again we caution that the explosion time for this station is less accurately known than for the other stations.

We show the peak vertical velocity versus horizontal distance from SGZ for the second test in Figure 33. The significantly lower velocities for Stations 4 and 7 stand out in comparison to other directions.

VI. DISCUSSION

These individual events are composed of single explosions of about 500 pounds of high explosive buried at much shallower depths than is the case for our nuclear experiments. One would expect differences between these explosions and nuclear explosions, and they exist. The most obvious difference, which one should assume was expected based on where we placed the GRMPY stations, is the much more rapid decrease in peak vertical velocity with horizontal distance for the Area 16 tests. The peak vertical velocity decreases by a factor of two in about 45 m in the first test (see Figure 16) and in about 20 m in the second test (see Figure 33). This compares with a minimum value of about 120 m for the events in the Los Alamos ground motion database (Deupree, et al. 1992). This expectation is founded on scaled distance arguments.

However, there are other differences which appear from the data. As a stress wave propagates through an inhomogeneous medium such as rock, it is both dispersed and attenuated. The amount of each depends on the rock properties and the amount of compression at each location as the wave passes through the rock. The SGZ surface vertical motion shows a peak acceleration that is about the value as that expected from a nuclear test, i.e., a few g's. However, the peak vertical velocity, a measure of the total strength of the pulse, is much smaller than the corresponding g levels would predict for a nuclear test. This means that the ratio of the dispersion to the attenuation for the Area 16 tests is different than the ratio for nuclear tests, most likely because the initial compression is much larger in nuclear tests.

This feature is shown in Figure 34, a plot of the SGZ peak vertical acceleration against the SGZ peak vertical velocity. The data for nuclear events form a reasonably well defined band, while the data for these two tests are well removed from this band. Both this point and the previous one on the horizontal fall off of

velocity are emphasized in Figure 35, a plot of the ratio of the peak vertical acceleration to peak vertical velocity versus the horizontal distance required for the peak vertical velocity to drop by a factor of two. Again, these two tests are well removed from the nuclear events in both variables. It should be noted that these plots include nuclear tests executed in a variety of material properties (Areas 3, 4, 6, 7, 12, 19, and 20). It is also worth mentioning that the MILROW Event, conducted in hard, saturated rock on Amchitka Island, would appear in the band in Figure 35, and would appear as a high amplitude extension of the band in Figure 34.

Based on these results, it should be possible to tell the difference between a single shallowly buried event and a deeper nuclear one. However, the question remains as to whether a collection of shallow events can be used to hide a more deeply buried nuclear test. The horizontal velocity decrease can be hidden by using a horizontal array of simultaneously conducted high explosive tests. However, altering the ratio of the peak acceleration to peak velocity is much more difficult. It should be possible by a superposition of the stress waves from two separate explosion, but the time window for the first pulses of the two waves to add is narrow. An example would be adding the SGZ station from the first test to Station 2 of the second test (they are at the same physical location). Here the time lag between the two waves was just enough for the pulse from the second test to appear only after the first pulse had passed. The same was true using adding the SGZ station from the second test to Station 2 of the first test.

Furthermore, the addition must take place in just the right way. For example, having the two pulses peak at the same time does not significantly change the ratio (we have linearly added the pulses from various stations to test this). The timing must be such that one pulse is arriving as the other has mostly passed. While timing accuracy in high explosive detonation can be done very precisely, the obstacle is determining what the timing needs to be. It is probably a fully three-dimensional problem to see that there is no location that could allow detection of a more deeply buried nuclear test.

The major impediment to the detection of a nuclear test in this situation would be the suppression of the ground motion produced by the nuclear test itself. This can be achieved by yield alone, but this may require such a low yield that all this subterfuge is not necessary. It may also be done by a judicious use of testing medium, assuming suitable options are available. One may also take efforts to decouple the nuclear explosion. One final method is simply to over-bury the nuclear test, but this requires a more extensive array of surface explosions to cover the horizontal surface "footprint" of the nuclear test. Nevertheless, close-in surface ground motion could play a significant role in the

successful on-site detection of a clandestine nuclear test.

VII. ACKNOWLEDGMENTS

It is a pleasure to thank Ross Oblad, Noor Khalsa, Wes Kiser, and Bernie Hawkins for their extremely valuable assistance in deploying the GRMPY system on the Area 16 events.

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Table 1. Station Locations for Test U16A_01

Station	North NTS (ft)	East NTS (ft)	SGZ Dist (ft)	Azimuth (deg)	Link to Unit
1	823499.6	637506.4	12	200	cable
2	823570.1	637591.6	100	54	cable
3	823553.6	637727.6	221	79	cable
4	823309.7	637557.3	207	167	cable
5	823399.6	637324.7	217	239	cable
6	823642.2	637379.9	185	315	cable
7	823160.1	637598.3	362	166	cable
8	823781.6	637328.4	326	313	radio

Table 2. Station Locations for Test U16A_02

Station	North NTS (ft)	East NTS (ft)	SGZ Dist (ft)	Azimuth (deg)	Link to Unit
1	823560.1	637591.6	34	135	cable
2	823499.6	637506.4	112	238	cable
3	823553.6	637727.6	127	97	cable
4	823309.7	637557.3	263	190	cable
5	823399.6	637324.7	392	225	cable
6	823642.2	637379.9	233	288	cable
7	823160.1	637598.3	408	180	cable
8	823781.6	637328.4	346	308	radio

Figure 1 - Location of the GRMPY stations (denoted by *) around surface ground zero (SGZ, denoted by o) for test U16A_01. The two circles have radii of 65m and 105m about SGZ (as indicated by the numbers in the upper right hand corner). Station 1 is the one closest to SGZ, Station 2 is about 30 degrees NE of SGZ, Stations 3-6 are on the 65m circle, moving clockwise beginning with the ENE station, Station 7 is the southernmost station, and Station 8 is the northernmost station.

Figure 2 - Location of the GRMPY stations (denoted by *) around surface ground zero (SGZ, denoted by o) for test U16A_02. The two circles have radii of 35m and 100m about SGZ (as indicated by the numbers in the upper right hand corner). Station 1 is the one closest to SGZ, Station 2 is about 35m SW of SGZ, and Stations 3-8 have the same locations as in Figure 1.

U16A_01 Calibration Test GM1 3.8m S20W

Figure 3a - One of the vertical acceleration records for the SGZ station on the calibration test for the first event in Area 16. Note the bit noise during the last half of the record. However, there is an obvious signal during the first 300 msec of the record.

Figure 3b - One of the vertical acceleration records for the SGZ station on the calibration test for the first event in Area 16.

U16A_01 Calibration Test GM1 3.8m S20W

Figure 3c - One of the vertical acceleration records for the SGZ station on the calibration test for the first event in Area 16.

Figure 4a - Radial acceleration record for Station 2 for the calibration test of the first event in Area 16.

U16A_01 Calibration Test GM2 30m N54E

Figure 4b - Transverse acceleration record for Station 2 for the calibration test of the first event in Area 16.

U16A_01 Calibration Test GM2 30m N54E

Figure 4c - Vertical acceleration record for Station 2 for the calibration test of the first event in Area 16.

U16A_01 Calibration Test GM3 67m N79E

Figure 5a - Radial acceleration record for Station 3 for the calibration test of the first event in Area 16.

Figure 5b - Transverse acceleration record for Station 3 for the calibration test of the first event in Area 16.

U16A_01 Calibration Test GM3 67m N79E

Figure 5c - Vertical acceleration record for Station 3 on the calibration test for the first event in Area 16.

Figure 6a - Radial acceleration record for Station 5 on the calibration test for the first event in Area 16.

Figure 6b - Transverse acceleration record for Station 5 on the calibration test for the first event in Area 16.

U16A_01 Calibration Test GM5 66m S59W

Figure 6c - Vertical acceleration record for Station 5 on the calibration test for the first event in Area 16.

Figure 7a - Radial acceleration record for Station 6 on the calibration test for the first event in Area 16.

Figure 7b - Transverse acceleration record for Station 6 on the calibration test for the first event in Area 16.

Figure 7c - Vertical acceleration record for Station 6 on the calibration test for the first event in Area 16.

Figure 8a - One of the three vertical accelerometer records for Station 1 on the first test in Area 16.

Figure 8b - One of the three vertical accelerometer records for Station 1 on the first test in Area 16.

Figure 8c - One of the three vertical accelerometer records for Station 1 on the first test in Area 16.

U16A_01 GM2 GMA_XA 30m N45E

Figure 9a - The radial acceleration record for Station 2 on the first test in Area 16.

Figure 9b - The transverse acceleration record for Station 2 on the first test in Area 16.

U16A_01 GM2 GMA_ZA 30m N45E

Figure 9c - The vertical acceleration record for Station 2 on the first test in Area 16.

Figure 10a - The radial acceleration record for Station 3 on the first test in Area 16.

U16A_01 GM3 GMA_YA 67m N79E

Figure 10b - The transverse acceleration record for Station 3 on the first test in Area 16.

U16A_01 GM3 GMA_ZA 67m N79E

Figure 10c - The vertical acceleration record for Station 3 on the first test in Area 16.

U16A_01 GM4 GMA_XA 66m S59W

Figure 11a - The radial acceleration record for Station 4 on the first test in Area 16.

Figure 11b - The transverse acceleration record for Station 4 on the first test in Area 16.

U16A_01 GM4 GMA_ZA 66m S59W

Figure 11c - The vertical acceleration record for Station 4 on the first test in Area 16.

Figure 12a - The radial acceleration record for Station 5 on the first test in Area 16.

U16A_01 GM5 GMA_YA 66m S59W

Figure 12b - The transverse acceleration record for Station 5 on the first test in Area 16.

Figure 12c - The vertical acceleration record for Station 5 on the first test in Area 16.

U16A_01 GM6 GMA_XA 56m N45W

Figure 13a - The radial acceleration record for Station 6 on the first test in Area 16.

U16A_01 GM6 GMA_YA 56m N45W

Figure 13b - The transverse acceleration record for Station 6 on the first test in Area 16.

U16A_01 GM6 GMA_ZA 56m N45W

Figure 13c - The vertical acceleration record for Station 6 on the first test in Area 16.

U16A_01 GM7 GMA_XA 110m S14E

Figure 14a - The radial acceleration record for Station 7 on the first test in Area 16.

U16A_01 GM7 GMA_YA 110m S14E

Figure 14b - The transverse acceleration record for Station 7 on the first test in Area 16.

Figure 14c - The vertical acceleration record for Station 7 on the first test in Area 16.

U16A_01 GM8 GMA_XA 99m N47W

Figure 15a - The radial acceleration record for Station 8 on the first test in Area 16.

U16A_01 GM8 GMA_YA 99m N47W

Figure 15b - The transverse acceleration record for Station 8 on the first test in Area 16.

U16A_01 GM8 GMA_ZA 99m N47W

Figure 15c - The vertical acceleration record for Station 8 on the first test in Area 16.

Figure 16 - Peak vertical velocity versus horizontal distance from SGZ for test U16A_01. Note the asymmetry in the velocity as a function of azimuth as given by the four values at ranges between about 55 and 70m.

U16A_02 Calibration Test GM1 10m S45E

Figure 17a - One of the vertical acceleration records for the SGZ station on the calibration shot for the second event in Area 16.

Figure 17b - One of the vertical acceleration records for the SGZ station on the calibration shot for the second test in Area 16.

Figure 17c - One of the vertical acceleration records for the SGZ station on the calibration shot for the second event in Area 16.

U16A_02 Calibration Test GM2 34m S58W

Figure 18a - Radial acceleration for Station 2 for the calibration test of the second event in Area 16.

U16A_02 Calibration Test GM2 34m S58W

Figure 18b - Transverse acceleration for Station 2 for the calibration test of the second event in Area 16.

Figure 18c - Vertical acceleration record for Station 2 for the calibration test of the second event in Area 16.

Figure 19a - Radial acceleration record for Station 3 on the calibration test of the second event in Area 16.

U16A_02 Calibration Test GM3 39m S83E

Figure 19b - Transverse acceleration record for Station 3 on the calibration test of the second event in Area 16.

U16A_02 Calibration Test GM3 39M S83E

Figure 19c - Vertical acceleration record for Station 3 on the calibration test of the second event in Area 16.

Figure 20a - Radial acceleration record for Station 5 on the calibration test of the second event in Area 16.

U16A_02 Calibration Test GM5 120m S45W

Figure 20b - Transverse acceleration record for Station 5 on the calibration test of the second event in Area 16.

Figure 20c - Vertical acceleration record for Station 5 on the calibration test of the second event in Area 16.

Figure 21a - Radial acceleration record for Station 6 on the calibration test of the second event in Area 16.

Figure 21b - Transverse acceleration record for Station 6 on the calibration test of the second event in Area 16.

Figure 21c - Vertical acceleration record for Station 6 on the calibration test of the second event in Area 16.

Figure 22a - One vertical acceleration record for the SGZ station on the second test in Area 16.

U16A_02 GM1 GMB_ZA 10.4m S45E

Figure 22b - A vertical acceleration record for the SGZ station on the second event in Area 16.

Figure 22c - A vertical acceleration record for the SGZ station on the second event in Area 16.

Figure 23 - The longer time scale vertical acceleration record for one of the vertical accelerometers in the SGZ station for the second test in Area 16. There is clear evidence of some signals after the original ground motion has stopped. The clearest signals are at about 3.8 and 4.2 seconds, but others are present as well.

Figure 24 - The longer time scale transverse acceleration record for Station 2 for the second test in Area 16. Like the data for Station 1, this record shows signals after the original ground motion has died away. Note particularly the signals at about 3.8 and 4.4 seconds.

Figure 25 - The entire transverse acceleration record for Station 3 for the second test in Area 16. There is some evidence of a signal at about 3.8 seconds.

Figure 26a - The radial acceleration record for Station 2 on the second test in Area 16.

Figure 26b - The transverse acceleration record for Station 2 on the second test in Area 16.

U16A_02 GM2 GMA_ZA 34m S58W

Figure 26c - The vertical acceleration record for Station 2 on the second test in Area 16.

Figure 27a - The radial acceleration record for Station 3 on the second test in Area 16.

U16A_02 GM3 GMA_YA 39m S83E

Figure 27b - The transverse acceleration record for Station 3 on the second test in Area 16.

U16A_02 GM3 GMA_ZA 39m S83E

Figure 27c - The vertical acceleration record for Station 3 on the second test in Area 16.

Figure 28a - The radial acceleration record for Station 4 on the second test in Area 16.

U16A_02 GM4 GMA_YA 80m S10W

Figure 28b - The transverse acceleration record for Station 4 on the second test in Area 16.

U16A_02 GM4 GMA_ZA 80m S10W

Figure 28c - The vertical acceleration record for Station 4 on the second test in Area 16.

U16A_02 GM5 GMA_XA 120m S45W

Figure 29a - The radial acceleration record for Station 5 on the second test in Area 16.

Figure 29b - The transverse acceleration record for Station 5 on the second test in Area 16.

U16A_02 GM5 GMA_ZA 120m S45W

Figure 29c - The vertical acceleration record for Station 5 on the second test in Area 16.

U16A_02 GM6 GMA_XA 71m N72W

Figure 30a - The radial acceleration record for Station 6 on the second test in Area 16.

U16A_02 GM6 GMA_YA 71m N72W

Figure 30b - The transverse acceleration record for Station 6 on the second test in Area 16.

Figure 30c - The vertical acceleration record for Station 6 on the second test in Area 16.

Figure 31a - The radial acceleration record for Station 7 on the second test in Area 16.

Figure 31b - The transverse acceleration record for Station 7 on the second test in Area 16.

Figure 31c - The vertical acceleration record for Station 7 on the second test in Area 16.

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Figure 32a - The radial acceleration record for Station 8 on the second test in Area 16.

Figure 32b - The transverse acceleration record for Station 8 on the second test in Area 16.

Figure 32c - The vertical acceleration record for Station 8 on the second test in Area 16.

Figure 33 - Peak vertical velocity versus horizontal distance from SGZ for the second test in Area 16. We note that, while less striking than for the first test, there is still an asymmetry of the peak vertical velocity with respect to azimuth.

Figure 34 - Plot of the peak vertical acceleration in the first pulse at SGZ versus the SGZ peak vertical velocity. The circles are nuclear weapons tests at the Nevada Test Site. The asterisks are the two high explosive events in Area 16.

Figure 35 - Ratio of the SGZ first pulse peak vertical acceleration to peak vertical velocity versus the horizontal distance from SGZ at which the peak vertical velocity has dropped by a factor of two. The circles represent individual NTS nuclear weapons tests, and the asterisks denote the two events in Area 16.

Appendix A: GRMPY Checklists

We include the GRMPY checklists because they have been found to be effective in allowing us to set up the system even after it has not been used for a long period. There are seven separate checklists plus a cover form for filling in location information about the stations. The seven checklists cover the full range of activities required to set up the system: 1) setting up the GRMPY control center, including connecting cables there, 2) executing all tasks required to make sure the individual stations are working properly, first in the Control Center and then at the individual station locations, 3) setting the configuration parameters in the database to indicate how communication and data collection will be done, 4) synchronizing the clocks in the individual units and relating them to GPS time, 5) performing dry runs, 6) executing the steps to arm the system for the event, and 7) performing the postevent tasks.

Checklist for GRMPY Deployments

A GRMPY deployment is not a complicated process, but a seemingly innocuous mistake can produce a failure to collect data. To avoid this a series of checklists have been prepared: system setup, station checkout, clock setting, dry runs, system configuration, final arming, and postshot activities. The reason for producing so many is that some of these may have to be repeated several times. If so, all should be a part of the final record. Retain all checklist information and give to the project leader at the end of the event.

Record the following information about the event.

Hole: _____

SGZ NTS Coordinates (ft): _____ N, _____ E

<u>GM</u>	<u>NTS (N)</u>	<u>NTS (E)</u>	<u>Dist from SGZ(ft)</u>	<u>Azimuth</u>
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—

Robert G. Deupree
September 16, 1991

VERSION 2.9

VERSION HISTORY

Version 1.0	Original	September 16, 1991
Version 2.0	Add Radio Check	November 1992
Version 2.1	Add MicroVax shut-down	August 12, 1993
Version 2.2	Add Radio Freq	August 17, 1993
Version 2.3	Add indiv GM to Sta setup and setting Config	April 25, 1995
Version 2.4	Add Radio Config Option in setup	May 1, 1995

Version 2.5	Add Display On/Off information	May 3, 1995
Version 2.6	Add display and time tag to postshot	May 4, 1995
Version 2.7	More detail in final checklist	May 4, 1995
Version 2.8	Check FIDU light and files in post-shot	May 8, 1995
Version 2.9	Change k to tr in radio GRMPY comm	June 5, 1995

GRMPY Checklist (Setup)

- [] Arrange to have generators and fuel tank moved on-site and cribbed if necessary.
- [] Move GRMPY van to specified location.
- [] Shock mount GRMPY van (see memo from Don Macy for procedure).
- [] Connect cable ends into GRMPY van (with signal box off). The color code is (for four pair cable):

<u>GRMPY Van</u>	<u>Cable</u>	<u>GRMPY Lid</u>	<u>Function</u>
Orange	Orange	Yellow	+Rx
Yellow	Orange's white	Orange	-Rx
Brown	Brown	Black	-Power
Red	Brown's white	Red	+Power
Green	Green	Blue	+Tx
Blue	Green's white	Green	-Tx
Gray	Blue	Brown	-FIDU
Violet	Blue's white	Violet	+FIDU

- [] When generators arrive, connect generator power cables and connect fuel cables to fuel tank. Start up one generator (in RUN mode) and put the other on standby (AUTO mode). Make sure that the standby generator cable goes to the generator that you want to be the standby generator on the shot. Run each generator off either internal fuel tank (MAIN TANK) or the external fuel tank (AUXILIARY TANK).
- [] Test that standby generator starts when primary generator is turned off. Make sure that UPS keeps MicroVax on when first generator is turned off but before the second generator has started.
- [] Check to make sure that the rings on the shock absorbers of the GRMPY van shock mounting system are all the way down.

GRMPY Checklist (Station Setup)

- [] Make sure that cable connected to GM10 is accessible at the MicroVax terminal and connect it to a station lid.
- [] Once the MicroVax has completed booting itself (initiated by turning both the MicroVax and the terminal on), hit the return key and type GRMPY (case insensitive) when requested for a Username. Then type GCOMMAND. You will be requested for what hole you want - respond with TEST10. The main menu will show up. Select the station selection option (#3) and select station 10 from the choices of the next menu. When the original menu returns, select station communication mode (#5) and attempt to communicate with the station. Troubleshoot until successful.
- [] For each unit, enter the accelerometer identifiers, calibration constants, and the GM location where the unit will be:

[illegible]

GRMPY Checklist (Station Setup)

2

- [] Once a unit is communicating, type EXIT and select station status from the original menu (#6). From the next menu, select the acceleration levels in g's (#1) and verify that all three change when you move the station lid around. Type E to exit this menu. If one or more of the accelerometer values fails to change, then either the unit is not taking the data or the accelerometers are not properly connected. Correct this if it occurs.

```
GM1[ ] GM2[ ] GM3[ ] GM4[ ] GM5[ ] GM6[ ] GM7[ ]
GM8[ ] GM9[ ] GM10[ ] GM11[ ] GM12[ ]
```

- [] Return to communication mode, attach the unit to batteries and connect the lid to the base while maintaining communications.

```
GM1[ ] GM2[ ] GM3[ ] GM4[ ] GM5[ ] GM6[ ] GM7[ ]
GM8[ ] GM9[ ] GM10[ ] GM11[ ] GM12[ ]
```

- [] Use the Y command to identify each unit and its three accelerometers. The preferred format is:

Ynm abcd efgh ijkl

where nm is the unit serial number, and abcd, efgh, and ijkl are the x, y, and z accelerometer identifiers.

```
GM1[ ] GM2[ ] GM3[ ] GM4[ ] GM5[ ] GM6[ ] GM7[ ]
GM8[ ] GM9[ ] GM10[ ] GM11[ ] GM12[ ]
```

- [] From the main menu, pick the change hole name selection (#1 of main menu) and enter the name of the hole for the event. Respond y when queried if you wish to create a new directory, and enter the number of stations deployed on the event when asked. Use this hole in the future when entering GCOMMAND.

- [] For each station that will be connected by radio, enter the main menu of GCOMMAND and pick that station (entry #3 of main menu). Then pick entry #4 of the main menu to enter station configuration mode. You can check the current station configuration parameters by entering #4. In any event, you want to modify the configuration parameters (#5 of this menu), and then choose select station type (#9) of the new menu. This will ask you if you want standard (hardwire=default) or radio. Choose appropriately. Exit back to the first menu under configuration and choose #7 to write the current configuration parameters to a data file. Failure to do this step will mean that you have to redo this task every time you exit and reenter GCOMMAND.

```
GM1[ ] GM2[ ] GM3[ ] GM4[ ] GM5[ ] GM6[ ] GM7[ ]
GM8[ ] GM9[ ] GM10[ ] GM11[ ] GM12[ ]
```

GRMPY Checklist (Station Setup)

3

- [] Take each unit to its specified location and establish communication. Check the patch panel in the rack in the GRMPY van to see that the appropriate computer port (CPU on patch panel) is connected to either the appropriate signal box (MUX) channel (usually the same number as the computer port) or the appropriate radio line. If the station communication is through a radio link, check which radio unit in the field (A-F) is the appropriate one for the station, and match the port on the patch panel (A=1, B=2, etc.). If the communication is by radio, use the Cushman Communication Monitor to see that the transmissions are taking place. You must set the appropriate frequency on the communication monitor. These frequencies are:

A	164.84375 MHz
B	165.80625
C	166.41875
D	166.65625
E	167.19375
F	171.21875

GM1[]	GM2[]	GM3[]	GM4[]	GM5[]	GM6[]	GM7[]
GM8[]	GM9[]	GM10[]	GM11[]	GM12[]		

- [] If transmission is not taking place, perform the following steps:

1) Exit the GCOMMAND program and type CONVERSE
xxxx:, where xxxx: is the MicroVax port
identifier (e.g., txa0:).

2) Type Ctrl C (i.e., simultaneously holding
down the control and the C buttons on the
keyboard) three times in succession.

3) Type si n<cr>. This should return some
information from the modem. If this does not
happen, repeat steps 2 and 3 until it does.

4) Set up the modem by typing the following
commands (case insensitive):

```
my base
8 y
f n
br n
no y
ne n
datam y
ch 0
cm 1
ad n
```

```

cra n
conm t
au n
lf y
si y

```

5) Type k<cr>. This returns the modem from command mode to transparent mode. If things still do not work, enter command mode again (steps 2 and 3) and type connect x ,where x is the identifier for the desired field radio (A-F). If this does not establish connection, use the commands in the modem manual to try to find the cause. If successful, exit command mode by typing k<cr>. Exit the CONVERSE program by hitting the break key and reenter GCOMMAND.

```

GM1[ ]  GM2[ ]  GM3[ ]  GM4[ ]  GM5[ ]  GM6[ ]  GM7[ ]
GM8[ ]  GM9[ ]  GM10[ ]  GM11[ ]  GM12[ ]

```

- [] Emplace and bury each station (making sure it is level and the arrow is pointing toward surface ground zero) while maintaining communication.

```

GM1[ ]  GM2[ ]  GM3[ ]  GM4[ ]  GM5[ ]  GM6[ ]  GM7[ ]
GM8[ ]  GM9[ ]  GM10[ ]  GM11[ ]  GM12[ ]

```

- [] Once the stations have been buried, get into station status mode (#6 of main menu) and examine the three g levels. Select the largest g level in magnitude and enter the absolute value and the axis for which it occurs in the table below. Add one g to this value, multiply this by the calibration constant for that accelerometer, and then multiply that result by 131.04. Write the decimal result in the table and convert it into hexadecimal. Record this result.

GM	Axis	Value(g)	+1g	Calib	Result	x131.04	Hex
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—

- [] Return to station communication mode, and use the O command with a four digit hexadecimal number to enter the ground motion trigger threshold. Remember that to give the command to one station only in the all station mode, precede the command with the station number. Thus, 50xxxx sends the O command only to the station at GM 5.

GM1[] GM2[] GM3[] GM4[] GM5[] GM6[] GM7[]
GM8[] GM9[] GM10[] GM11[] GM12[]

- [] Once the threshold has been entered for all stations, select the All Stations option using the station option menu (#3 of main menu) and enter station communication mode from the main menu.

- [] Enter the following commands:

Z
W
E
QC
C
B0
O
M2
R0
D

Check to see that the response to the O command is correct for each station. If the response to the R0 command is FFFF for any station, put that unit into sleep mode (Z command) and wake it up (W command) and try R0 again (all before you give the D command). Wait to see that no stations trigger for about five minutes. If a station receives a trigger, resulting in a BANK NUMBER 0 FILLED message on the screen, then the ground motion triggering threshold has been set too low for that station and must be increased. Do so and repeat this step until no triggers are received.

- [] Give the E command to all stations to exit data collection mode and cancel all triggering.
- [] Enter the station status option (#6 of main menu) and check the battery voltages. Adjust the voltage to each station using the front panel of the signal box until the input voltage of the unit is about 6.8 volts (if possible).

GM1[] GM2[] GM3[] GM4[] GM5[] GM6[] GM7[]
GM8[] GM9[] GM10[] GM11[] GM12[]

GRMPY Checklist (Setting Configuration)

- [] Enter GCOMMAND program and for each station in turn enter the configuration mode (#4 of main menu).

```
GM1[ ]   GM2[ ]   GM3[ ]   GM4[ ]   GM5[ ]   GM6[ ]
GM7[ ]   GM8[ ]   GM9[ ]   GM10[ ]  GM11[ ]  GM12[ ]
```

- [] Display current configuration parameters (#4 of configuration menu). In particular, all gains should be unity.

```
GM1[ ]   GM2[ ]   GM3[ ]   GM4[ ]   GM5[ ]   GM6[ ]
GM7[ ]   GM8[ ]   GM9[ ]   GM10[ ]  GM11[ ]  GM12[ ]
```

- [] Select to modify the current configuration (#5 of configuration menu).

```
GM1[ ]   GM2[ ]   GM3[ ]   GM4[ ]   GM5[ ]   GM6[ ]
GM7[ ]   GM8[ ]   GM9[ ]   GM10[ ]  GM11[ ]  GM12[ ]
```

- [] For those stations which you wish to trigger all stations when they receive a ground motion trigger, set accordingly (#6 of the modify configuration menu). It is advisable to do this for only two or three stations at different horizontal ranges from surface ground zero.

```
GM1[ ]   GM2[ ]   GM3[ ]   GM4[ ]   GM5[ ]   GM6[ ]
GM7[ ]   GM8[ ]   GM9[ ]   GM10[ ]  GM11[ ]  GM12[ ]
```

- []- For each station enter the calibration constants (#7 of configuration modification menu) and accelerometer offsets (#8 of configuration modification menu) for each accelerometer.

```
GM1[ ]   GM2[ ]   GM3[ ]   GM4[ ]   GM5[ ]   GM6[ ]
GM7[ ]   GM8[ ]   GM9[ ]   GM10[ ]  GM11[ ]  GM12[ ]
```

- [] For each station for which the communication is by radio, select station type (#9 of configuration menu) and then select Radio (option #2). Standard refers to hardwire communication and is the default.

```
GM1[ ]   GM2[ ]   GM3[ ]   GM4[ ]   GM5[ ]   GM6[ ]
GM7[ ]   GM8[ ]   GM9[ ]   GM10[ ]  GM11[ ]  GM12[ ]
```

- [] For each station return to the main configuration menu, display the current configuration again, and write it to a file (#7 of configuration menu) when you are satisfied with it. This configuration will then be retained for each station even if you terminate GCOMMAND and rerun it.

```
GM1[ ]   GM2[ ]   GM3[ ]   GM4[ ]   GM5[ ]   GM6[ ]
GM7[ ]   GM8[ ]   GM9[ ]   GM10[ ]  GM11[ ]  GM12[ ]
```

GRMPY Checklist (Setting Clocks)

- [] Run the GCOMMAND program, use the select station option (#3 of main menu) to choose all stations and enter communication mode (#5 of main menu).

- [] Give the following commands:

QC
C
Z
W
R0
B0
M5
JF

- [] Hit the FIDU button on the signal box, noting the exact time at which this was done:

Date: _____ Time: _____

This resets the millisecond counters in all units simultaneously.

- [] About ten seconds after hitting the FIDU button, each station should return a "BANK NUMBER 0 FILLED" message to the screen. If this does not happen for a station, that station did not receive the trigger and something is incorrect.
- [] Give the "E" command to exit data collection mode and remove triggering.
- [] Give the "P" command and see that the millisecond count (returned in hexadecimal) is a small number and about the same for all stations (implying that the clocks were all reset).

GRMPY Checklist (Dry Run)

- [] Use the GCOMMAND program options #3 and #5 to get into communication mode with all stations and enter the following commands:

E
Z
W
QC
C
B0
O
M5
R0
D

- [] Check to see that the response for each station to the O command is correct and that the response to the R0 command is not FFFF.
- [] Enter the command AUTOLOAD ON.
- [] At the desired time (preferably during a dry run countdown), hit the FIDU button on the signal box. Each station should respond with TRIGGER BY FIDU and then with BANK NUMBER 0 FILLED. Shortly afterward each station should load data in turn into the Microvax. Loading data takes about 90 seconds per bank per station. You can tell which station is currently loading data by seeing which one has L/a as the last entry on the screen (all others should have D/a as the last entry).
Write the time the FIDU was sent:

Date: _____ Time: _____

- [] When uploading has been completed for all stations, enter the command AUTOLOAD OFF. This must be the next command.
- [] Enter the E command to get out of data collection mode and disable triggers.
- [] For each station in turn, enter the data presentation menu (#7 of main menu) and read the data set (#1 of the presentation menu). The name of the data set should be UPLOAD_BANK0.DAT.
- [] Display header information (#4 of the data presentation menu) and write down the time at which the trigger occurred. Compare this time for all stations with the known elapsed time since the millisecond counters were

Actual Elapsed Time: _____

<u>GM</u>	<u>GRMPY Unit</u>	<u>Elapsed Time</u>
—	—	—
—	—	—
—	—	—
—	—	—
—	—	—
—	—	—
—	—	—
—	—	—
—	—	—
—	—	—
—	—	—

- [] Plot the data for each of the three axes (#6,7,8 of the data presentation menu) in g's and check the noise level of the data.
- [] Determine the data reduction offsets for each station (#2 in data presentation menu). Choose to get the data from the file and pick the current data file. Check that all gains are unity and exit the menu. Write down the offsets when they appear:

<u>GM</u>	<u>X Offset</u>	<u>Y Offset</u>	<u>Z Offset</u>
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—

- [] For any station that did not automatically upload, return to the main menu and perform the following:
- [] Select that station using the station selection option and enter communication mode.
 - [] Type B0.
 - [] Type LOG ON filename, where filename is the name you wish to assign (e.g., DRYRUN.DAT).
 - [] Type nLOAD where n is the GM station number.

- [] Numbers will now start flashing across the screen - these can be made to disappear (and speed up the uploading) by typing DISPLAY OFF.
 - [] When the message Data upload complete appears on the screen, type DISPLAY ON.
 - [] When the data is uploaded (about two minutes), type LOG OFF.
 - [] Repeat the previous steps to obtain offsets and plot data.
- [] Exit GCOMMAND and delete unwanted dry run data files. These are in the directories [GRMPY.FILES.holename.*], where the * refers to the station (STATION01, etc.).

GRMPY Checklist (Final Arming)

- [] Check generators, fuel, UPS, UPS batteries, and signal box to see that all are operating correctly. In particular, make sure the FIDU received light is off (if not, hit the black button near it) and that the power (PWR) and connected (CON) lights are on for the modems in the trailer for the radio GRMPY units. Also set the GPS clock to the time tag screen and then do not touch the clock any more.
- [] Run GCOMMAND program, pick the All Station option in the station selection menu, and enter communication mode.
- [] Enter the following commands and make sure that each station responds appropriately:
 - E
 - Z
 - W
 - QC
 - C
 - B0
 - O
 - M7
 - R0
 - D
- [] Type TRIGGER ON to enable automatic triggering for those stations configured to trigger all stations when they receive a ground motion trigger.
- [] Type AUTOLOAD ON to enable automatic uploading.
- [] Do not exit communication mode.
- [] Turn down the computer console intensity. This is done by hitting the SETUP key and then the down arrow key. When the intensity is low, hit the SETUP key again. The communication mode screen should reappear, but be very dim.
- [] Unplug the keyboard and put it in one of the vehicles to be removed from the area.
- [] Tie down the computer terminal.
- [] Remove all heavy and loose items (chair, toolbox, etc.).
- [] Make sure all remaining items are protected against ground motion. In particular, make sure that all the cabinets are locked.
- [] Close and lock GRMPY van.

GRMPY Checklist (Postshot)

- [] Reconnect the keyboard to the terminal and bring up the screen intensity (using the SETUP and up arrow keys).
- [] If you were expecting a FIDU signal, check to see that the FIDU received light on the signal box panel is lit.
- [] Check the communication mode windows to see that triggers have been received, how many data sets have been uploaded, and current status for each station. Write down anything that is unusual.
- [] Type the command AUTOLOAD OFF.
- [] Enter the E command to disable triggers and see that all stations respond. This may require more than one sending of the E command for the radio stations.
- [] Find out what stations have been uploaded. You can do this without leaving GCOMMAND by picking a single station, getting into data presentation mode, and selecting to load data from a file. Once the files are listed you may exit without uploading a file. Repeat this for each station individually. Obtaining this information may also be done by exiting the GCOMMAND program and then by typing

dir [grmpy.files.holename...]

where holename is the designation of the event. This will cause the files in all the subdirectories to fly by the screen. The screen can be temporarily halted with the no scroll key on the lower left corner of the keyboard. To restart the listing, hit the no scroll key again.

- [] Upload any data not automatically uploaded with the following procedure (reentering GCOMMAND if necessary):
 - [] Exit communication mode and select the appropriate station.
 - [] Reenter communication mode for that station only.
 - [] Type K to find out which of the six memory banks have data in them which have not been uploaded (these will have a 1 in them, the others a 0). Remember that the memory banks run from 0 to 5.
 - [] Type Bx, where x is the memory bank to be uploaded.

- [] Type LOG ON filename, where filename describes both the fact that it is event data and what memory bank (e.g., SHOTB0.DAT).
- [] Type nLOAD, where n is the GM number.
- [] Once the stream of numbers appears, you may wish to speed up the process and get rid of the numbers by typing DISPLAY OFF.
- [] When the console indicates that data uploading has been completed, type DISPLAY ON.
- [] Type LOG OFF when the data from this memory bank has been uploaded.
- [] Repeat this procedure for other memory banks and stations.
- [] After all data is uploaded, place a TK50 tape into the TK50 tape drive of the MicroVax. Stick the tape in and flip the switch to lock the tape in place.
- [] When the green light to the left of the tape drive stops blinking, push the red button on the right of the tape drive to the in position. Wait for the green light to stop blinking.
- [] Exit the GCOMMAND program and do each of the following at the \$ prompt.
- [] Type INIT MUA0: label, where label is the hole name.
- [] Type MOUNT/FOREIGN MUA0: .
- [] Type SET DEFAULT [GRMPY.FILES.holename], where holename is the hole in which the event is being conducted.
- [] Type BACKUP/LIST [...]*. *;* MUA0:holename.BCK. This will list the files being copied to tape. Verify that this is what you expect and want.
- [] Type DISMOUNT MUA0:. When the green light stops blinking, push the red button so that it goes to the out position. When the green light stops blinking, raise the handle and remove the tape.
- [] Put the tape into read only by shifting the tab on the

tape.

- [] This tape has the shot data on it. Don't lose it! Write the labeling information on a label and slide it into the tape label panel.
- [] Use the PREV and NEXT buttons on the GPS clock front panel to get to the time tag screen. There should be up to three time tag entries. Write these three down, beginning with the top one on the screen:

Time Tag Top: _____
 Time Tag Middle: _____
 Time Tag Bottom: _____

- [] You now have all the data uploaded into the MicroVax and written onto tape for transfer to Los Alamos. You will probably want to plot the data (if not already done). In any event, record the following information from the header of each bank of data:

<u>GM</u>	<u>Bank</u>	<u>Time</u>	<u>Trigger type</u>	<u>v peak</u>
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Proceed with the post shot cleanup, station retrieval, etc. One thing you should do is

- [] Measure the displacement of the rings on the shock absorbers on the GRMPY van and record:

Left Front: _____ Right Front: _____
 Left Rear: _____ Right Rear: _____

- [] Sign off the MicroVax by logging out as GRMPY, logging in as SYSTEM, and then type the following:
 set def [syxexe]
 @shutdown

Hit the carriage return in response to each question asked during the shutdown process. When shutdown has been completed, turn off the console first and then the MicroVax. The console switch is on the back of the VT100 on the left-hand side.