US Army Corps of Engineers

EM61-MK2 NOISE AND PEAK AMPLITUDE EVALUATION

U.S. Army Engineering and Support Center, Huntsville
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Close hold the information in this appendix. Only Government personnel are to have access to the locations of Grid 1 unknowns and all Grid 4 seed items.

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Acronyms

BRAC	Base Realignment and Closure
CEHNC	Corps of Engineers Huntsville Center
cm	Centimeter
CX	Center of Expertise
DERP-FUDS	Defense Environmental Restoration Program for Formerly Used Defense Sites
DGM	Digital geophysical mapping
DGPS	Differential global positioning system
DQOs	Data Quality Objectives
EM	Electro Magnetic
ft	Foot
FUDS-OE-IT	Formerly Used Defense Sites- Ordnance and Explosive-Innovative Technology
GFE	Government Furnished Equipment
GPS	Global positioning system
GX	Geosoft Executable
IR	Installation Restoration
m	Meter
mm	Millimeter
ms	Millisecond
mV	Millivolt
OE	Ordnance and Explosive
RF	Radio frequency
RTK DGPS	Real-time kinematic differential global positioning system
SNR	Signal to Noise Ratio
SFO	Service for Others
QC/QA	Quality Control/Quality Assurance
USAESCH	U.S. Army Engineering and Support Center Huntsville
UTM	Universal Transverse Mercator
UXO	Unexploded ordnance

1.0 INTRODUCTION

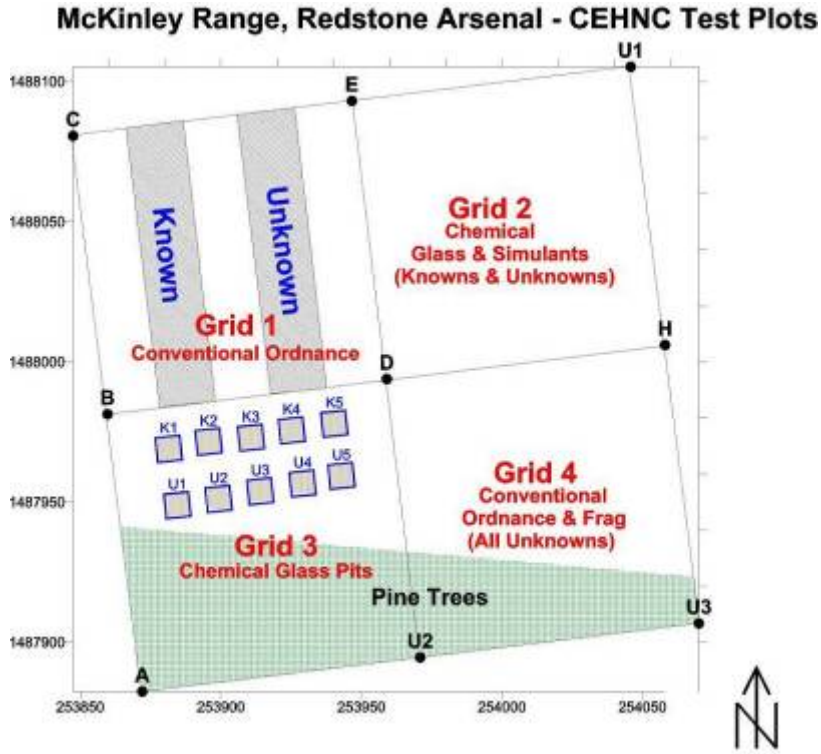
1.1 Background

The U.S. Army Corps of Engineers, Engineering and Support Center, Huntsville (CEHNC) is the Mandatory Center of Expertise (CX) for the Ordnance and Explosive program. The mission is to eliminate or reduce the imminent danger to the public posed by abandoned OE at current or formerly used defense sites through education, policy, performance and quality assurance. As the CX we are responsible for OE activities in support of Defense Environmental Restoration Program for Formerly Used Defense Sites (DERP - FUDS), Installation Restoration (IR), Base Realignment and Closure (BRAC), and Service for Others (SFO) programs.

Digital geophysical mapping is a primary method used to locate unexploded ordnance (UXO). Effectiveness is determined by a quality reproducible systemized approach using accurate navigation, clean digital geophysical data without operator induced anomalies, thorough data analysis and anomaly discrimination, accurate dig sheets, and precise anomaly reacquisition and field marking.

This report provides the results of a study to determine the effects of sensor speed and stability on the noise levels and anomaly characteristics of measured EM data. The signal response characteristics for various acquisition speeds and platform configurations were quantified by measuring sensor responses over the USAESCH McKinley Test Area.

Figure 1-1: McKinley Range Test Plots



1.2 Objectives

The objectives of the work were:

1. Determine the differences in background noise levels in EM61-MK2 measurements when deployed at different speeds and using different platform configurations (wheeled versus skids versus tub)

2. Determine the differences in peak EM61-MK2 anomaly responses when collected at different speeds and using different platform configurations.

3. Define one or more suitable approaches to quantifying measured noise levels for the purpose of comparing the data sets collected as part of this work and for calculating signal to noise ratio (SNR).

2.0 EQUIPMENT AND SURVEY METHODOLOGY

2.1 The following equipment was used for this field effort:

- Two complete, 1m X 0.5m coil, EM61-MK2 units with synchronization option
- One NovaTel RTK DGPS
- One Honda ATV and one pick-up truck, each equipped with a tow-hitch and interchangeable tow-ball
- One non-metallic (plastic) tow platform “tub” with 15 foot tow bar
- One all-wood platform mounted on two wooden skids

3.0 2.2 The EM61-MK2 deployment platforms described in Table 2-1 below were evaluated at the USAESCH Ordnance and Geophysical Test Grid Site located on McKinley Range (see Appendix A for pictures). Grid 1, measuring 100’ by 100’, and Grid 4, (open portion) measuring 100’ by 55’, at the McKinley Range QA/QC test area were evaluated. Grid 4 was not surveyed for all platforms at all planned speeds due to the rough terrain conditions in this grid at the time of these surveys.

Table 2-1: EM61-MK2 Deployment Platforms Evaluated

Survey Speed	**Man-portable, single coil, wheeled**	**Towed, single coil, wheeled**	**Towed, dual coil, wheels, sturdy frame**	**Towed, dual coil, wheels, loosened frame**	**Towed, dual coil, skids, sturdy frame**	**Towed, dual coil, in tub, sturdy frame**
Slow (~1.5 mph)	√					
Normal (~3 mph)	√	√	√		√	√
Fast (~4.5 mph)		√ *	√*	√*	√*	√
Very fast (~6 mph)			√*		√*	√

* Grid 1 only

2.3 Data was acquired for each platform and survey speed indicated in Table 2-1 according to the following methodology. We used a time-based technique to trigger instrument measurements at a rate of no less than 8 measurements per second for each instrument, collected along parallel lines spaced 2.5 feet, or less, apart. RTK DGPS readings were recorded at 1 per second. This resulted in 22 datasets. Color grid maps of each dataset are included in Appendix B.

3.0 DATA QUALITY OBJECTIVES / QUALITY CONTROL

The following are the minimum data quality objectives (DQOs) for the data acquisition and the data processing processes:

- *Positioning of the final processed data is to be accurate to 30cm or better.* This DQO was met as can be seen in the results of the navigation cross tests, and the locations of the survey nails in Grid 1.

- *Repeatability of observations for each platform and each test mode is to be assessed.* The data was shown to be repeatable by analyzing repeated portions of Grid 1 for each platform evaluated.

- *All channels of EM61-MK2 data shall be leveled to a mean background level that is within ±2mV of zero millivolts*. This metric was met for all platforms and speeds except for the tub data. This data has a higher background level due to the sensors being much closer to the ground.

- *Equipment functionality checks shall include the following standard tests for each platform evaluated: warm-up period of at least 1 minute, cable shake/cable connection verification (to be conducted concurrent with static background test), static background monitoring for a minimum of 30 seconds, static instrument response (spike test) for a minimum 10 seconds. Each of these tests shall be performed pre- and post-survey, and each time a system is powered on.* These tests were performed with acceptable results.

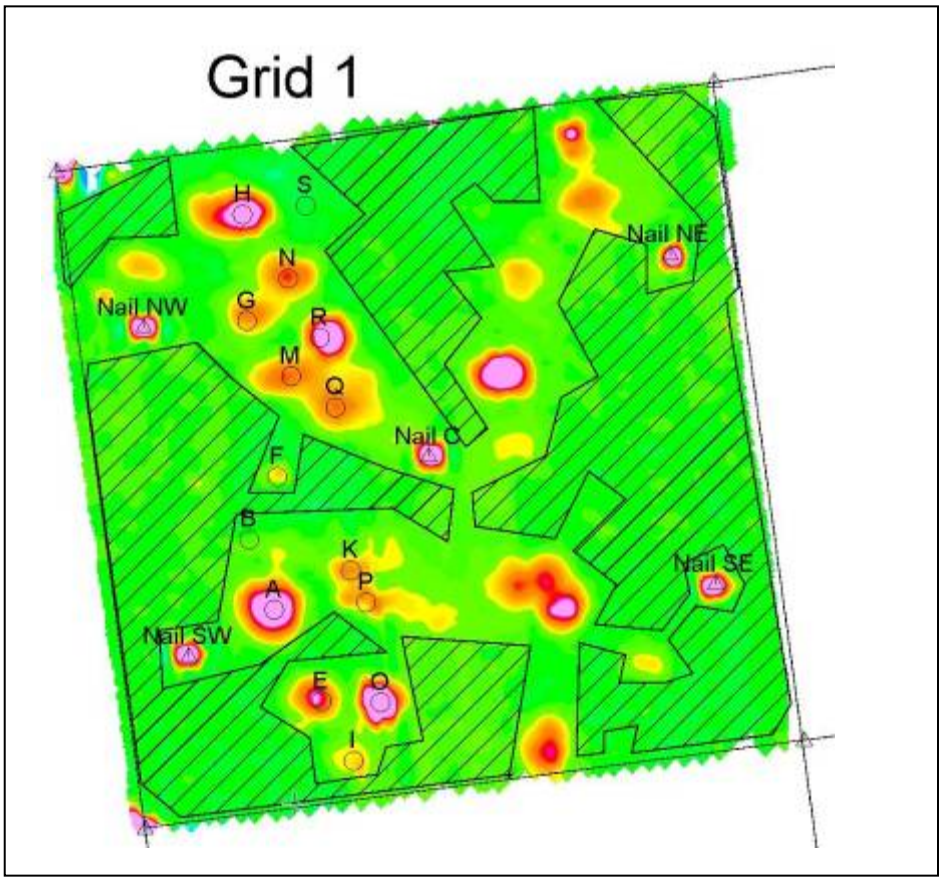
- *Minor occurrences of data gaps shall not exceed 0.5 feet in across-line separations (i.e. line spacing shall not exceed 3.0 feet) and shall not total more than 25 square feet of un-surveyed area (based on a 2.5-foot line spacing) for each dataset in each grid*. This DQO was revised to meet the needs of this project in the following manner: Minor occurrences of data gaps shall not exceed 0.5 feet in across-line separations over those anomalies used to calculate peak response characteristics and/or signal to noise ratios. This revised DQO was achieved.

4.0 DATA PROCESSING AND ANALYSIS

All data was processed and corrected for instrument drift, latency and offset from navigation antenna (when applicable) using Geosoft Oasis Montaj software. Once this initial processing was complete, the background noise and target responses were analyzed. For the analyses of target responses, a sub-set of thirteen seeded items from Grid 1 was selected, upon which the analyses were performed. These seed items were selected on the basis that their above-background measurements could easily be defined, that all 13 were detected in each dataset, and that they represent a group of items having a wide range of characteristics: the items varied from small sub-munitions to large projectiles, having burial depths ranging from between 0.3m to more than 2m below ground surface, and having peak anomaly responses ranging from several tens of millivolts above background to over a thousand millivolts above background. These thirteen seeded items were also selected to include seven seeded items that are buried in the known portion of Grid 1, whose burial characteristics can be released to the general public.

4.1 <u>Background Noise</u>- An analysis was done of the changes in noise with changing speed and platform stability. The first step was to decide how to calculate the statistics. If statistics are calculated on the entire dataset, then the number and size of anomalies dominate the values. We were interested in the background noise, so one option was to clip all values above a threshold number determined to be background. This proved to be problematic because the values are highly variable depending on the threshold selected, and are also dependent on the number of anomalies. We chose to use background datasets, which we created by masking out target response areas (see Figure4-1 below).

Figure 4-1: Mask for Background Noise Statistics (Data from hatched areas was saved into subset background databases)



The resulting background statistics for the sum channel (sum of all time gate channels) and time gate 2 channel are presented in Tables 4-1 and 4-2 below. Additional tables for all data channels are presented in Appendix C. Standard deviations of the background datasets were used as a measure of noise. As expected, the standard deviation of the background data increased as platform speed increased. This finding is illustrated in Figures 4-2 and 4-3, which summarize the calculated standard deviations of the datasets as functions of the average speed of the datasets. (The tub and loose wheel responses were not included in these plots to provide for a better display scale. The results for these two platforms are presented in Appendix C). The noise also increased slightly when using a dual coil system versus the single coil. The tub platform showed significantly higher noise levels than all other platforms used for all speeds evaluated; however, this was expected because the coils were located no more than four inches above the ground. The dual wheel loose configuration shows significantly higher noise levels, demonstrating that the stability of the coils with respect to each other contributes greatly to noise levels produced in the data. Some of this movement may also have contributed to a portion of the noise exhibited with the tub assembly. Grid 4 datasets exhibited higher noise levels than the datasets for the same configurations and speeds collected in Grid 1. This was expected because the terrain is much more variable in Grid 4.

Table 4-1: Background Statistics (Sum of all 4 Channels)

Grid_Data_source	Speed (m/s)	Minimum	Maximum	Mean	Median	Mode	StdDev	4th_diff_StD	# points
g1_manPort_slow	0.73	-16.22	16.15	0.01	0.64	0.3	2.14	3.52	4640
g1_manPort_norm	1.57	-18.97	11.57	0.02	0.76	0.44	2.88	4.81	2259
g1_sing_wheel_norm	1.06	-16.33	8.54	-0.14	0.25	0.5	2	3.25	3223
g1_sing_wheel_fast	2.64	-10.53	12.61	-0.61	0.08	-0.17	2.53	3.65	1392
g1_multi_wheel_norm	1.75	-16.61	21.29	-1.72	-1.61	-2.79	3.42	5.89	1979
g1_multi_wheel_fast	2.58	-20.52	22.88	-1.99	-1.53	-2.89	4.1	6.43	1510
g1_multi_wheel_Xfast	3.37	-16.37	18.83	-2.13	-1.7	-0.6	4.62	9.27	1239
g1_multi_wheel_loose	2.17	-25.92	34.1	-0.07	0.34	0.96	8.45	11.92	896
g1_multi_skid_norm	1.48	-19.52	12.13	-2.24	-1.71	-2.7	3.18	4.26	2974
g1_multi_skid_fast	2.07	-15.19	13.62	-2.37	-1.99	-2.89	3.42	6.17	2049
g1_multi_skid_Xfast	3.12	-22.66	12.53	-2.94	-2.13	-3.23	4.66	8.97	1304
g1_multi_tub_norm	1.55	-53.41	68.54	-7.69	-7.68	-11.49	14.09	16.86	2363
g1_multi_tub_fast	2.3	-48.6	40.77	-9.83	-9.5	-8.57	11.79	16.83	2012
g1_multi_tub_Xfast	3.07	-51.21	215.03	-10.38	-6.84	-9.61	14.3	55.99	1750
g4_manPort_slow	0.63	-10.27	12.67	0.09	0.24	0	2.12	4.03	1763
g4_manPort_norm	1.58	-10.84	8.02	-1.39	-1.02	-0.04	2.64	5.74	685
g4_sing_wheel_norm	1.48	-8.34	11.97	-1.73	-1.14	-0.09	2.77	4.2	745
g4_multi_wheel_norm	1.56	-22.09	27.27	-1.79	-1.53	-4.1	4.83	7.8	681
g4_multi_skid_norm	1.54	-16.76	9.89	-4.19	-3.44	-3.16	4.09	8.65	805
g4_multi_tub_norm	1.54	-39.6	36.12	-0.74	1.42	-0.95	12.71	16.77	820
g4_multi_tub_fast	2.02	-78.55	27.07	-19.98	-19.14	-24.64	21.21	25.92	643
g4_multi_tub_Xfast	2.27	-78.98	23.55	-23.86	-21.31	-19.17	20.59	30.4	576

Table 4-2: Background Statistics (Channel 2)

Grid_Data_source	speed(m/s)	Minimum	Maximum	Mean	Median	Mode	StdDev	4th_diff_StD	points
g1_manPort_slow	0.73	-6.41	5.59	-0.36	-0.16	-0.29	0.89	1.18	4640
g1_manPort_norm	1.57	-6.4	3.76	0.04	0.16	0.06	1.06	2.19	2259
g1_sing_wheel_norm	1.06	-3.71	4.85	-0.27	-0.14	-0.05	0.71	1.47	3223
g1_sing_wheel_fast	2.64	-5.11	5.36	-0.53	-0.31	-0.42	0.97	1.51	1392
g1_multi_wheel_norm	1.75	-8.97	10.24	-0.2	-0.16	-0.36	1.45	2.49	1979
g1_multi_wheel_fast	2.58	-7.16	6.74	-0.23	0.08	-0.06	1.56	2.99	1510
g1_multi_wheel_Xfast	3.37	-7.82	6.4	0.03	0.18	0.03	1.67	3.46	1239
g1_multi_wheel_loose	2.17	-7.39	10.51	0.1	0.44	1	2.31	3.77	896
g1_multi_skid_norm	1.48	-4.12	4.34	-0.23	-0.24	-0.15	1.14	1.92	2974
g1_multi_skid_fast	2.07	-7.64	9.15	-0.11	0.05	-0.12	1.69	3.69	2049
g1_multi_skid_Xfast	3.12	-7.92	4.96	-0.07	0.13	0.26	1.63	3.41	1304
g1_multi_tub_norm	1.55	-11.2	20.26	-0.54	-0.71	-1.04	4.04	5.3	2363
g1_multi_tub_fast	2.3	-12.77	15.73	-0.69	-0.9	-1.19	3.82	5.64	2012
g1_multi_tub_Xfast	3.07	-12.91	38.87	0.17	0.04	0.58	4.45	10.01	1750
g4_manPort_slow	0.63	-3.14	3.87	-0.01	0.07	0.14	0.65	1.28	1763
g4_manPort_norm	1.58	-4.12	1.95	-1.07	-0.96	-0.52	1.06	1.93	685
g4_sing_wheel_norm	1.48	-4.84	3.41	-0.68	-0.54	-0.11	0.98	1.58	745
g4_multi_wheel_norm	1.56	-7.3	7	0.12	0.45	0	1.6	3.54	681
g4_multi_skid_norm	1.54	-6.73	4.37	-0.55	-0.49	-0.83	1.68	3.94	805
g4_multi_tub_norm	1.54	-9.87	16.13	2.21	2.05	1.78	5.56	6.24	820
g4_multi_tub_fast	2.02	-15.18	22.61	2.76	2.93	-0.62	7.82	8.98	643
g4_multi_tub_Xfast	2.27	-15.03	21.56	3.93	4.03	2.88	7.2	10.14	576

Figure 4-2: Background Noise, Sum of all Channels

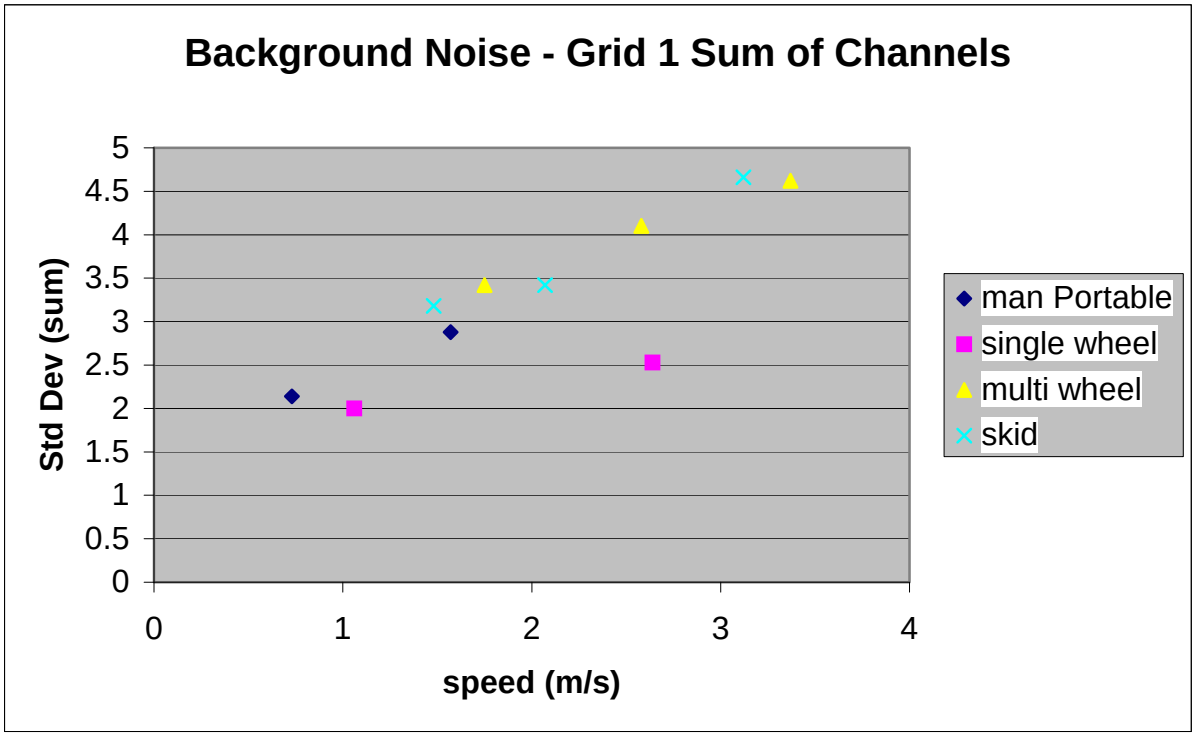
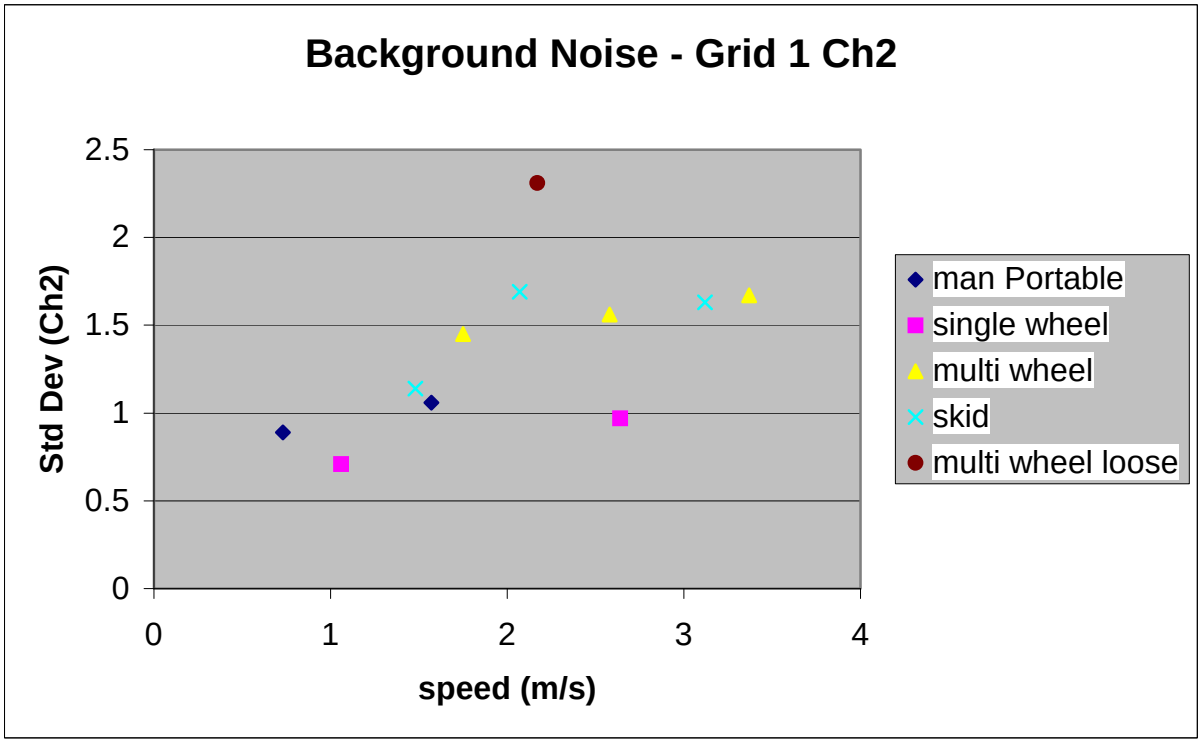


Figure 4-3: Background Noise, Channel 2



4.2 Peak Amplitude Response Analyses

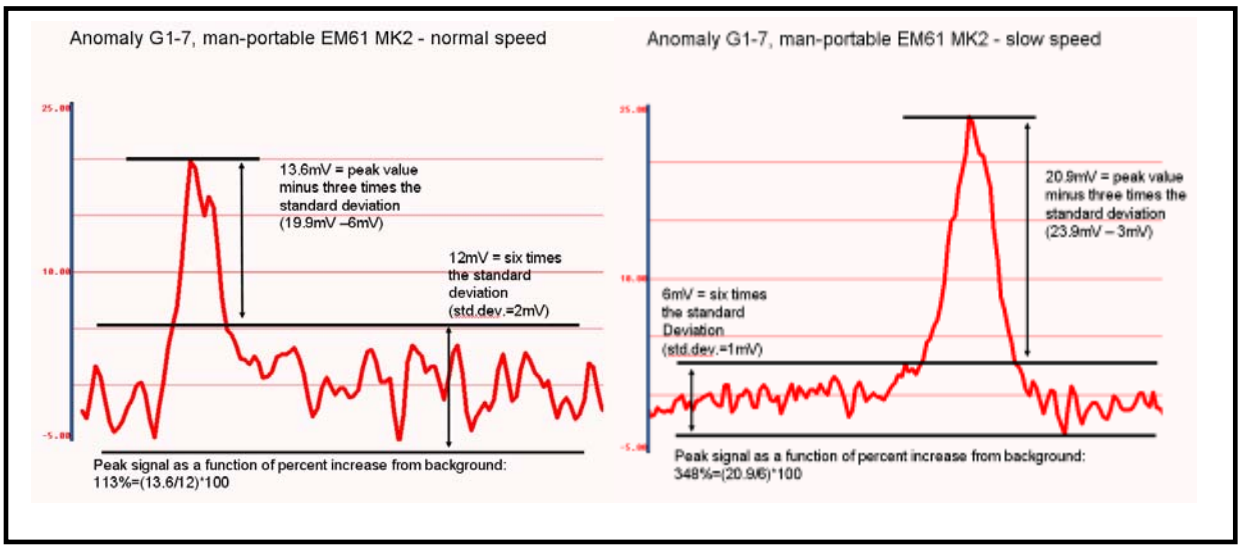
The following process was used to assess the peak response for the sum of all four time gates of the EM-61 MK2 data:

1- define circular mask that best encompasses full extent of anomaly and immediate background area without extending into responses associated with adjacent anomalies.

2- Identify the highest response within the masked region as the anomaly peak response.

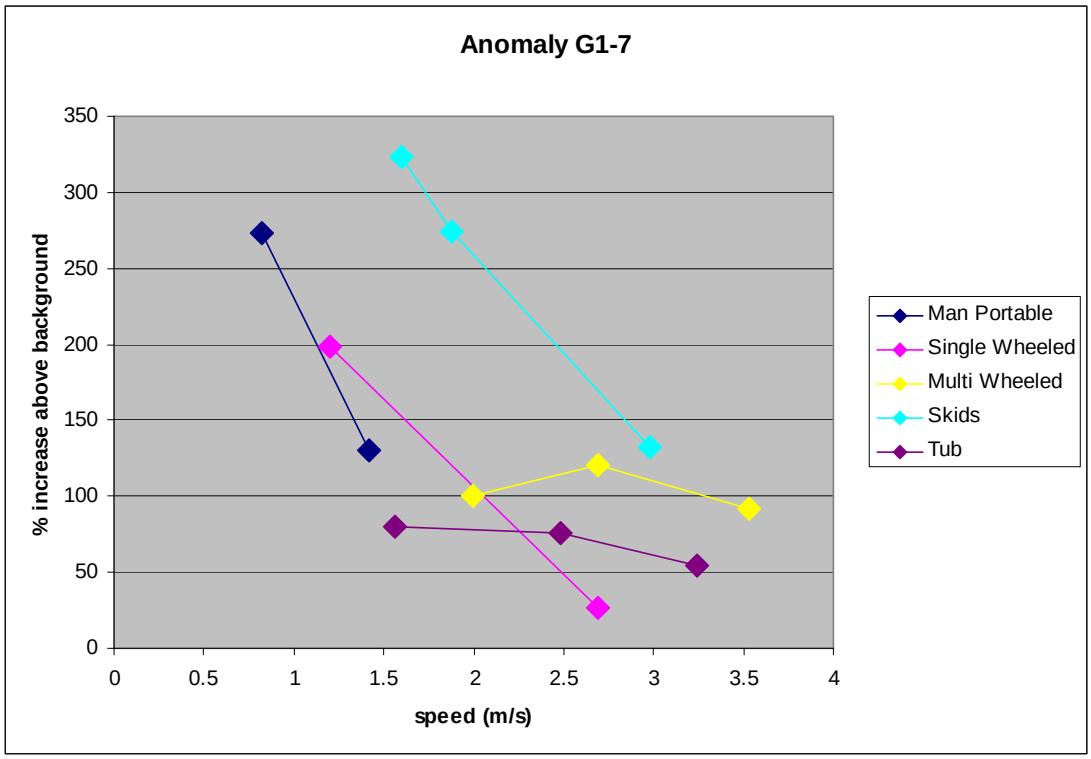
3- Calculate the peak response as a percent increase above background signal. Background signal is estimated as being six times the standard deviation of the background, assuming a Gaussian random noise. Figure 4-4 below shows two examples of this calculation where the standard deviations are derived from the data to the left and to the right of the anomalies.

Figure 4-4: Example Calculation of Percentage Increase Above Background



This process was performed for all datasets collected over the thirteen seeded items included in our analyses. The results of these calculations were then summarized for each seed item as line-graphs showing the results for each dataset grouped by platform. Figure 4-5 below shows an example of how these results are presented; Appendix D presents the results for all thirteen seed items analyzed. The standard deviations used to produce the line-graphs in Appendix D are those shown in Table 4-1 above.

Figure 4-5: Percent Change above background for anomaly G1-7



For most cases, it was seen that the peak response over a seeded item decreased as the collection speed increased. Figure 4-5 above illustrates the decreasing peak response trends that are shown in the line-graphs of Appendix D.

4.3 Signal to Noise Ratio Analyses

The following process was used to assess SNRs of the EM-61 MK2 data:

1- define circular mask that best encompasses full extent of anomaly and immediate background area, without extending into responses associated with adjacent anomalies.

2- define the total signal power (power associated with seed item plus power associated with noise), in the region of above-background readings, as the sum of the squares of all above-background anomaly signals. Above background readings were defined as responses greater than three times the standard deviation of the noise. The standard deviations for the various datasets were taken from the background statistics presented in Appendix C and section 4.1 above.

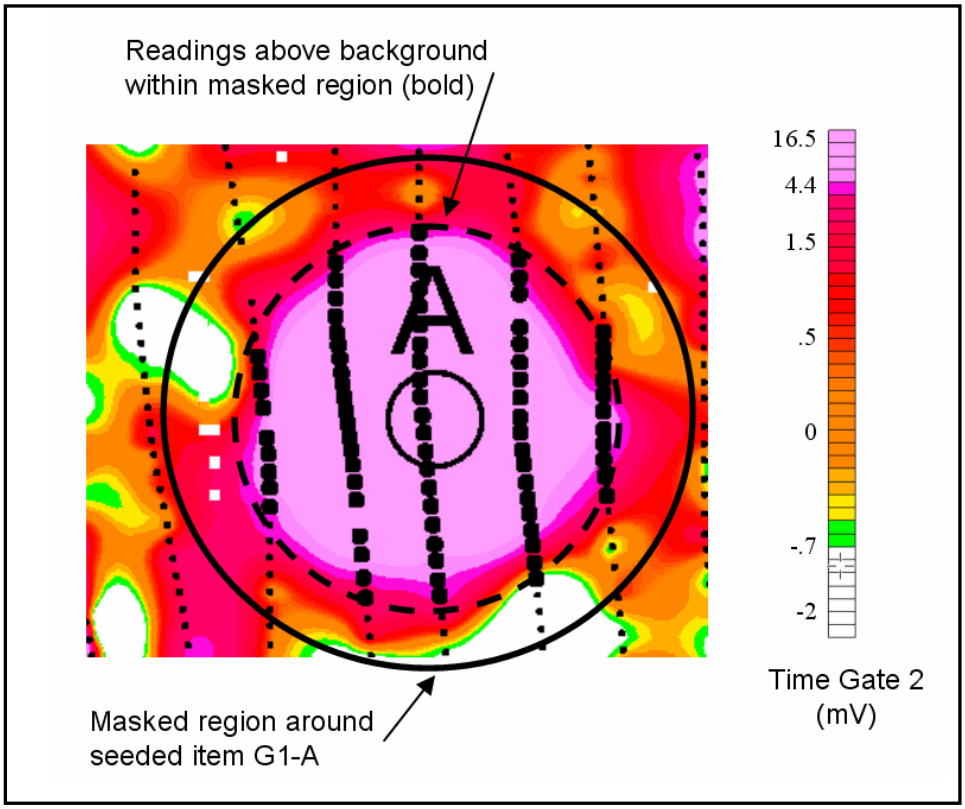
3- estimate the power of the noise, in the region of above-background readings, as the number of above-background readings multiplied by the square of the standard deviation of the noise, assuming a Gaussian random noise.

4- calculate SNR as the power of the signal associated with the seed item divided by the

power of the noise. The signal associated with the seed item was calculated as the total signal power from step 2 minus the power estimated to be associated with noise from step 3.

Figure 4-6 below shows an example of the readings selected for SNR calculations over seed item G1-A from the man-portable dataset collected at a normal walking speed.

Figure 4-6: Example of readings associated with SNR analyses



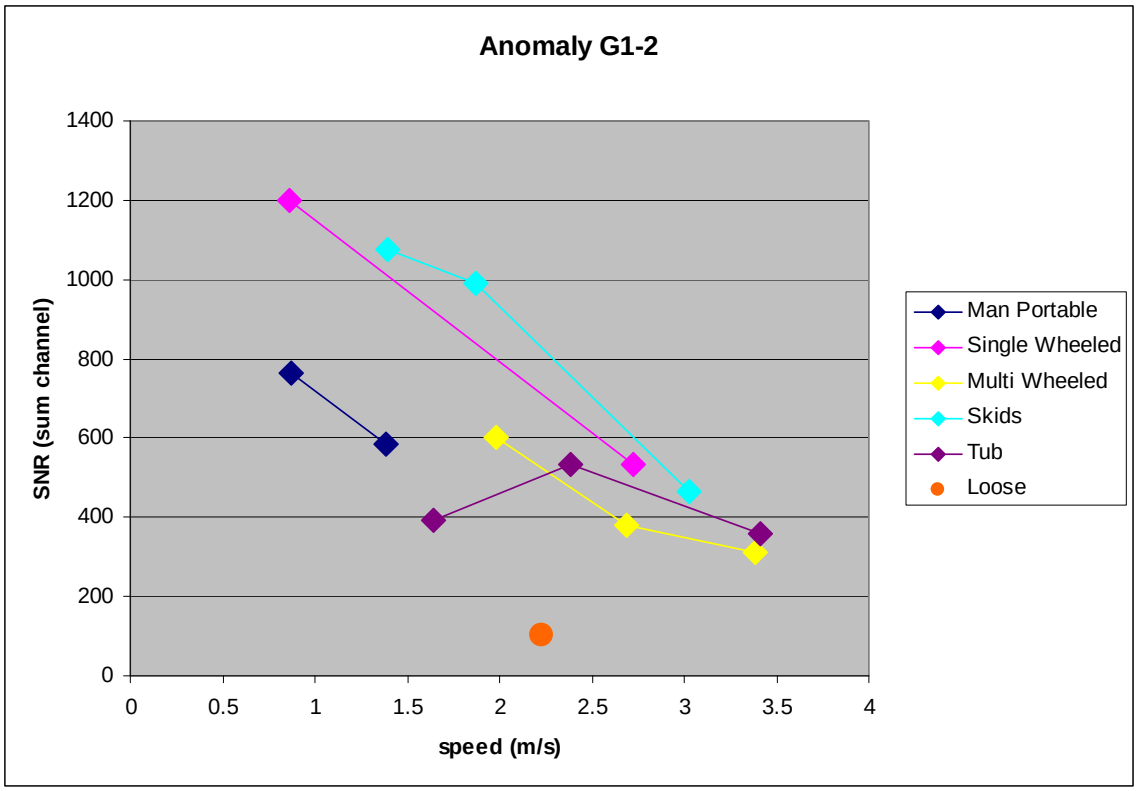
The above process was repeated for each time gate, as well as the sum channel, for each dataset collected over the thirteen seeded items analyzed. The SNR calculations were then summarized for each seed item as line-graphs showing the results for each dataset collected for each platform and platform speed. Figure 4-7 below shows an example of how these results are presented; Appendix E presents the results for all thirteen seed items analyzed. In almost all instances, the SNR over a given seed item decreased noticeably as the data collection speed increased. This trend mimics that observed in peak anomaly responses as discussed above. Figure 4-7 illustrates the decreasing SNR trends that are shown in the line-graphs of Appendix E. Other observations we noted from our analysis of the line graphs in Appendix E are:

- For multi-sensor platforms at a given speed, noticeably higher SNRs are achieved when the platform is not bumped or jostled by un-even terrain conditions. In our evaluations, this was achieved by using a platform mounted on narrow wooden skids and using coils mounted inside a PVC tub. The wooden skids effectively “glided” over the uneven terrain. The tub, however, at lower speeds, seemed to transmit more movement, or jolts,

to the EM coils. This appeared to be caused by bumps in the uneven terrain and resulted in lower SNRs. At higher speeds, the tub appeared to glide over the terrain a little better, which resulted in increased SNRs in the mid-speed ranges. As with all other platforms, the tub datasets showed overall decreases in SNR at the higher speeds. An example of these trends is shown in Figure 4-7.

- For multi-sensor platforms, the degree of movement between coils seems to significantly decrease the SNR. Our "loose" configuration, which allowed for a high degree of movement between the two coils, shows very low SNRs over all seeded items. An example of this finding is shown in Figure 4-7.
- For the single sensor platforms, the SNRs of the towed datasets are categorically higher than those of the man-portable datasets. This observation is not fully understood, however, we speculate that a combination of 1) having the electronics and power supplies for the EM and GPS equipment greatly removed from the platform in the towed setup, and 2) having the tow-point fixed at a uniform height in the towed setup (as opposed to being "variable" as the unit is pulled by the operator) contributed to this observation.

Figure 4-7: Change in SNR with Speed for anomaly G1-2



4.4 Anomaly Size

Anomaly size (spatial extent) was measured directly from the data maps in Oasis montaj. Size was measured for 21 anomalies in 14 datasets. Some of the target responses merge together due to the seed items being buried closer together than the spatial extent of the anomaly. In this case,

the sizes were either not measured, or the size of the combined anomaly was used. A color scale was chosen such that the change from background noise to signal response was as clear-cut as possible.

It is clear from the analysis that anomaly size increases directly with collection speed. It can also be seen that anomaly size increases when using a dual-coil array, versus a single coil. See Appendix F for individual measured anomaly sizes.

Figure 4-8: Anomaly Size Example 1

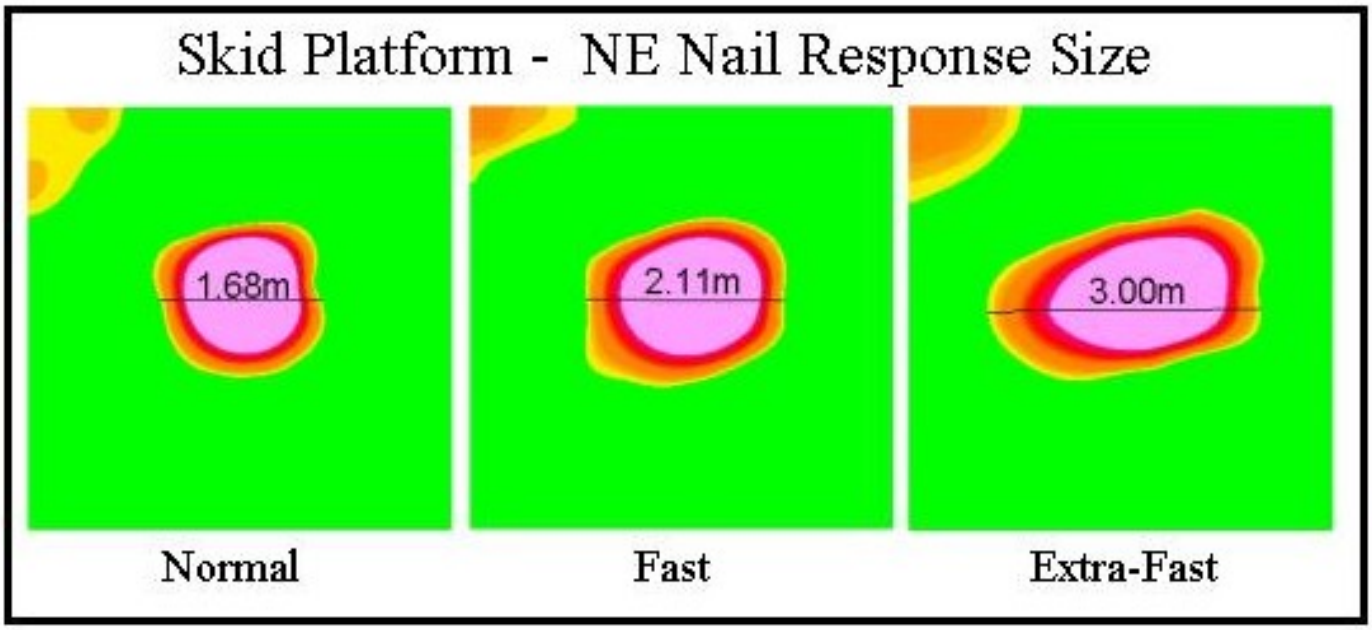


Figure 4-9: Anomaly Size Example 2

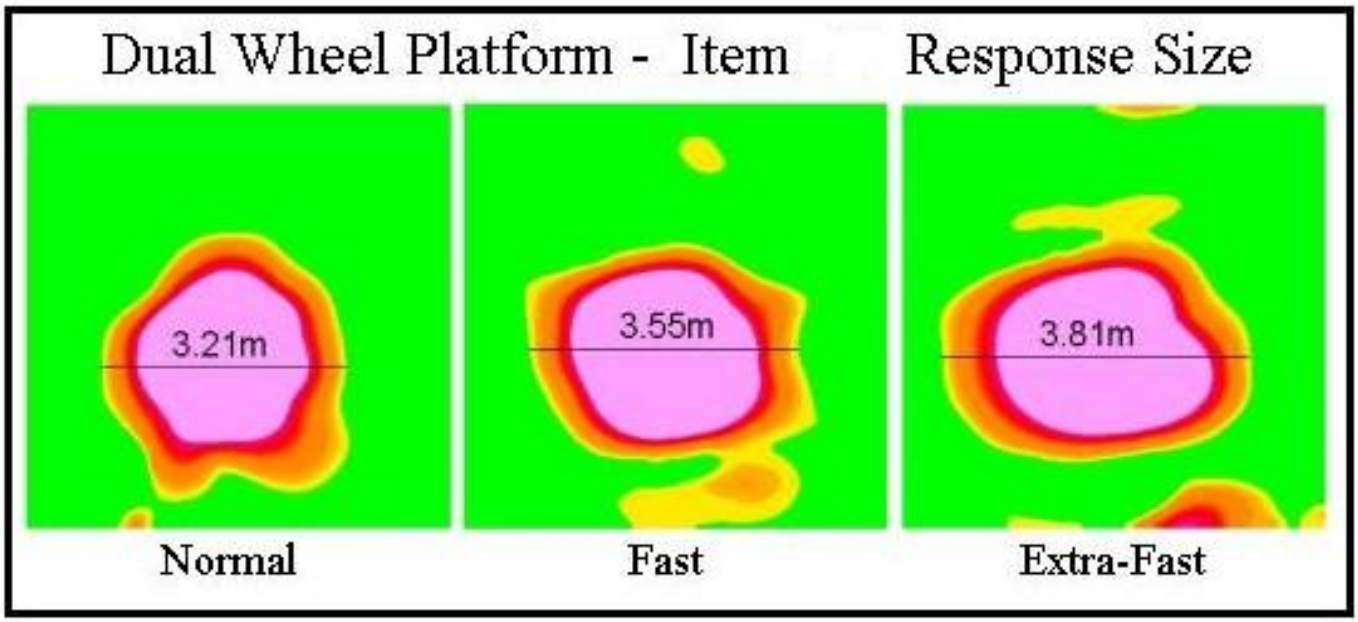
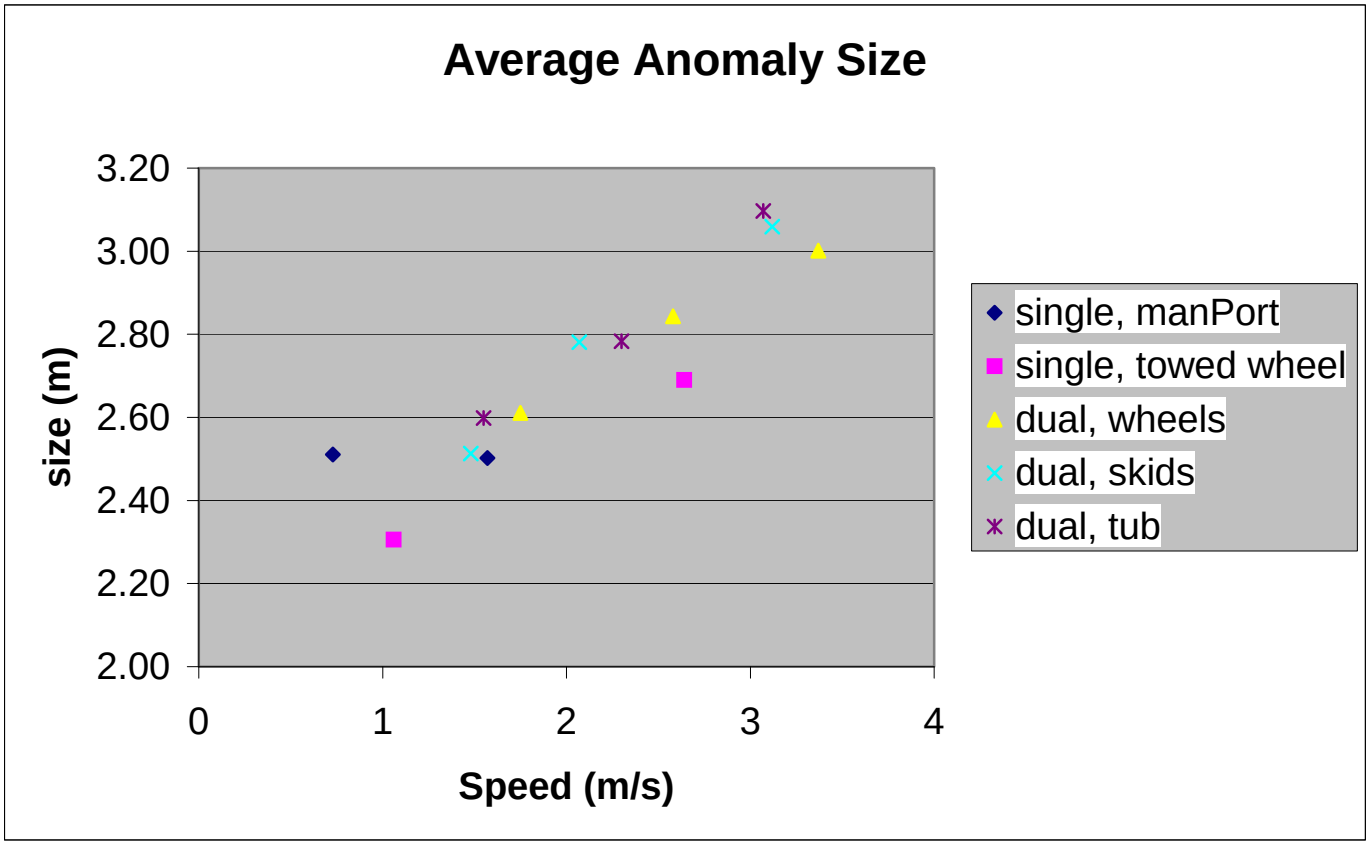


Figure 4-10: Average Anomaly Size vs. Speed



4.5 Anomaly Detection

Our results do not show significant differences in detection rates among the more than 50 seeded items located throughout Grids 1 and 4. The USAESCH McKinley Test Area is not designed to test the variability in detection limits, it is designed to evaluate different geophysical systems.

Based upon the observed decreases in SNR with increased speed, we believe that small MEC items and MEC items buried deep will be less likely to be detected and/or selected for digging from datasets collected at high speeds. Similarly, such items would be less likely to be selected from datasets with higher than normal noise levels, such as those from platforms having multiple coils where the coil arrangements are not rigid. Though the USAESCH McKinley Test Area is not designed to evaluate this hypothesis, we did observe a change from "detected" at slow speeds to "not detected" at moderate to high speeds over one small sub-munition and one large indirect-fire munition. Both items are buried at depths approaching their expected maximum detection depths.

5.0 RESULTS SUMMARY

Our data show that signal noise increases as data collection speeds increase. We attribute this finding with increased roll, pitch and yaw of the coils, which is inherent in the platforms as their speeds increase. In effect, the movement of the platform over variable terrain results in the coils being bounced, somewhat randomly, in three dimensions. Since this effect is due to a combination of the coils being bounced from variable terrain conditions, this noise could be classed as both instrument noise (resulting from the motion of the coils) and terrain noise (since it is the terrain that is causing the un-even motions of the coils)

With few exceptions, anomaly peak responses and SNRs decreased as the collection speeds increased. As can be seen in the line graphs shown in Appendix E, for any given platform, the SNRs decrease for a platform as its speed is increased. We believe this observation is due to several factors: first, the increased noise observed at the higher speeds directly results in decreased SNRs. Second, since the SNRs decrease at rates that are proportionally greater than the observed increases in noise alone, some other factor must be contributing to the observed decreases in SNR. This observation is believed to be the result of each recorded EM61 MK2 measurement actually being a resultant value from multiple readings that are digitized over a given period of time, or over a given number of transmit and receive cycles. We believe that the observed decreases in SNR are due to an "averaging" effect: At lower speeds, the measurement reported by the firmware is based upon greater numbers of instantaneous readings collected over the target, whereas at higher speeds, fewer instantaneous readings are actually being taken over the target and greater numbers of readings to either side of the target (along the shoulders of the anomaly or completely beside the anomaly) are being included in the calculated measurement.

The trends in decreased SNR with increased speed suggest that small MEC items or MEC items buried at or near their expected maximum detection depths may go undetected or would not be selected as anomalies to be included on a dig list. The data collected over two MEC items in Grid 1 tend to corroborate this hypothesis.

On average, the data show that the spatial extent of anomalies increased as tow speed increased.

This observation would also be explained by the averaging effect described above.

Our results also suggest that improvements to platform stability result in lower background noise levels and increased SNRs. As can be seen in the line graphs shown in Appendix E, at any given speed, the SNRs tend to increase with increased stability in the platform.

We also found that the background noise and anomaly response amplitudes increased when the sensor height above the ground was reduced, however, there were no appreciable increases in signal to noise ratios.

When deriving processes to assess the levels of background noise in a dataset, we found that the use of polygon masks, to "window" areas interpreted by the geophysicist as being background, provided results that were not biased by the buried items in the test grids. Though not tested by us, an alternative to using manually define polygons would be to first select anomalies and then automatically define masks around each selected anomaly such that the masks fully encompass each anomaly. Background statistics would then be derived from all data outside of the masks around each anomaly. We used the statistics of mean and standard deviation to quantify our observations of the background data for each dataset. The mean background values were used to assess how well drift and leveling had been performed on each line of data. Lines with mean values that varied significantly from zero were analyzed and often found to be biased from atypical positive or negative spikes in the data (such values were not repeated between dataset and were attributed to terrain induced effects.) We also found that the use of the standard deviation of the background datasets was a good measure for defining the upper limit of the background levels (better than 99% of all background readings being less than the mean plus three standard deviations) and the range of the background readings (over 99% of all background readings being within the mean ±6 standard deviations.) We found that the use of simple clipping routines to calculate background statistics, such as clipping all values above an estimated background milliVolt threshold, were prone to bias from the number of anomalies in a given dataset. This approach yielded noticeably different results between two datasets collected from adjacent grids where the only difference between the two was the number of anomalies in the dataset.

6.0 CONCLUSIONS

The significance of our findings is important for both automated anomaly selection routines and anomaly discrimination routines that are designed for EM61 MK2 data. For automated anomaly selection routines that use anomaly amplitude as the sole or primary detection/selection criteria, our results show that the speed at which the data is collected can significantly impact the functionality of those criteria, particularly when selection decisions are based on narrow tolerances in the measure of anomaly amplitude.

Our results also suggest that high speeds can adversely affect the detection rate, as well as the selection, of MEC-related anomalies where the target MEC items are either small or may be buried at depths approaching their maximum expected detection depths.

For anomaly discrimination routines that use anomaly peak response, anomaly power, and/or anomaly size in their discrimination criteria, our results show that the speed at which the data is collected can significantly influence each of those characteristic measures. Discrimination routines that base decisions on narrow tolerances of these measures should factor for the variability in anomaly characteristics as a function of the data collection speed.

Appendix A: Pictures of Survey Platforms

Towed, dual coil, with wheels, sturdy frame:

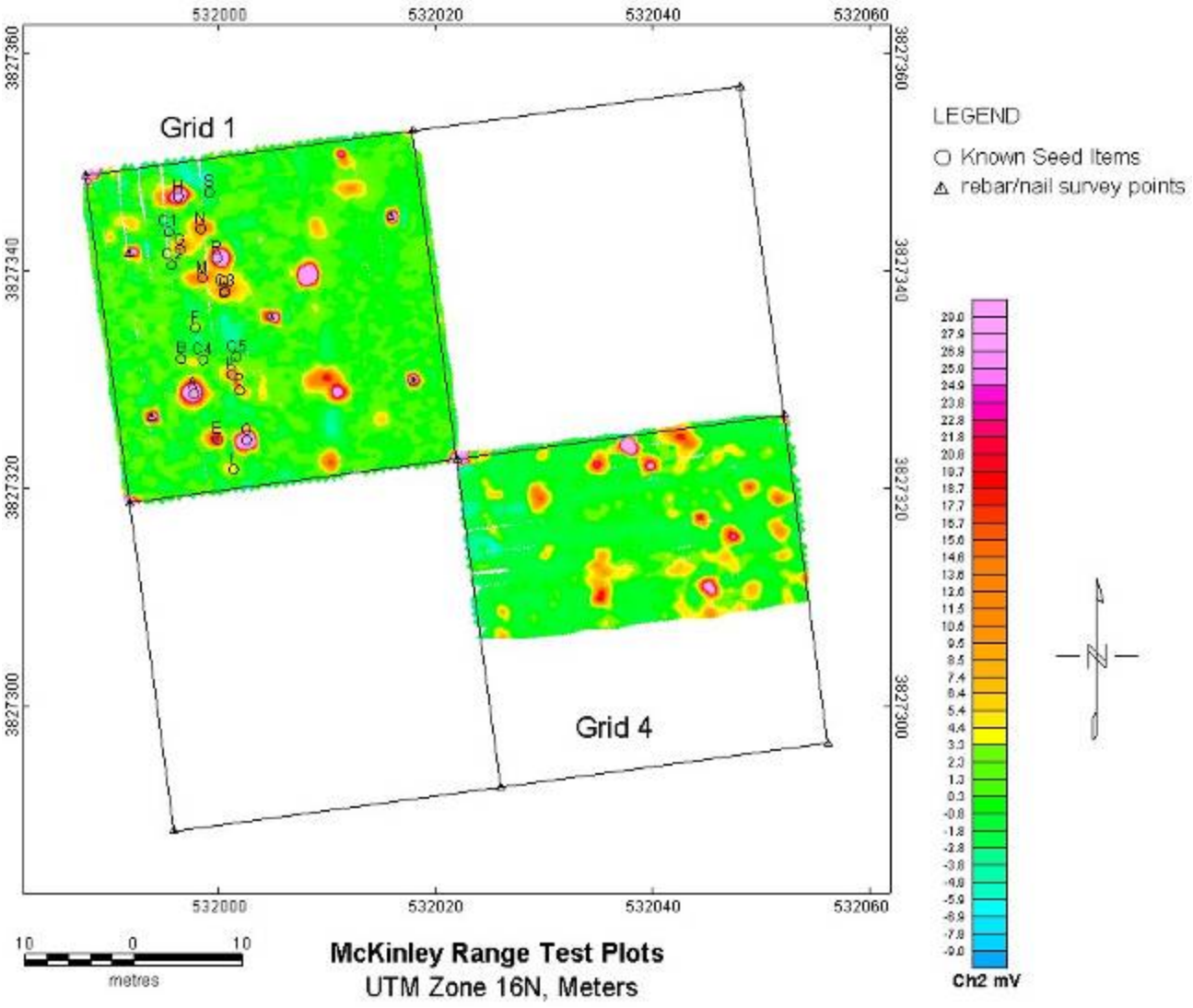
Towed, dual coil, with wheels, loosened frame:

Towed, dual coil, with skids, sturdy frame:

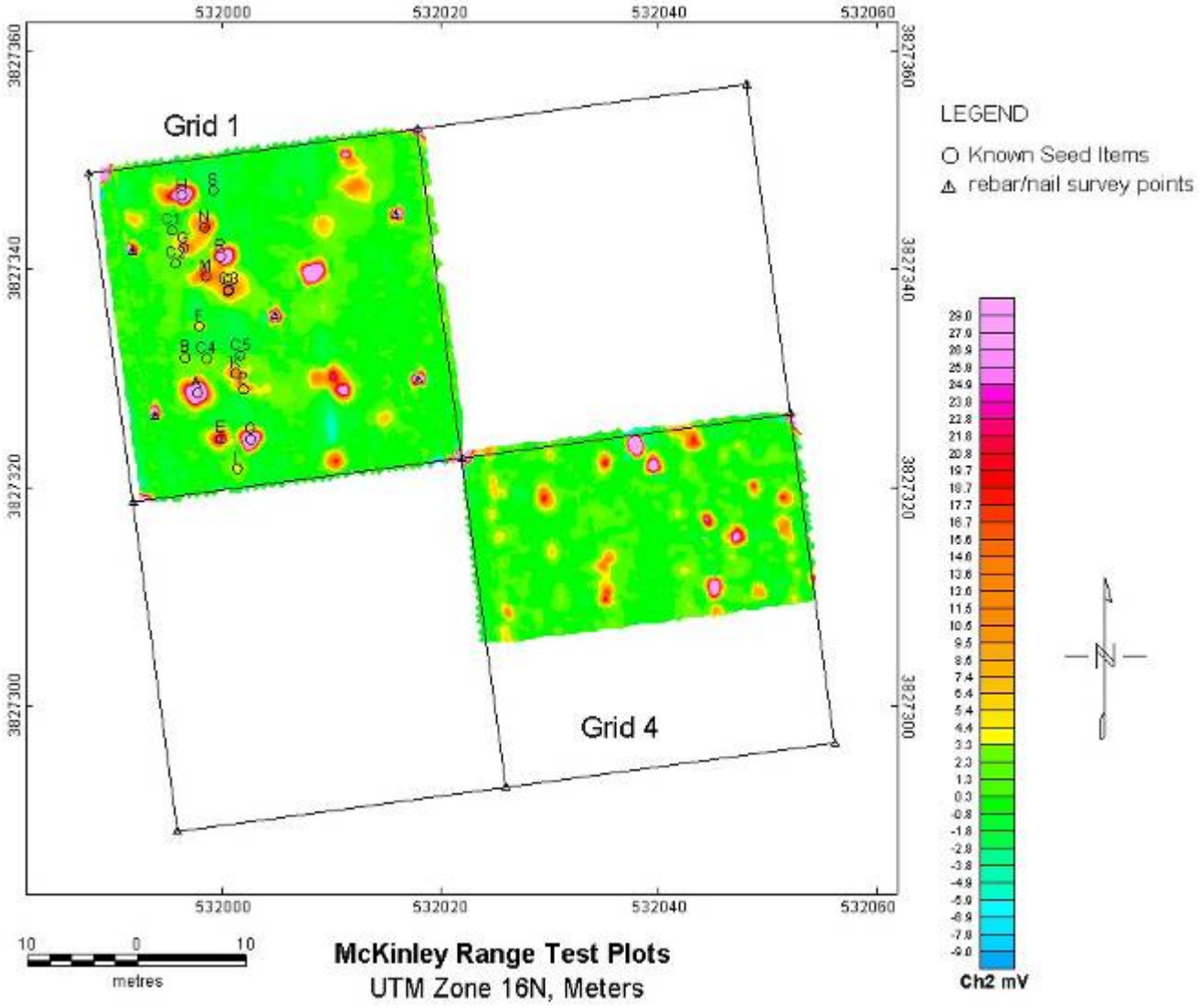
Towed, dual coil, in tub, sturdy frame:

Appendix B: Data Maps

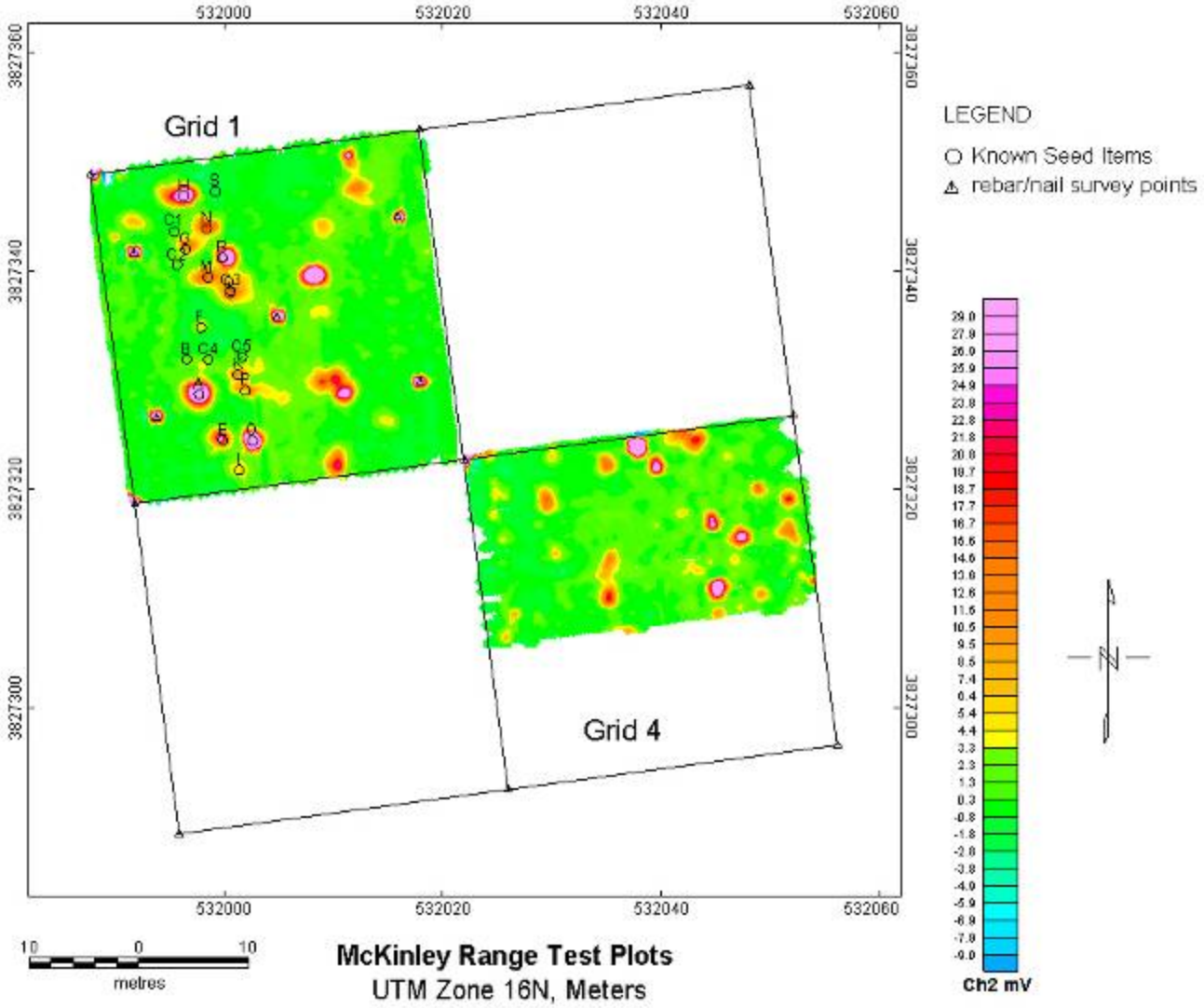
Man-portable, single coil, wheel, normal speed:



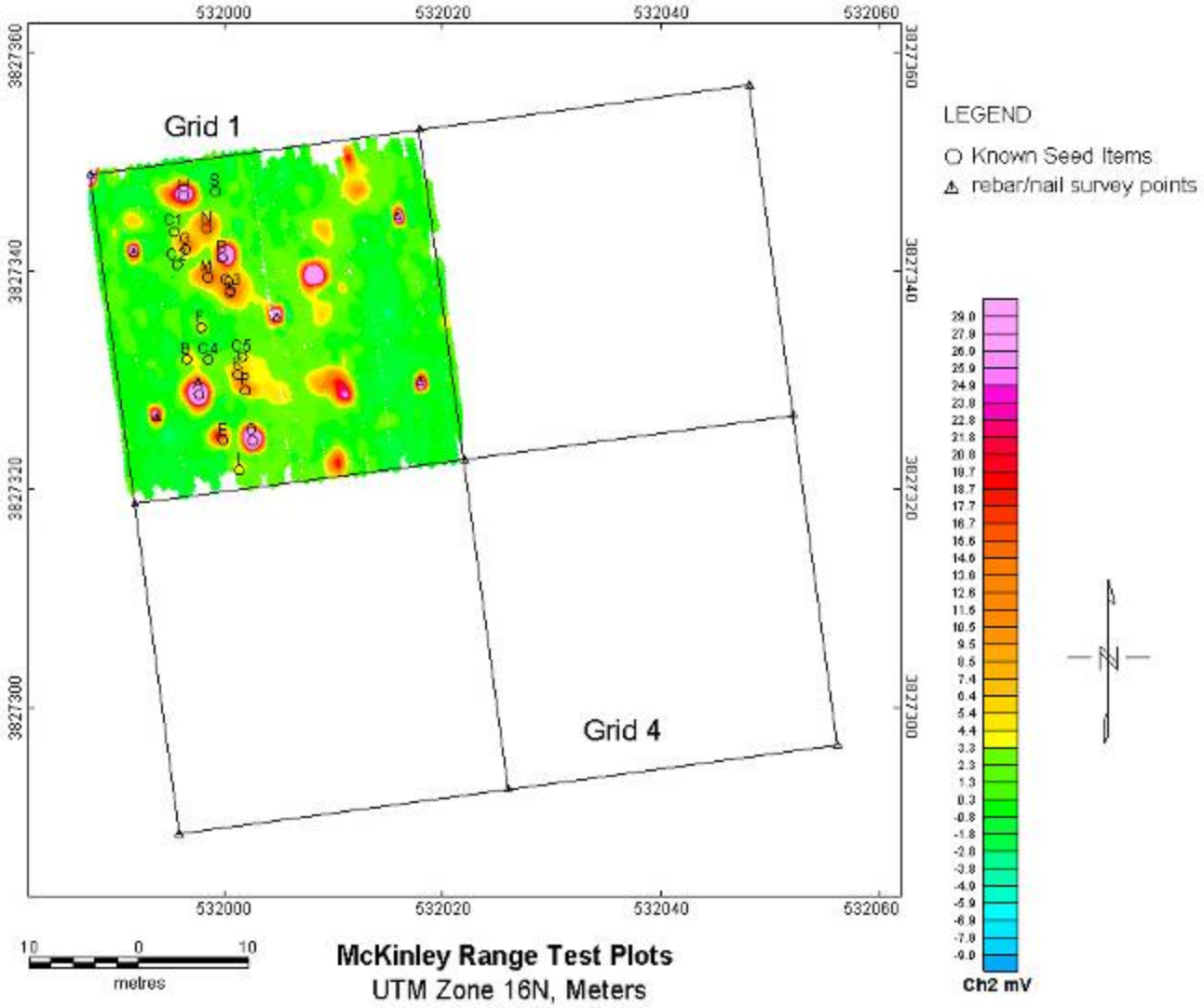
Man-portable, single coil, wheel, slow speed:



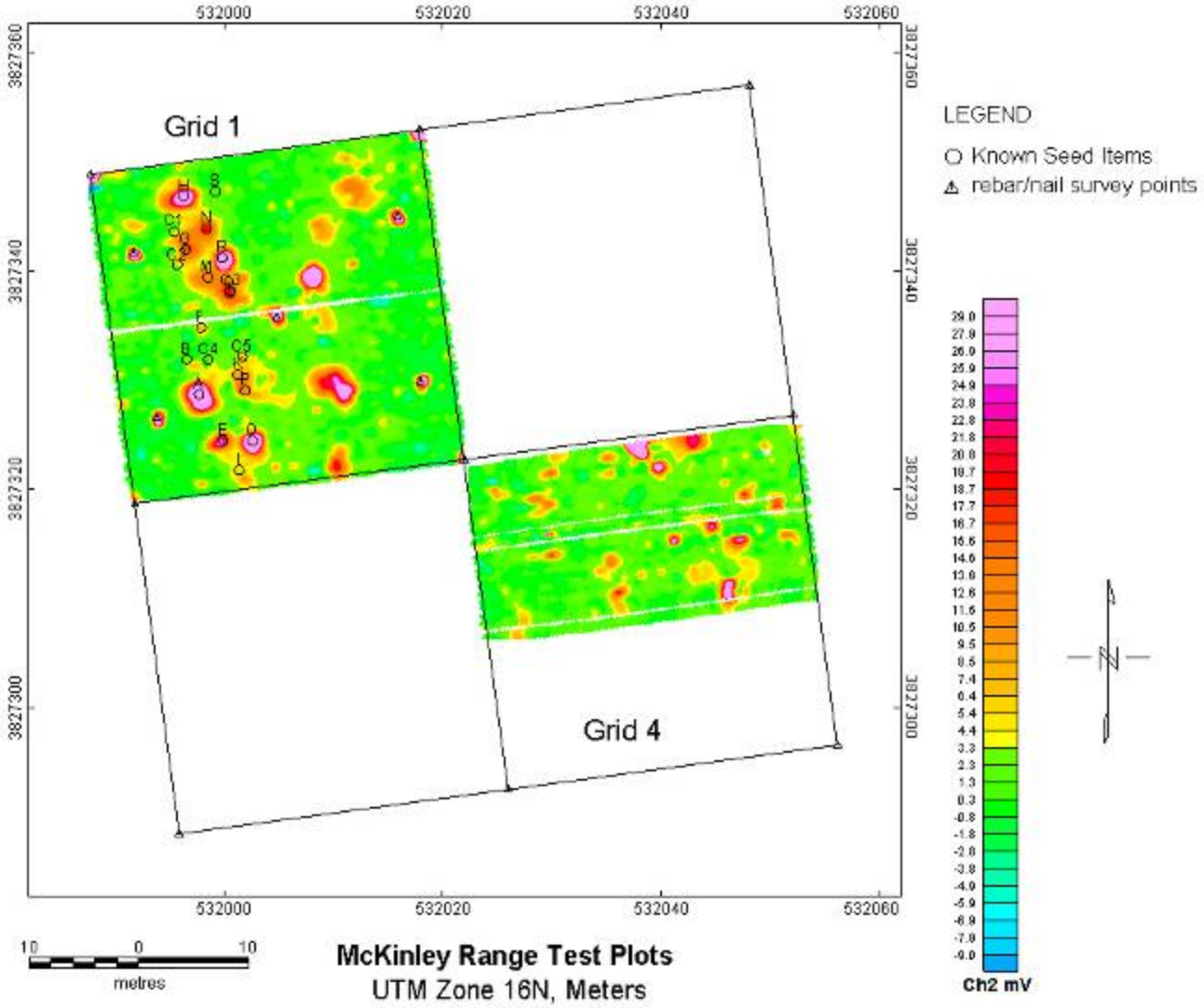
Towed, single coil, wheels, normal speed:



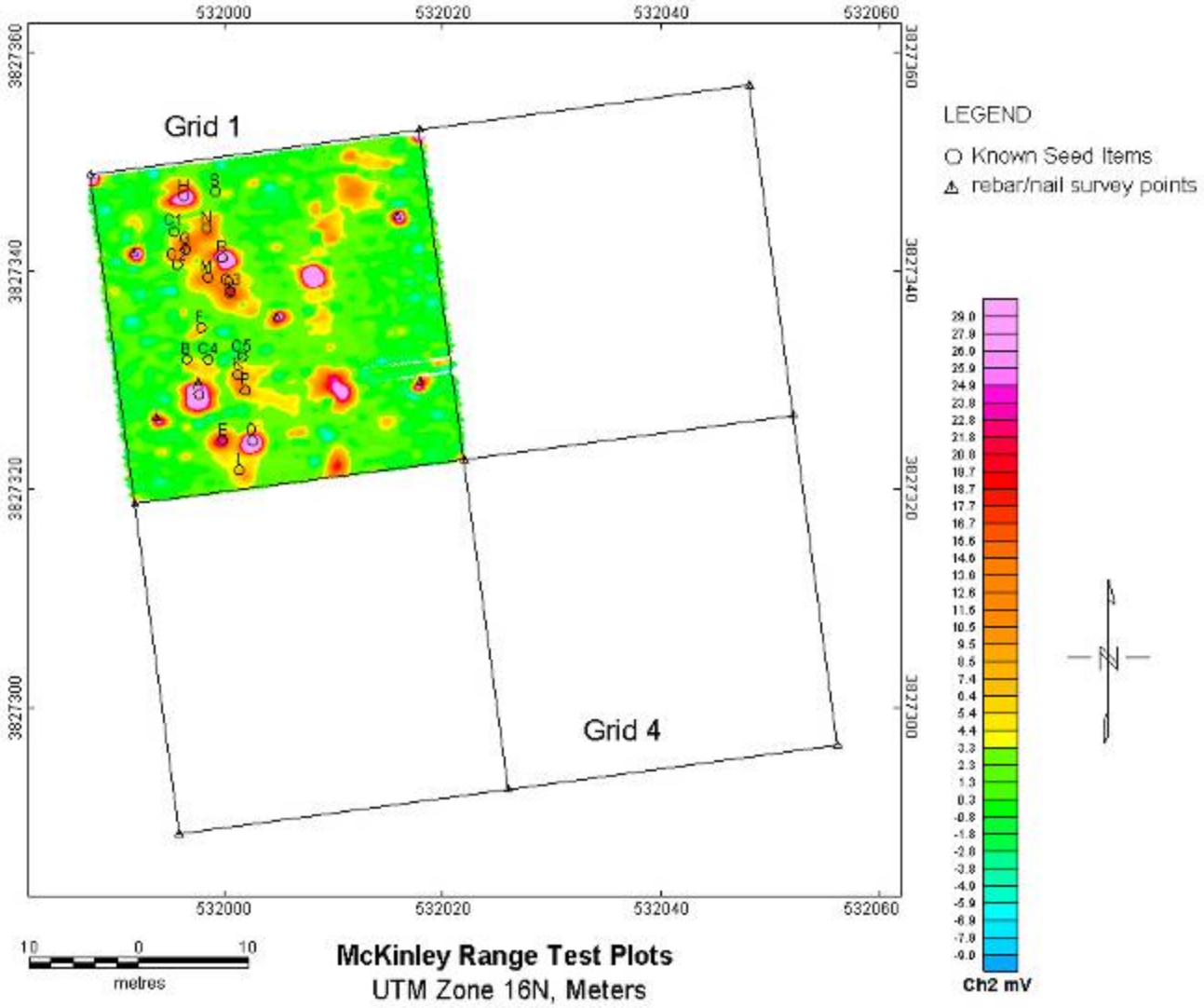
Towed, single coil, wheels, fast speed:



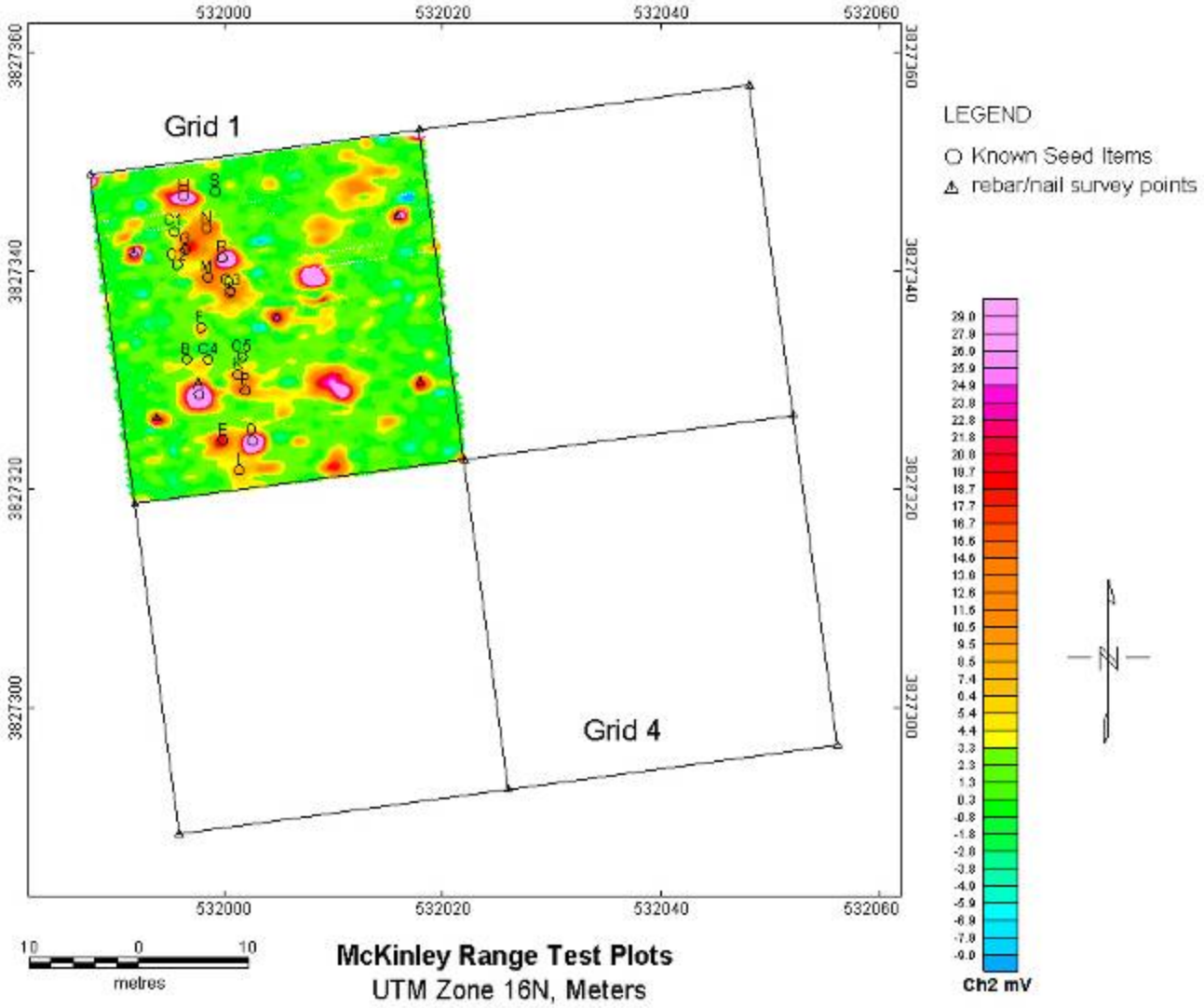
Towed, dual coil, wheels, normal speed:



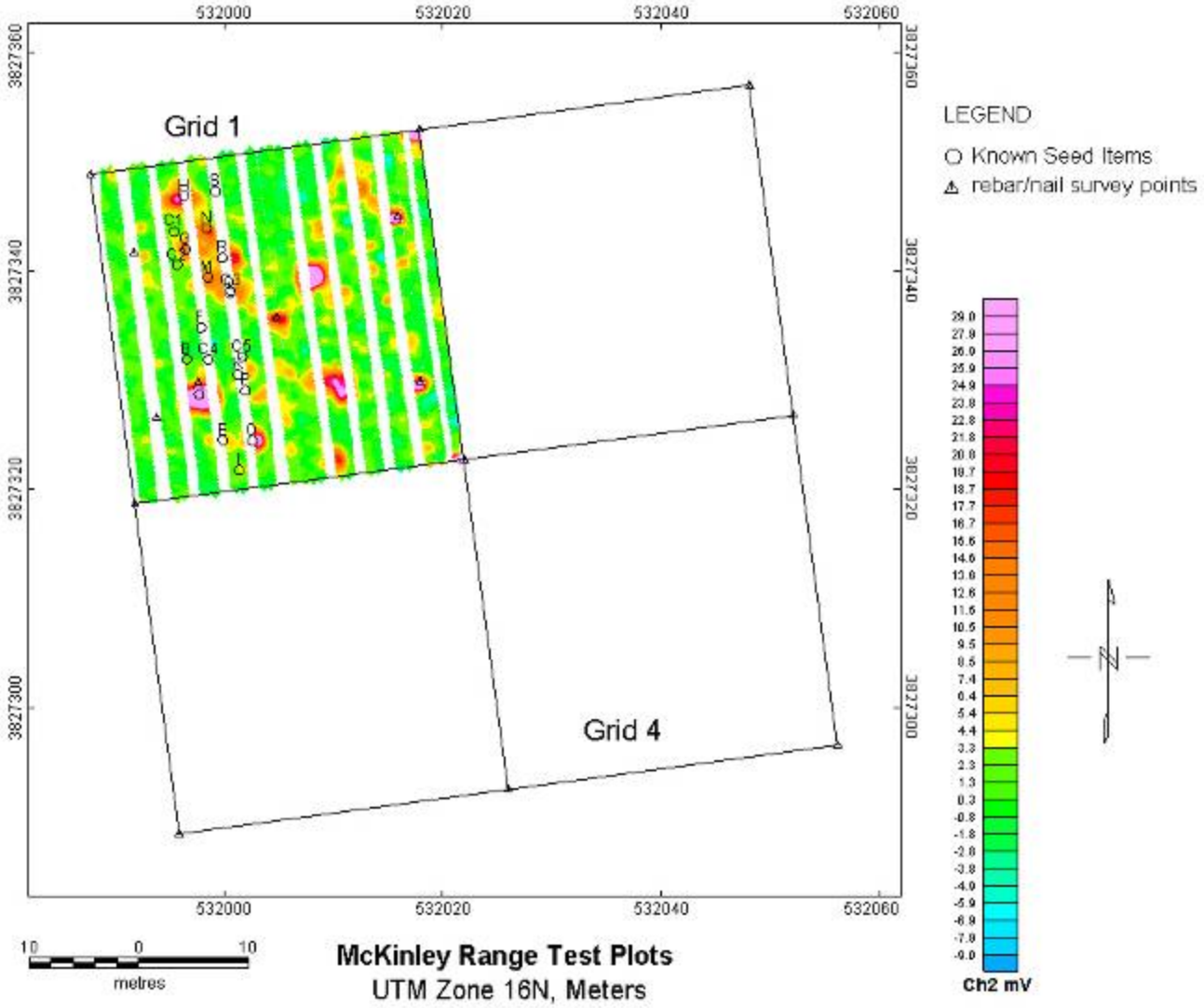
Towed, dual coil, wheels, fast speed:



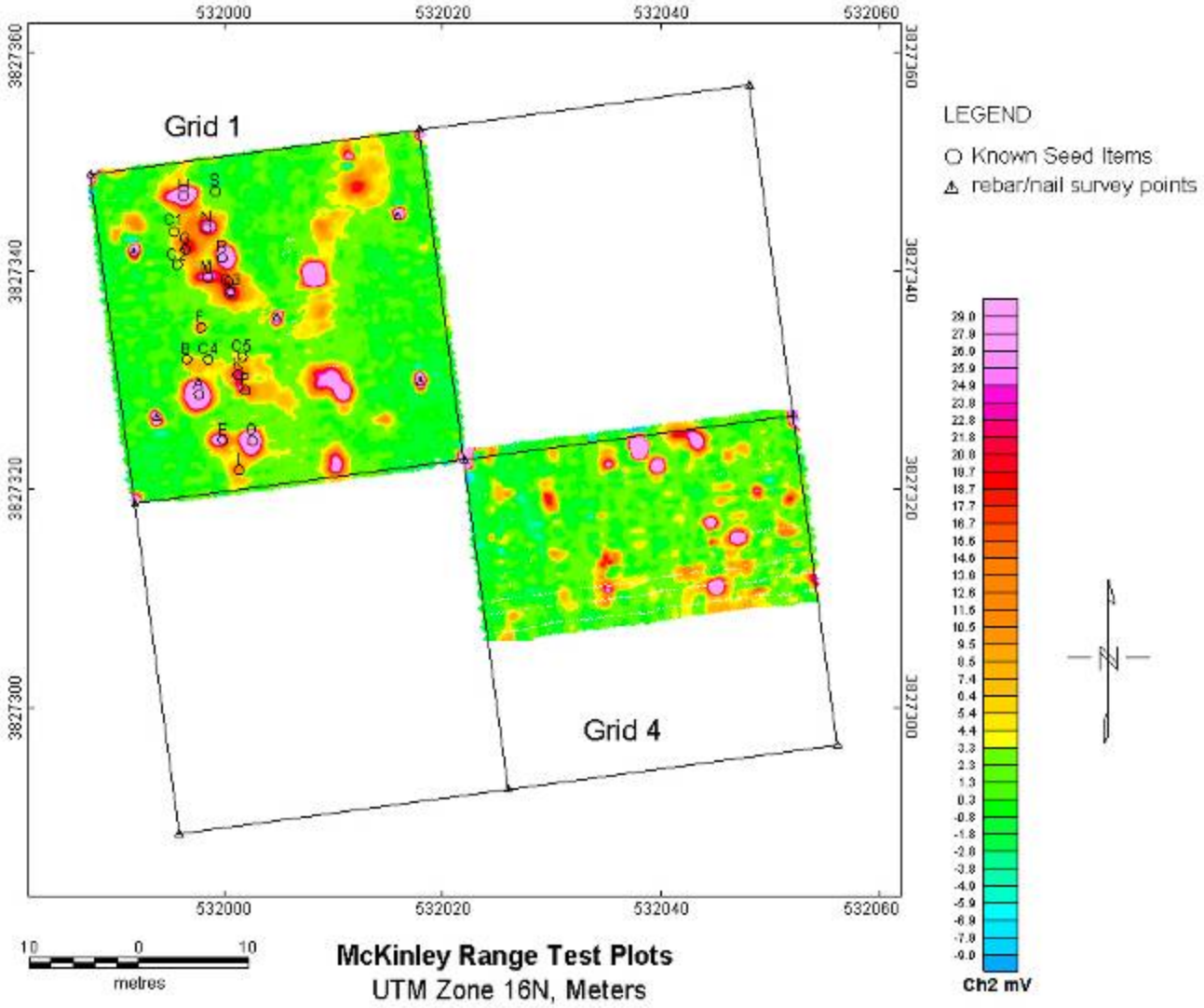
Towed, dual coil, wheels, very fast speed:



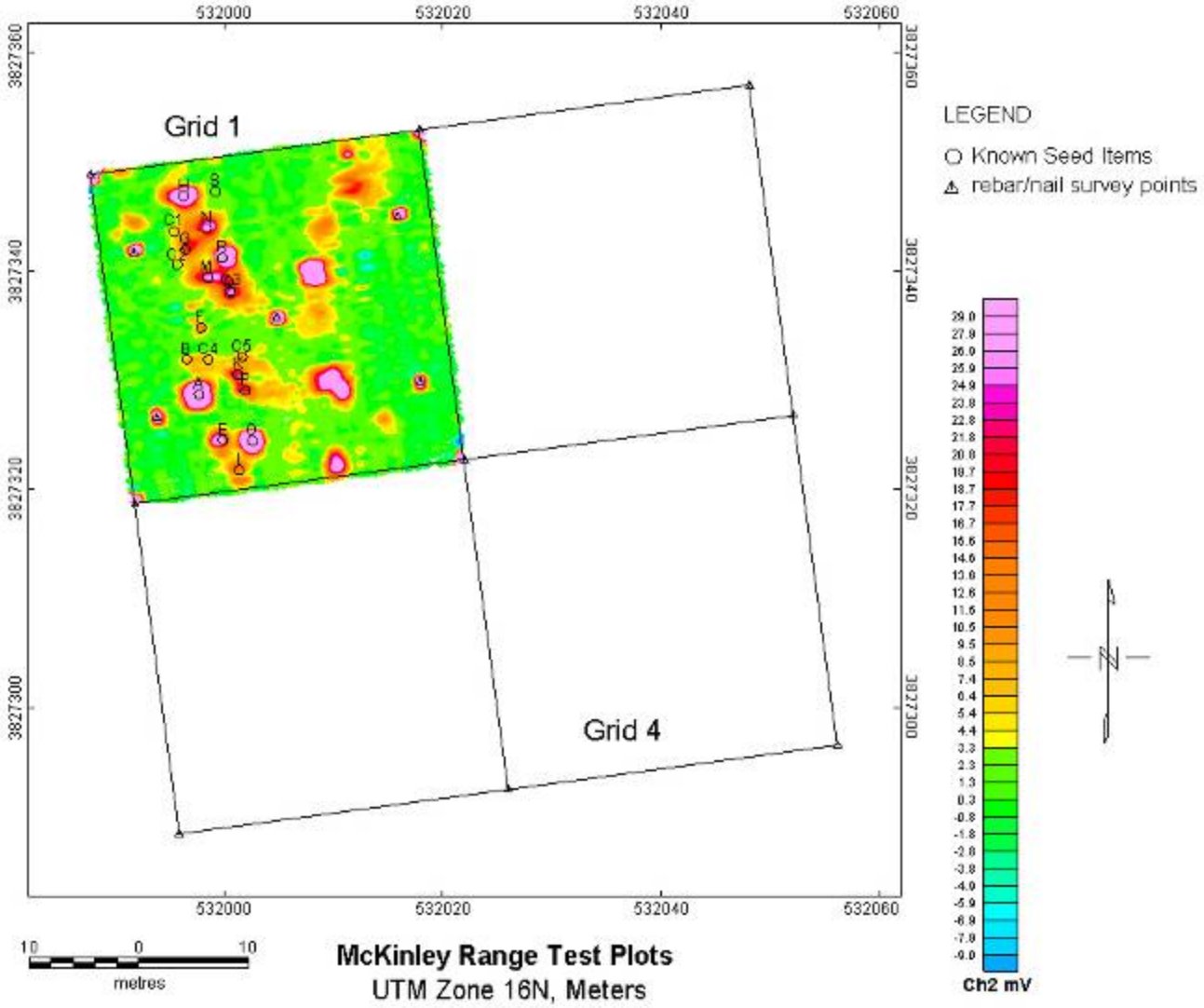
Towed, dual coil, wheels, loose frame (only left coil):



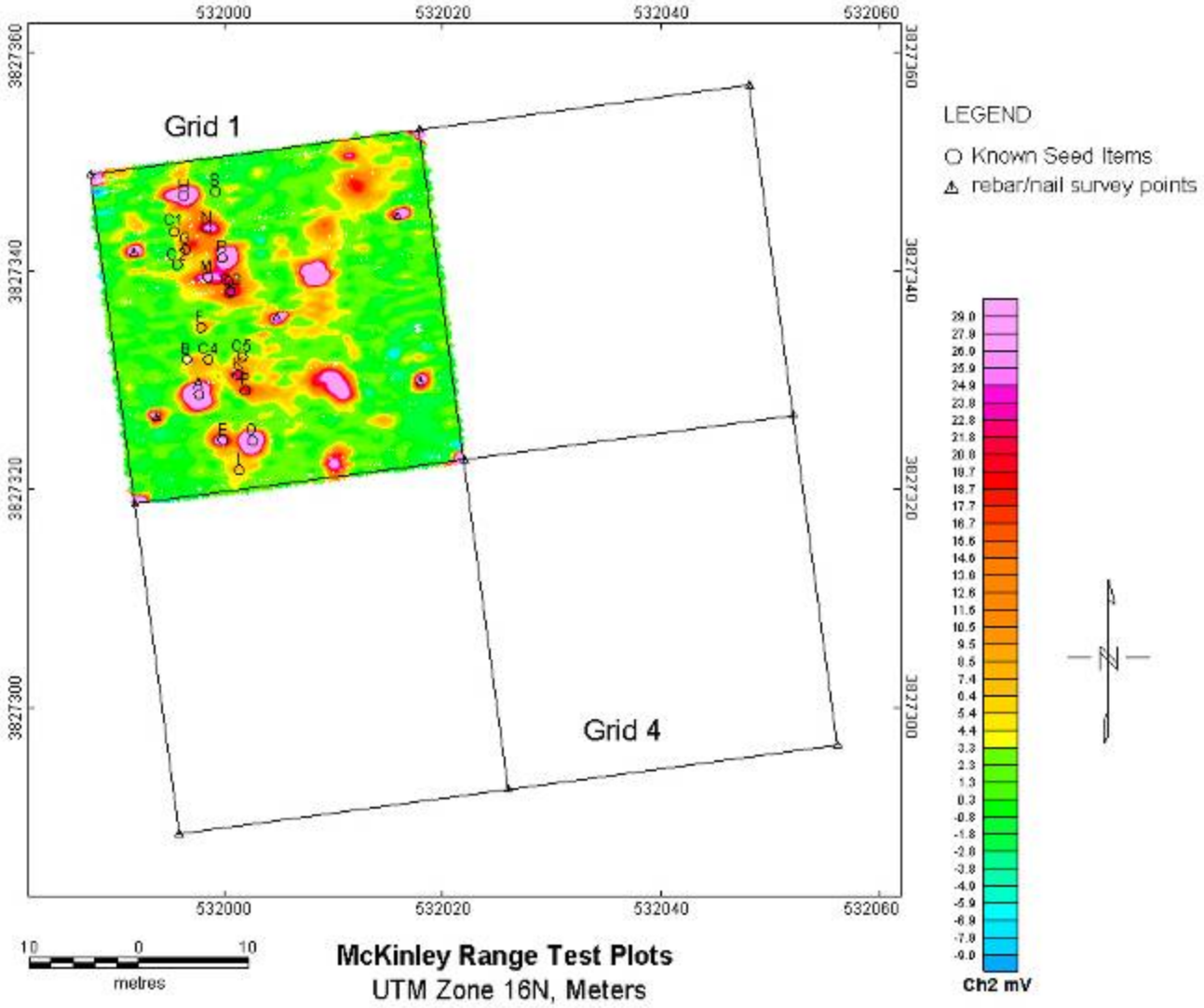
Towed, dual coil, skids, normal speed:



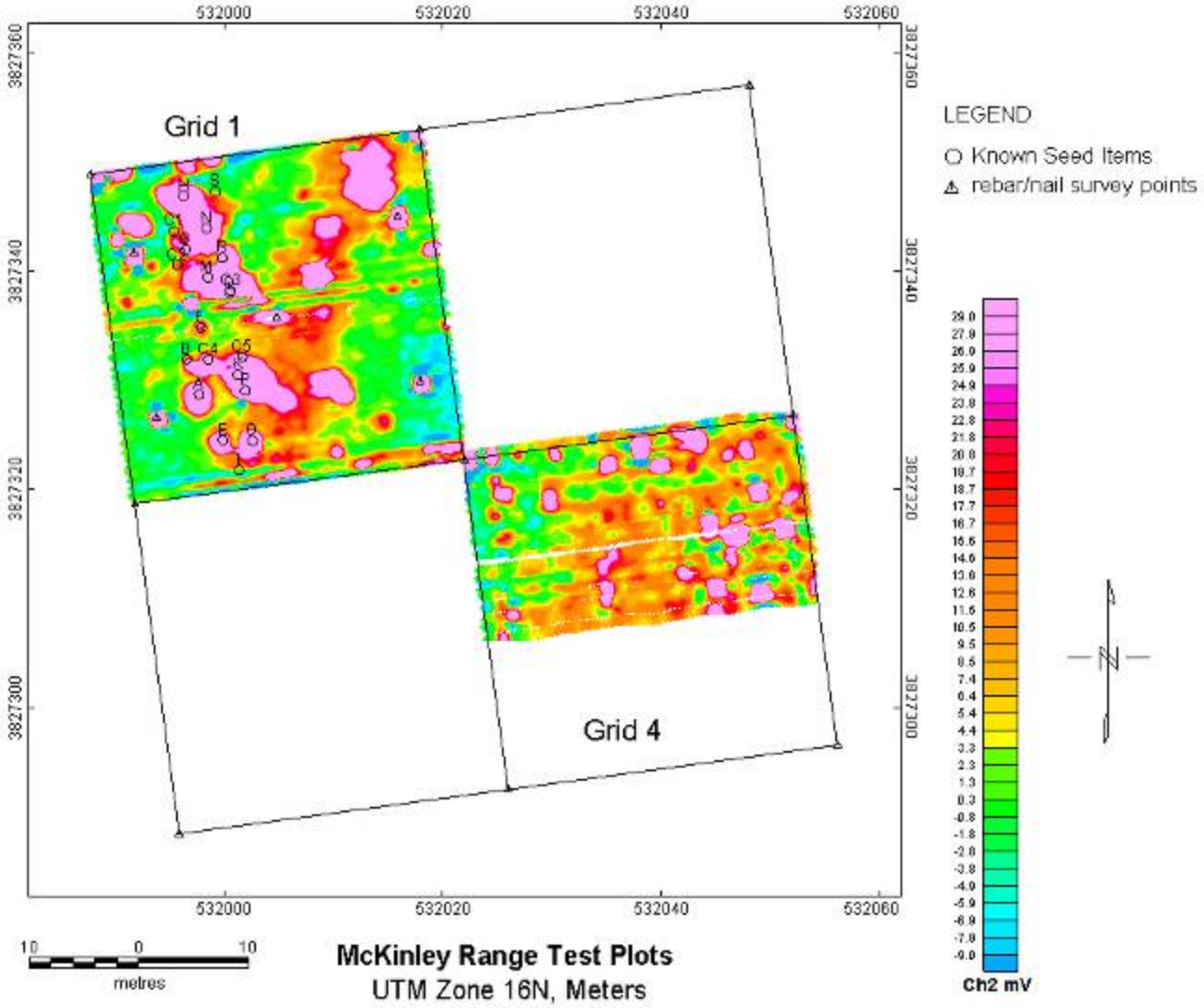
Towed, dual coil, skids, fast speed:



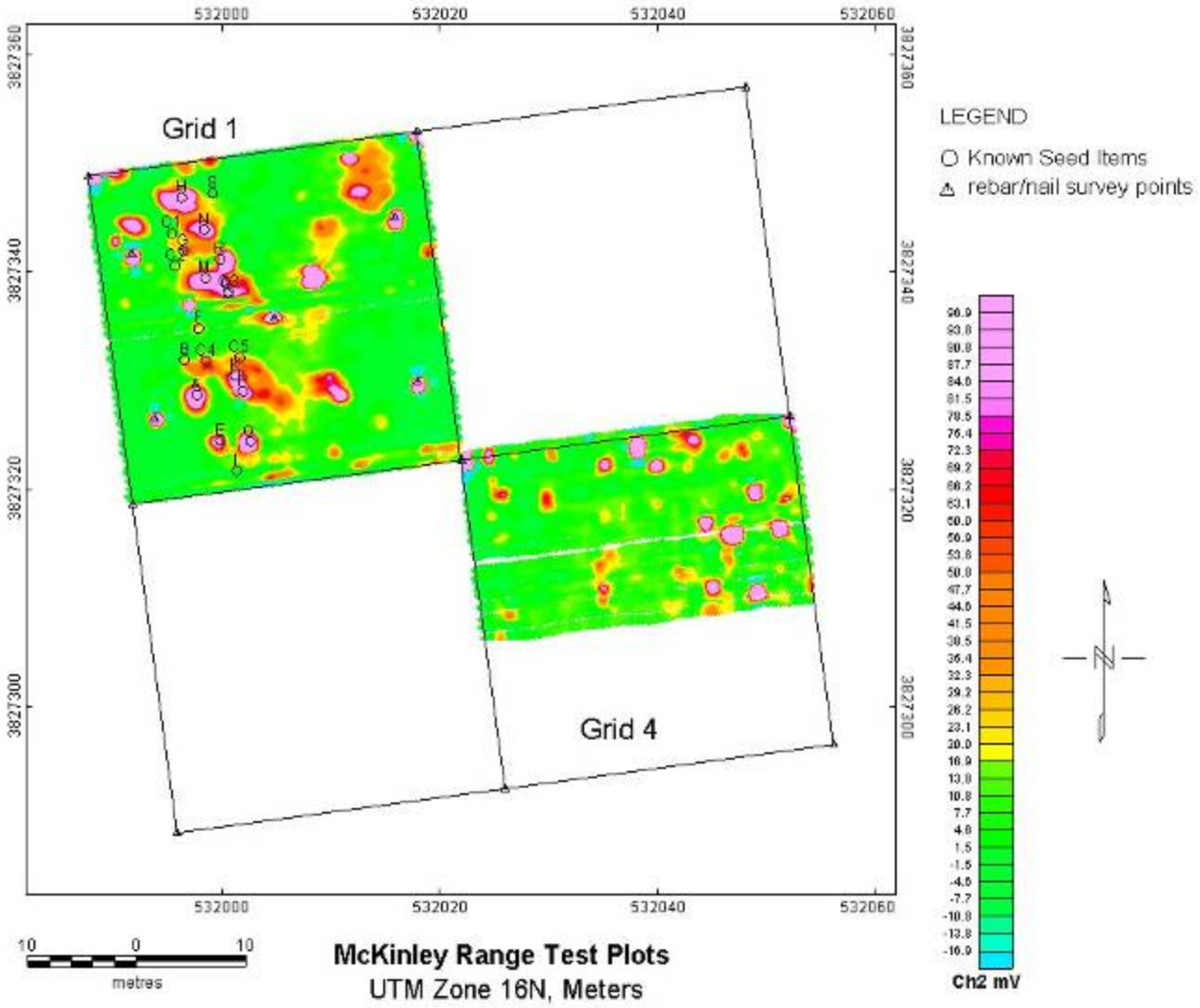
Towed, dual coil, skids, very fast speed:



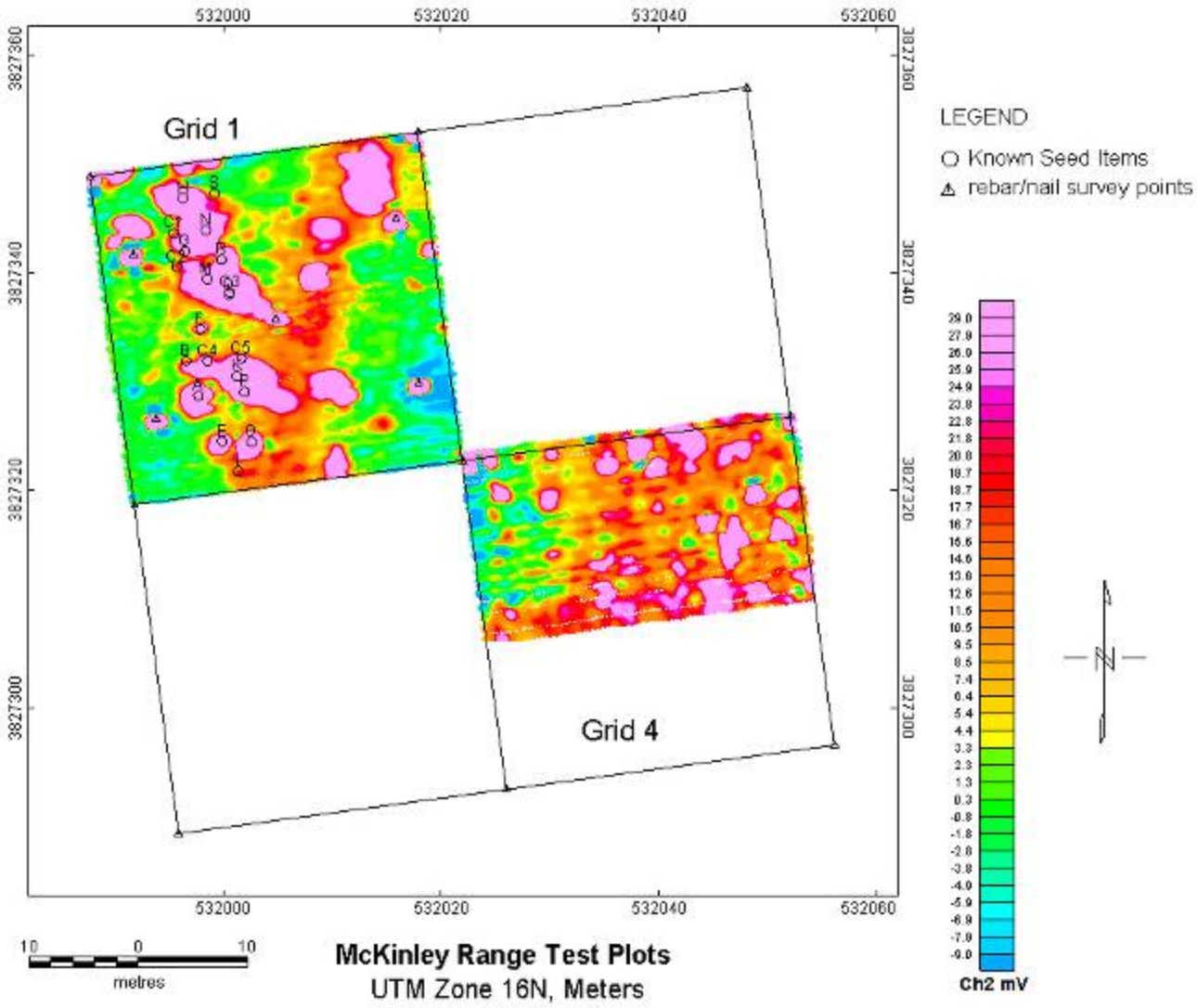
Towed, dual coil, tub, normal speed (same color scale):



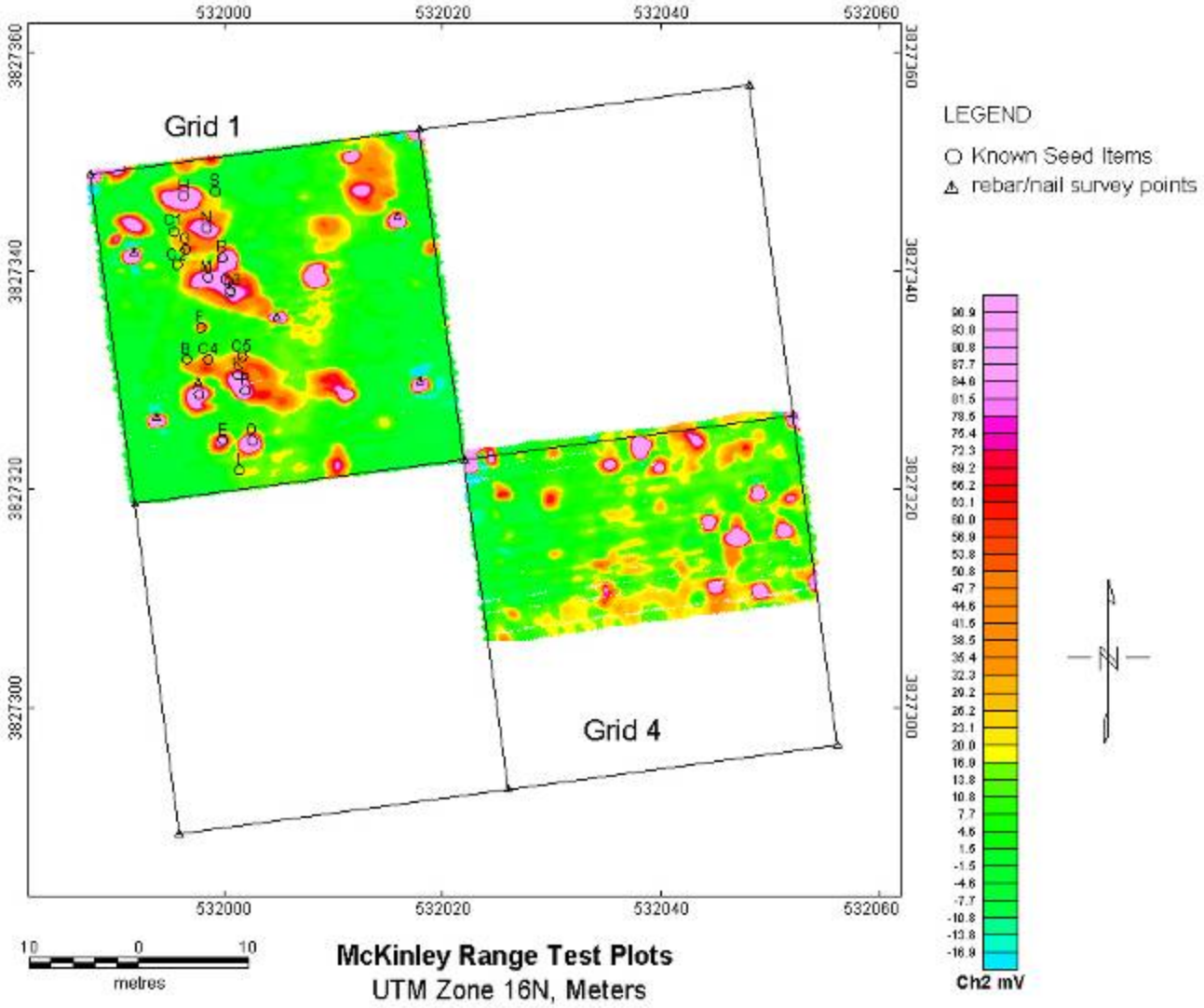
Towed, dual coil, tub, normal speed (different color scale):



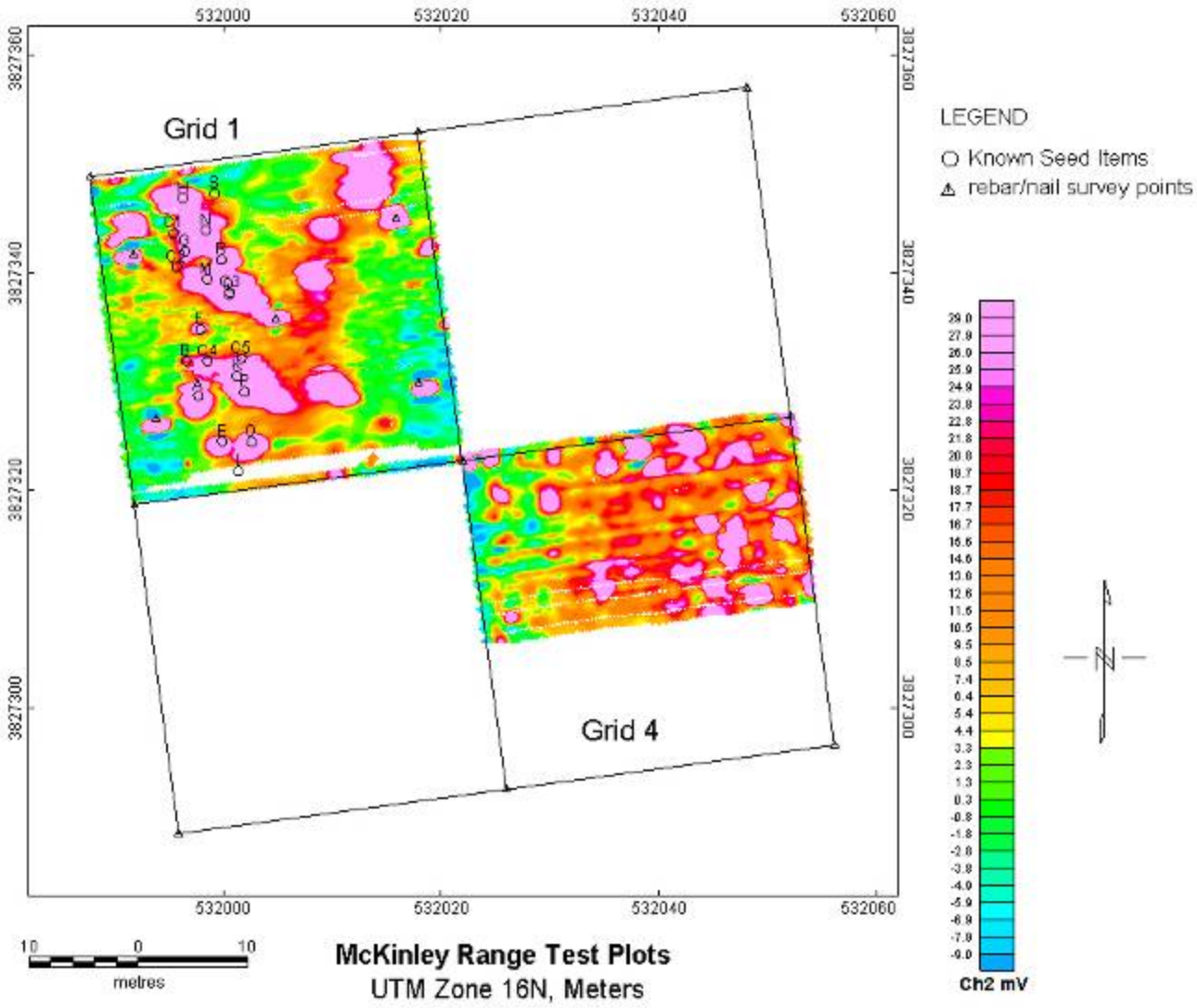
Towed, dual coil, tub, fast speed:



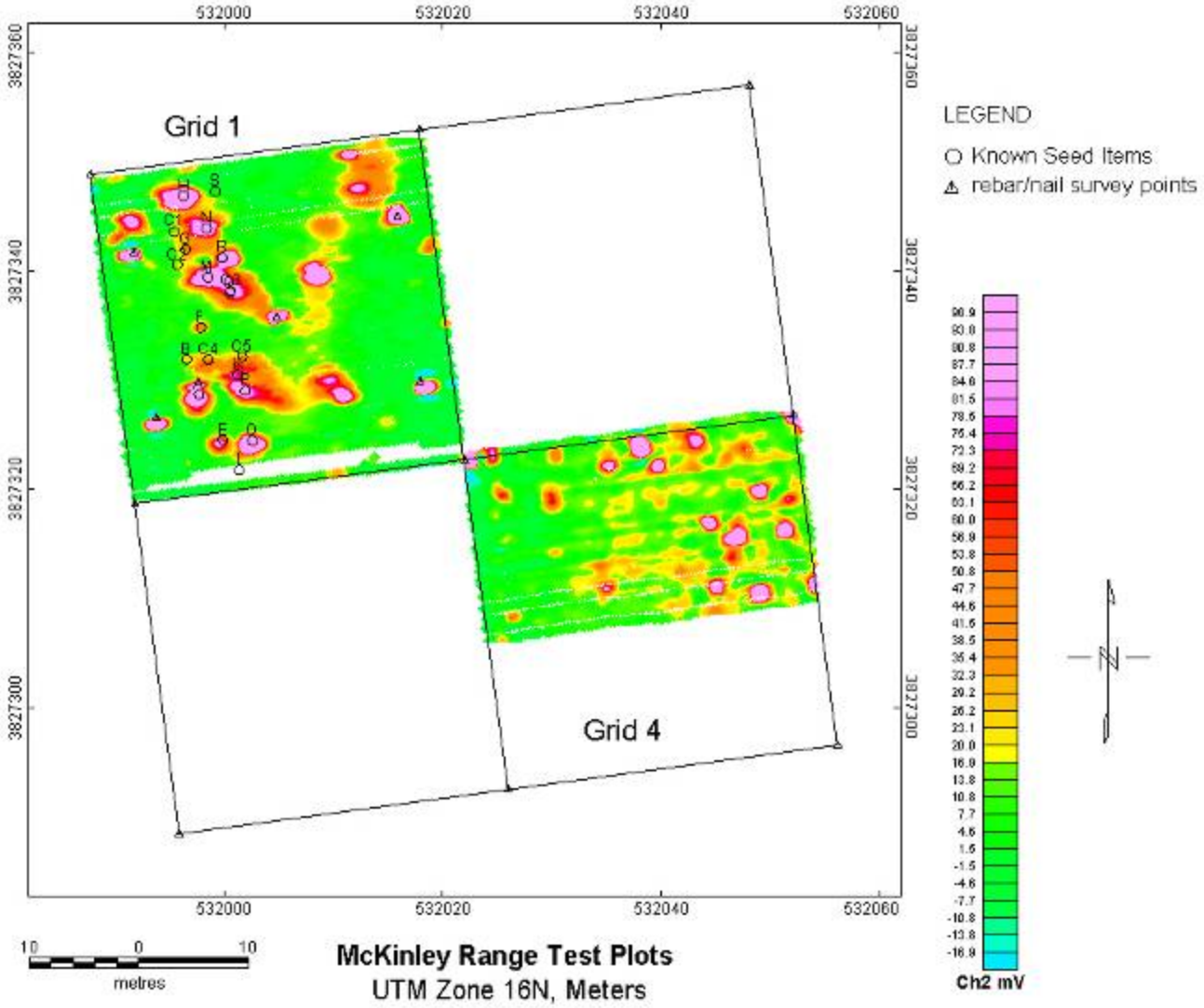
Towed, dual coil, tub, fast speed (different color scale):



Towed, dual coil, tub, very fast speed:



Towed, dual coil, tub, very fast speed (different color scale):



Appendix C: Background Statistics & Noise

Channel 1 background statistics:

Grid_Data_source	Speed(m/s)	Minimum	Maximum	Mean	Median	Mode	StdDev	4th_diff_StD	# points
g1_manPort_slow	0.73	-9.37	10.08	0	0.36	0.16	1.07	1.83	4640
g1_manPort_norm	1.57	-7.57	5.11	0.01	0.09	0.23	1.24	2.18	2259
g1_sing_wheel_norm	1.06	-5.9	6.7	-0.39	-0.13	-0.26	1.06	1.44	3223
g1_sing_wheel_fast	2.64	-7.21	5.6	-0.84	-0.8	-0.94	1.39	2.16	1392
g1_multi_wheel_norm	1.75	-14.14	14.02	-0.28	-0.06	-0.36	2.12	3.77	1979
g1_multi_wheel_fast	2.58	-15.66	22.12	-0.11	0.08	-0.31	2.78	4.24	1510
g1_multi_wheel_Xfast	3.37	-12.98	16.95	0.01	0.12	-0.19	2.54	5.11	1239
g1_multi_wheel_loose	2.17	-7.46	9.34	0.03	0.24	0.77	2.31	3.85	896
g1_multi_skid_norm	1.48	-6.12	7.54	-0.3	-0.15	-0.29	1.66	2.51	2974
g1_multi_skid_fast	2.07	-8.5	7.32	-0.01	0.07	-0.43	1.85	3.23	2049
g1_multi_skid_Xfast	3.12	-10.36	7.39	0.04	0.37	0.18	2.13	4.51	1304
g1_multi_tub_norm	1.55	-17.43	37.87	-0.75	-1.3	-3.03	6.02	7.74	2363
g1_multi_tub_fast	2.3	-17.13	27.86	-0.99	-1.2	-4.48	5.45	7.36	2012
g1_multi_tub_Xfast	3.07	-16.71	157.71	-0.1	1.46	-0.35	7.34	37.42	1750
g4_manPort_slow	0.63	-4.84	5.59	-0.04	-0.06	-0.17	1	1.51	1763
g4_manPort_norm	1.58	-4.02	4.63	-0.17	-0.06	-0.51	1.21	2.63	685
g4_sing_wheel_norm	1.48	-4.19	4.84	-0.9	-0.8	-0.33	1.28	2.19	745
g4_multi_wheel_norm	1.56	-17.15	17.89	0.52	1.1	1.47	2.99	5.14	681
g4_multi_skid_norm	1.54	-6	7.71	1.16	1.42	2.42	2.37	5.04	805
g4_multi_tub_norm	1.54	-15.74	21.75	2.7	2.23	-0.51	8.16	7.86	820
g4_multi_tub_fast	2.02	-24.14	33.53	3.23	3.49	7.7	11.55	12.49	643
g4_multi_tub_Xfast	2.27	-19.45	29.65	5.12	6.12	6.63	10.59	12.7	576

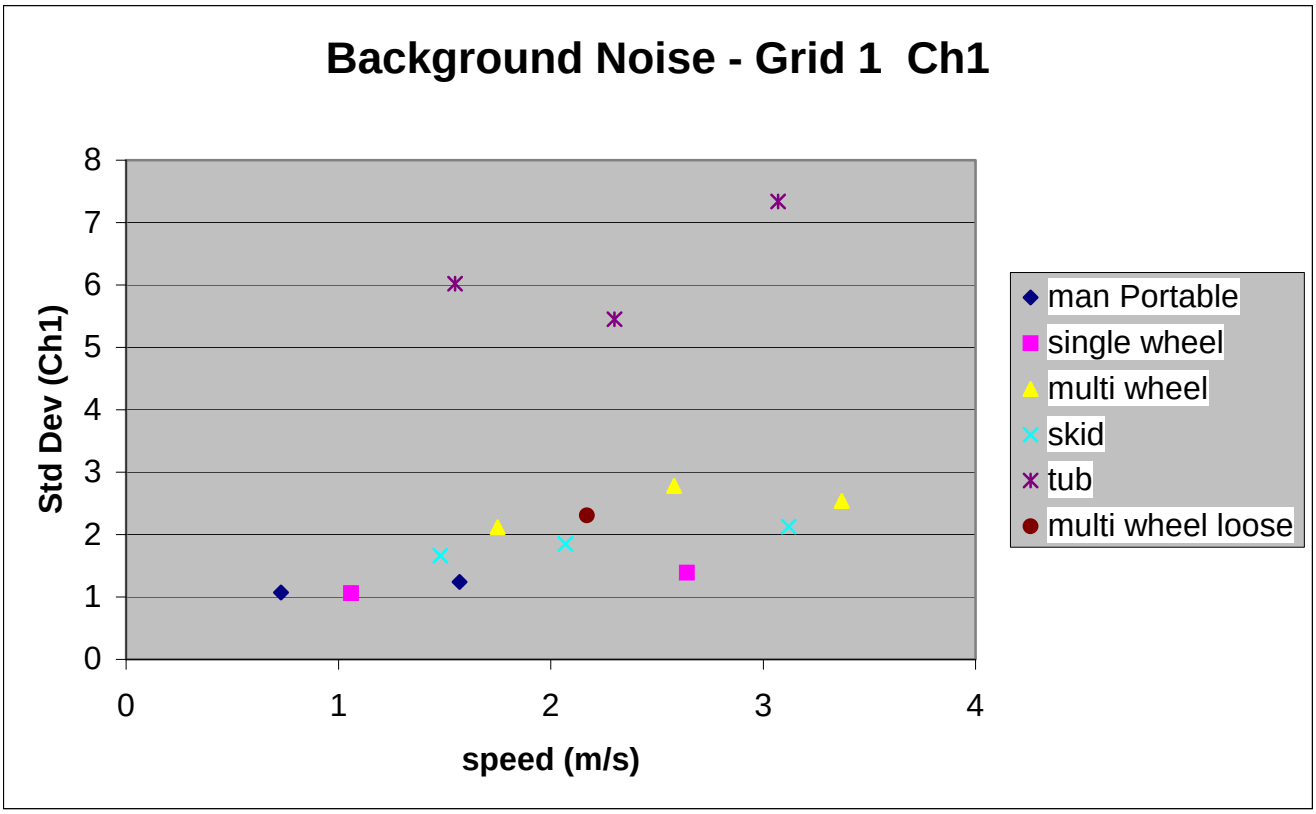
Channel 3 background statistics:

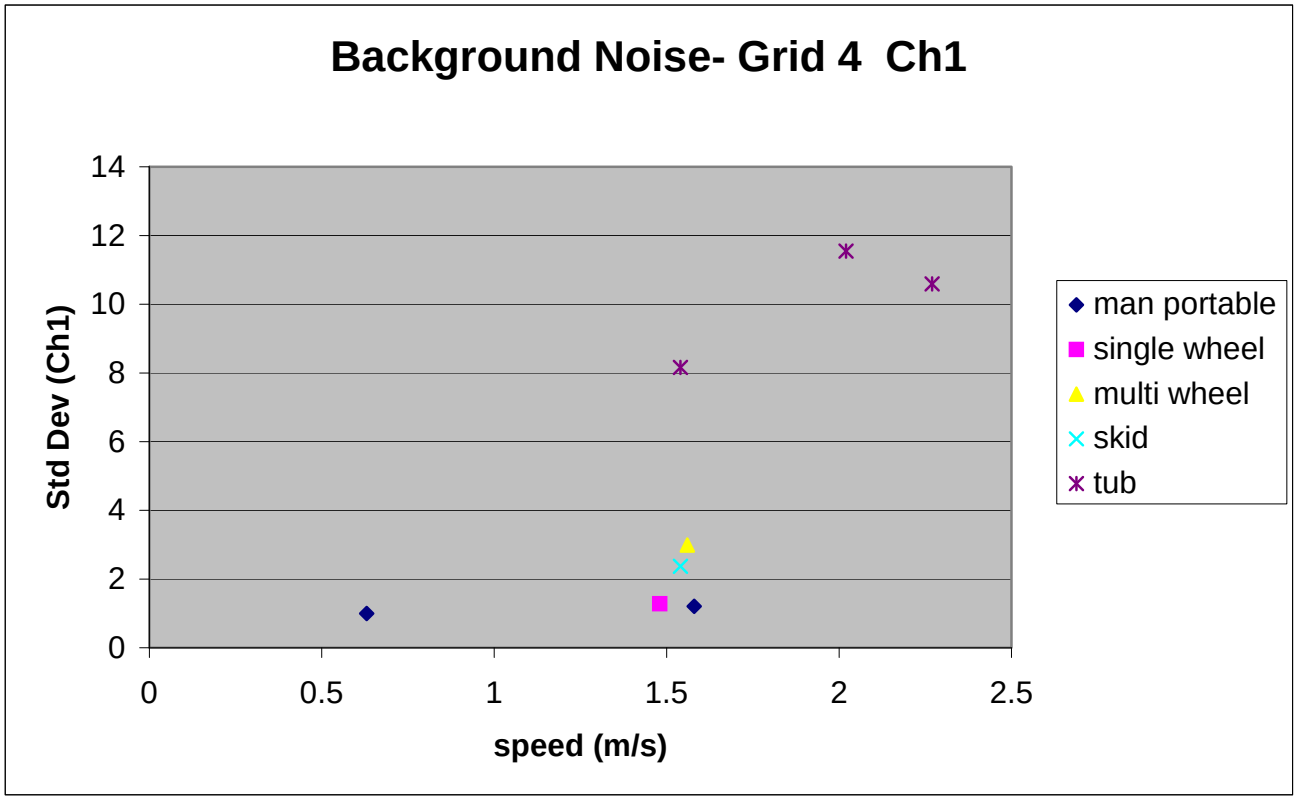
Grid_Data_source	speed (m/s)	Minimum	Maximum	Mean	Median	Mode	StdDev	4th_diff_StD	# points
g1_manPort_slow	0.73	-5.62	3.38	0.01	0.19	0.1	0.54	1.54	4640
g1_manPort_norm	1.57	-4.48	3.62	0.04	0.08	0.16	0.86	1.82	2259
g1_sing_wheel_norm	1.06	-2.38	1.4	-0.18	-0.09	0.02	0.44	1.19	3223
g1_sing_wheel_fast	2.64	-2.74	1.51	-0.34	-0.26	-0.21	0.58	1.07	1392
g1_multi_wheel_norm	1.75	-5.43	5.34	-0.17	-0.04	-0.16	0.93	1.87	1979
g1_multi_wheel_fast	2.58	-8.05	5.12	-0.1	0.18	-0.09	1.16	1.94	1510
g1_multi_wheel_Xfast	3.37	-5.26	4.97	0.04	0.06	-0.25	1.36	2.8	1239
g1_multi_wheel_loose	2.17	-7.07	8.38	0.21	0.33	0.49	2.11	2.99	896
g1_multi_skid_norm	1.48	-2.9	3.81	-0.12	-0.1	-0.03	0.76	1.41	2974
g1_multi_skid_fast	2.07	-3.7	5.16	0.07	0.18	0.08	1.07	1.87	2049
g1_multi_skid_Xfast	3.12	-6.99	6.4	-0.01	-0.02	-0.16	1.22	2.61	1304
g1_multi_tub_norm	1.55	-7.08	8.5	-0.39	-0.59	-0.75	2.36	3.17	2363
g1_multi_tub_fast	2.3	-10.45	7.77	-0.53	-0.58	-1.91	2.32	3.42	2012
g1_multi_tub_Xfast	3.07	-9.6	19.95	0.03	0.25	-1.29	2.77	5.92	1750
g4_manPort_slow	0.63	-2.33	1.95	-0.03	-0.02	0.03	0.41	1.65	1763
g4_manPort_norm	1.58	-1.73	2.13	-0.09	-0.04	0.08	0.53	1.48	685
g4_sing_wheel_norm	1.48	-1.69	1.06	-0.34	-0.31	-0.34	0.51	0.92	745
g4_multi_wheel_norm	1.56	-5.4	8.3	0.13	0.31	0.31	1.15	2.27	681
g4_multi_skid_norm	1.54	-4.73	3.84	0.24	0.45	0.18	1.13	2.47	805
g4_multi_tub_norm	1.54	-5.81	9.26	1.14	1.1	1.57	3.31	3.67	820

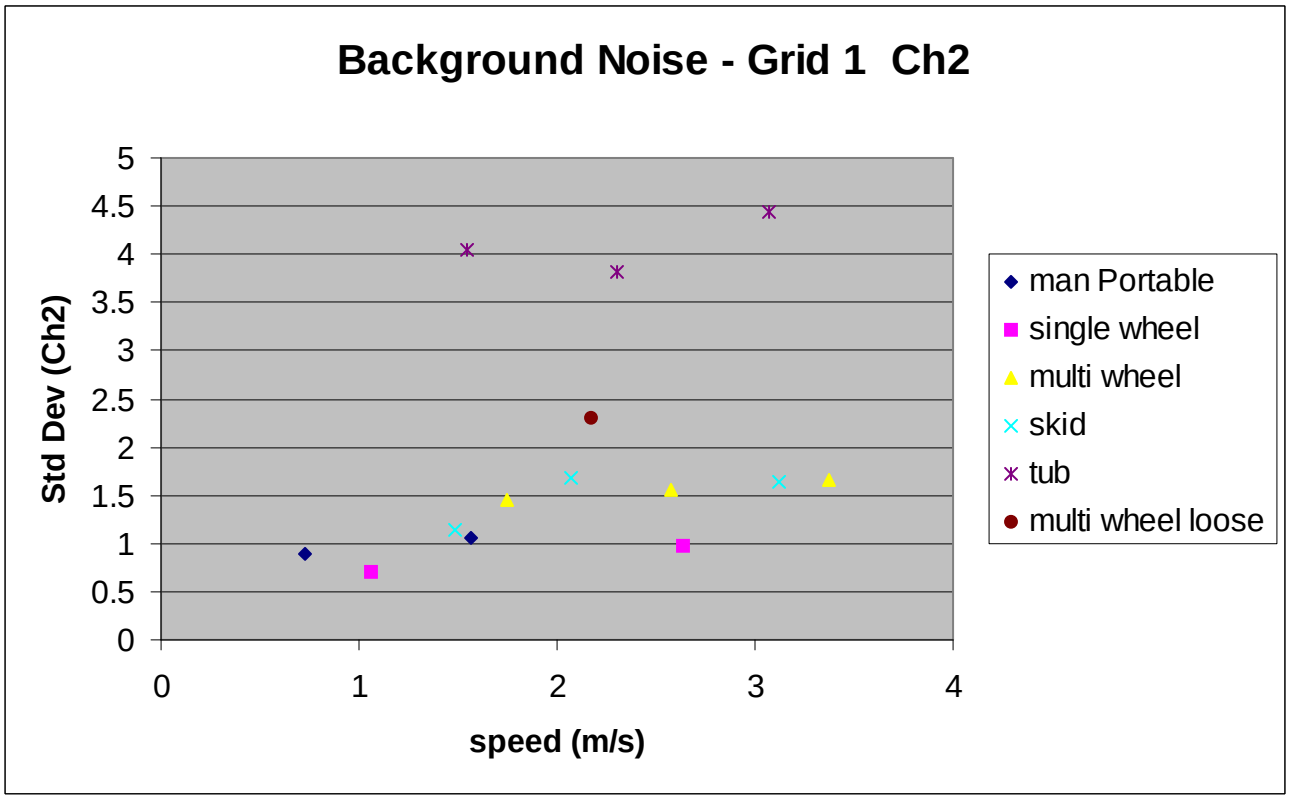
g4_multi_tub_fast	2.02	-8.86	15.41	1.65	1.76	1.5	4.7	5.29	643
g4_multi_tub_Xfast	2.27	-7.86	13.49	2.28	2.82	3.48	4.24	6.19	576

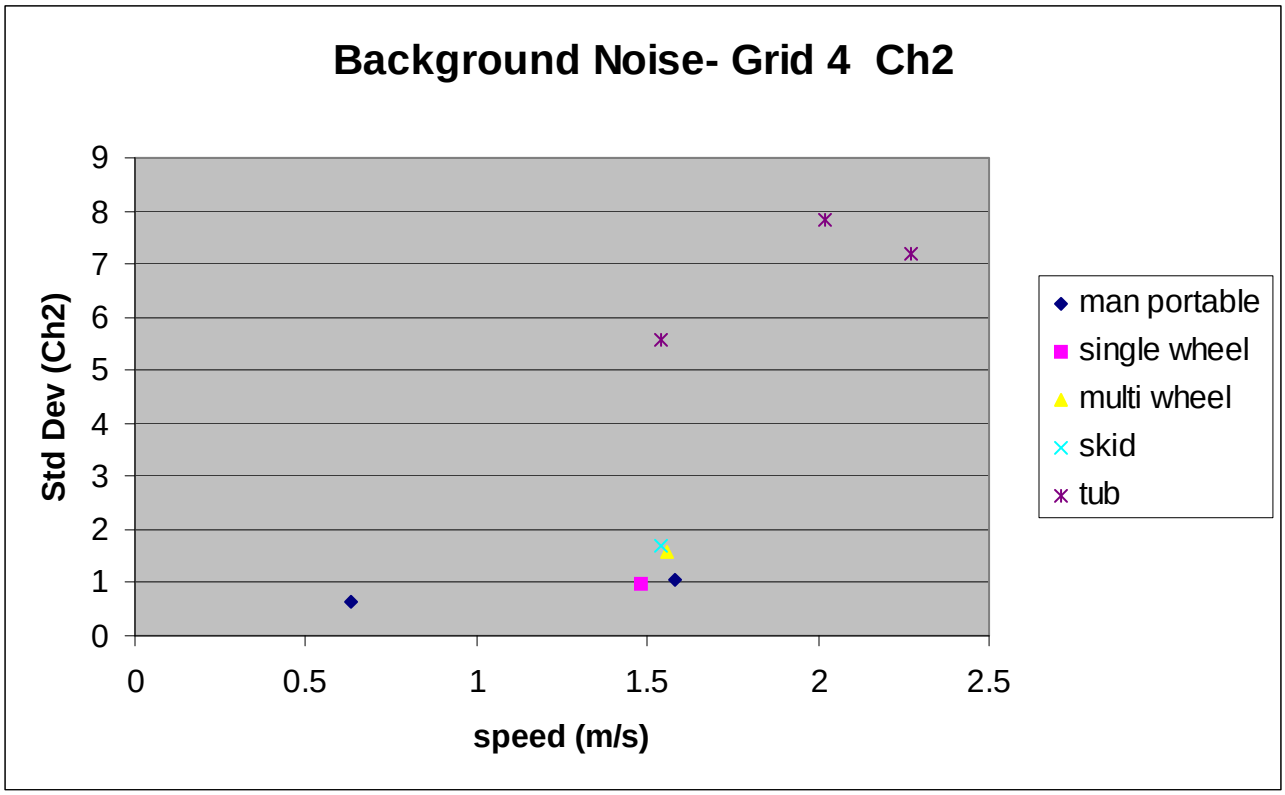
Channel 4 background statistics:

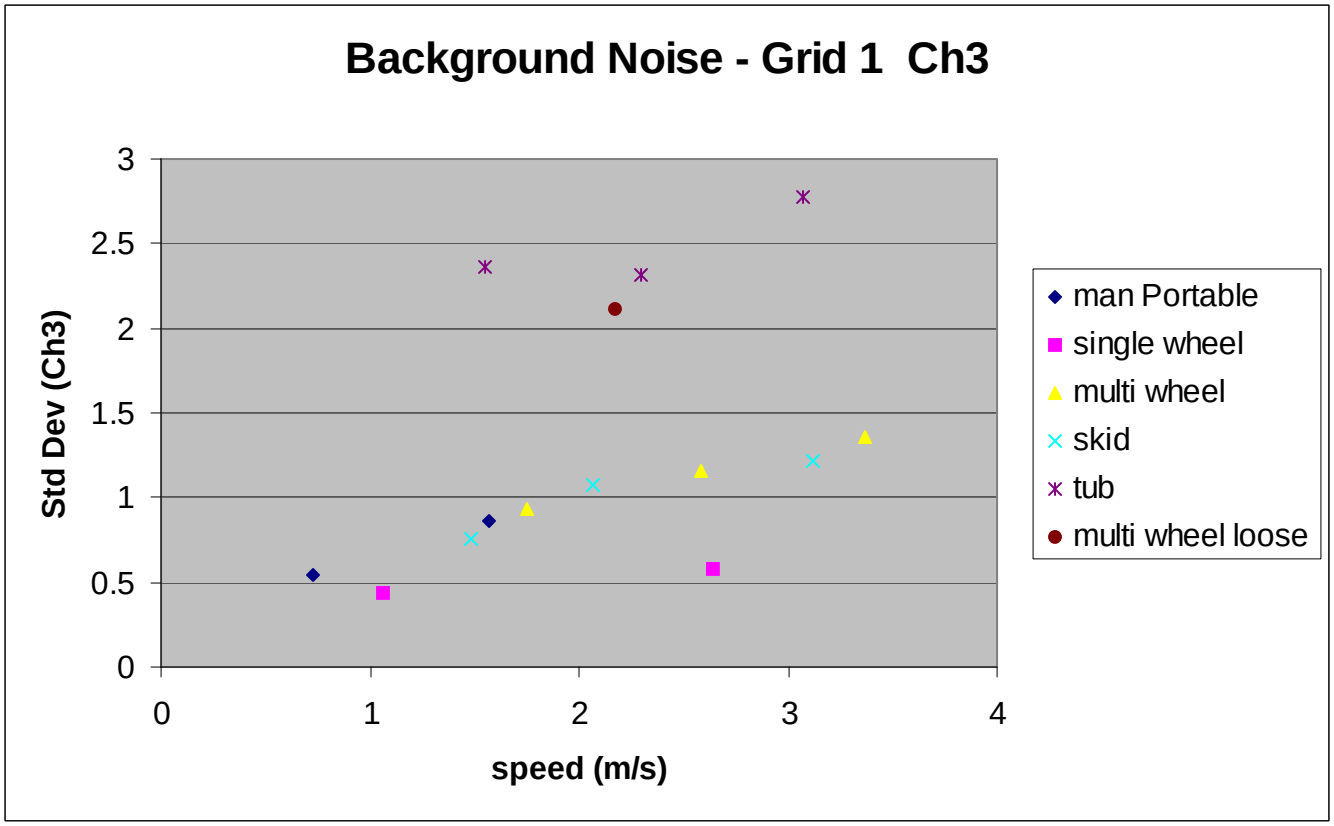
Grid_Data_source	Speed (m/s)	Minimum	Maximum	Mean	Median	Mode	StdDev	4th_diff_StD	# points
g1_manPort_slow	0.73	-2.83	1.78	0.04	0.15	0.1	0.36	1.31	4640
g1_manPort_norm	1.57	-2.18	2.94	0.1	0.17	0.01	0.66	1.71	2259
g1_sing_wheel_norm	1.06	-1.16	0.96	-0.07	-0.01	0.06	0.25	1.29	3223
g1_sing_wheel_fast	2.64	-1.65	1.34	-0.15	-0.09	0.07	0.35	0.88	1392
g1_multi_wheel_norm	1.75	-3.56	3.21	-0.06	-0.04	0.04	0.62	1.65	1979
g1_multi_wheel_fast	2.58	-3.97	4.03	0.01	0.03	0.11	0.8	1.69	1510
g1_multi_wheel_Xfast	3.37	-3.35	4.91	0.14	0.26	0.35	1.05	2.53	1239
g1_multi_wheel_loose	2.17	-6.5	7.35	0.2	0.14	0.14	1.84	2.45	896
g1_multi_skid_norm	1.48	-2.18	2.17	-0.06	-0.01	-0.05	0.49	1.21	2974
g1_multi_skid_fast	2.07	-4.01	6.86	0.05	0.07	-0.05	0.82	2.21	2049
g1_multi_skid_Xfast	3.12	-4.37	3.55	-0.05	0.08	0.17	0.97	2.11	1304
g1_multi_tub_norm	1.55	-4.78	4.76	-0.17	-0.21	-0.7	1.22	2.12	2363
g1_multi_tub_fast	2.3	-7.81	6.89	-0.21	-0.15	-0.61	1.38	2.59	2012
g1_multi_tub_Xfast	3.07	-8.15	14.5	0.03	0.35	-0.36	1.89	5.36	1750
g4_manPort_slow	0.63	-1.32	0.84	0	0.03	-0.04	0.29	1.85	1763
g4_manPort_norm	1.58	-1.09	1.55	-0.03	0.01	-0.13	0.36	1.17	685
g4_sing_wheel_norm	1.48	-1.14	0.62	-0.14	-0.15	0.02	0.28	0.79	745
g4_multi_wheel_norm	1.56	-1.81	2.87	0.2	0.14	0.19	0.63	1.44	681
g4_multi_skid_norm	1.54	-5.29	2.44	0.19	0.35	0.43	0.69	1.9	805
g4_multi_tub_norm	1.54	-3.45	4.61	0.59	0.58	0.5	1.55	2.42	820
g4_multi_tub_fast	2.02	-5.07	6.85	0.56	0.64	0.02	2.01	3.4	643
g4_multi_tub_Xfast	2.27	-5.95	6.74	1.06	1.19	1.32	2.21	4.58	576

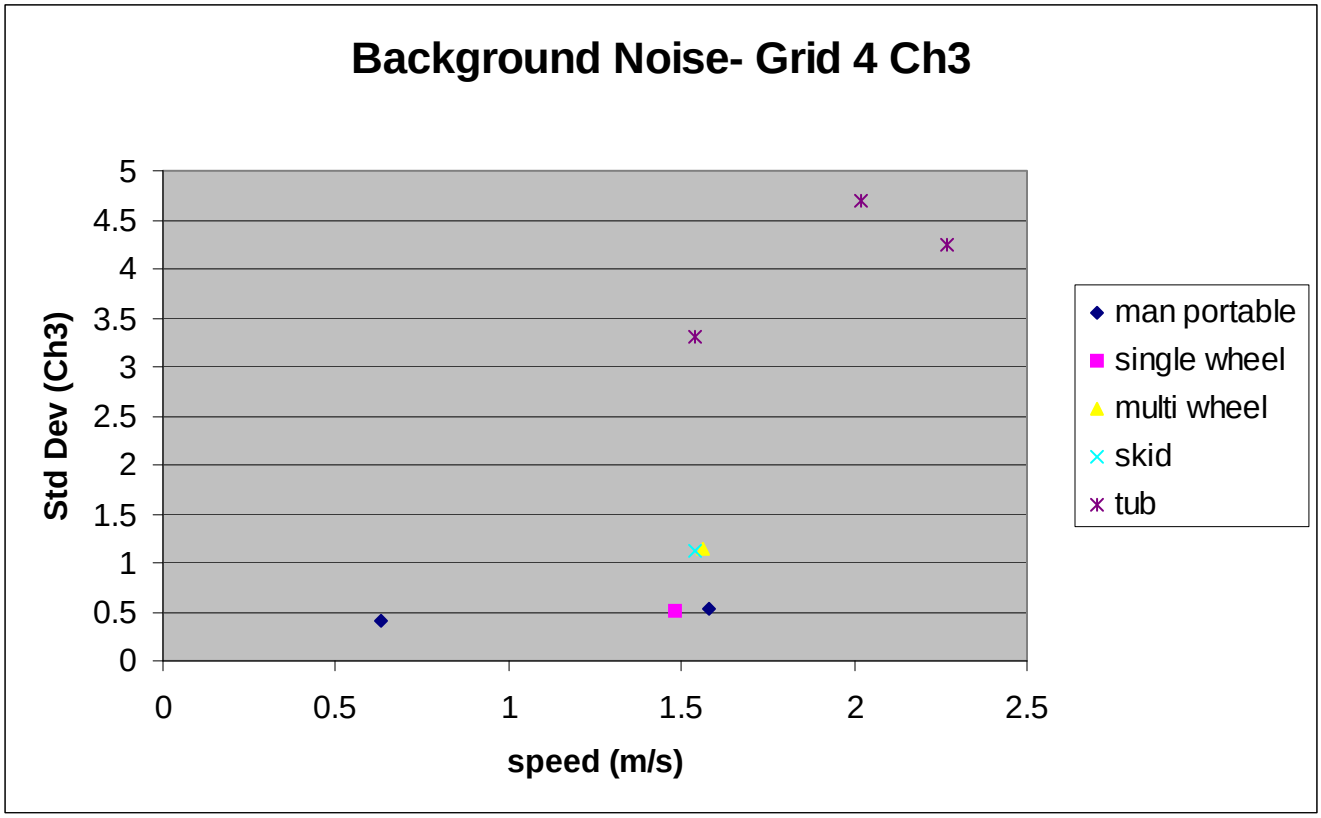

Background Noise - Grid 1 Ch1
Std Dev (Ch1)
8
7
6
5
4
3
2
1
0
0
1
2
3
4
speed (m/s)
man Portable
single wheel
multi wheel
skid
tub
multi wheel loose

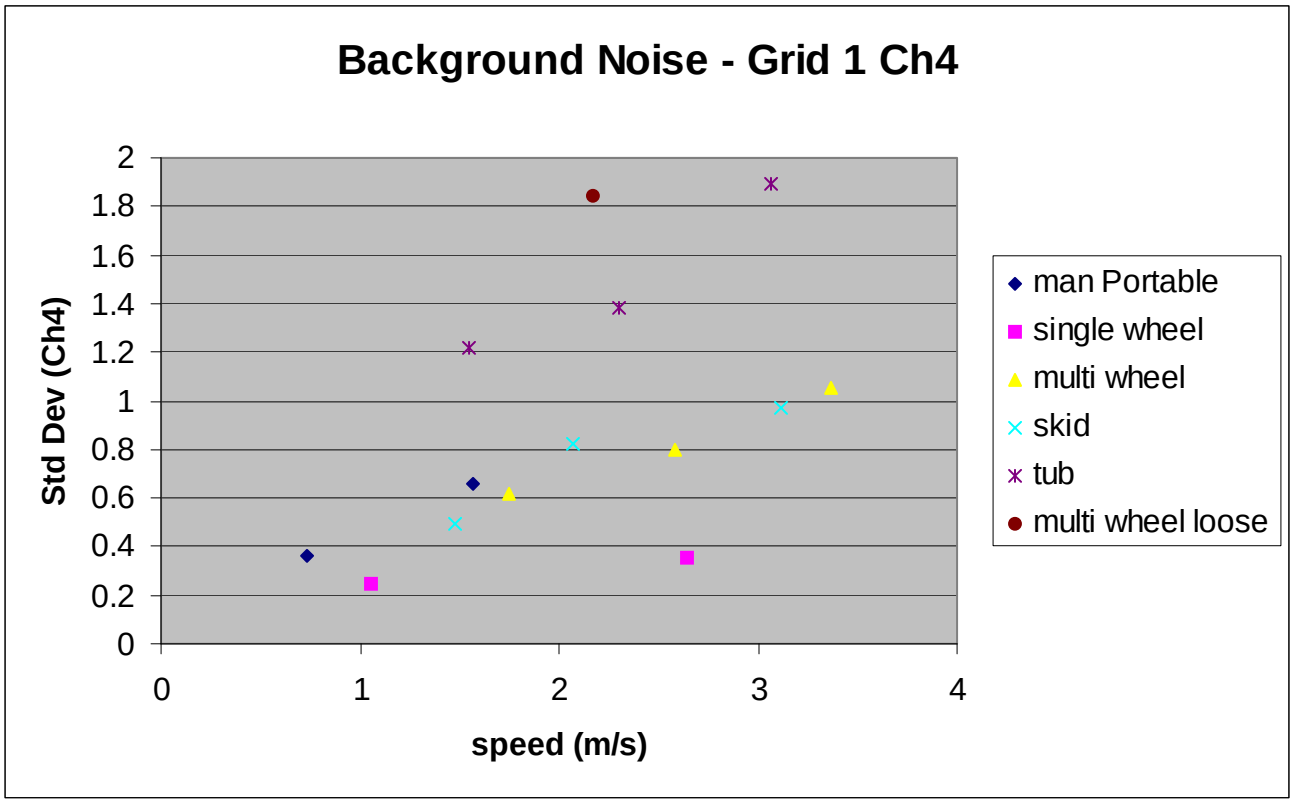

Background Noise- Grid 4 Ch1
Std Dev (Ch1)
14
12
10
8
6
4
2
0
0
0.5
1
1.5
2
2.5
speed (m/s)
man portable
single wheel
multi wheel
skid
tub

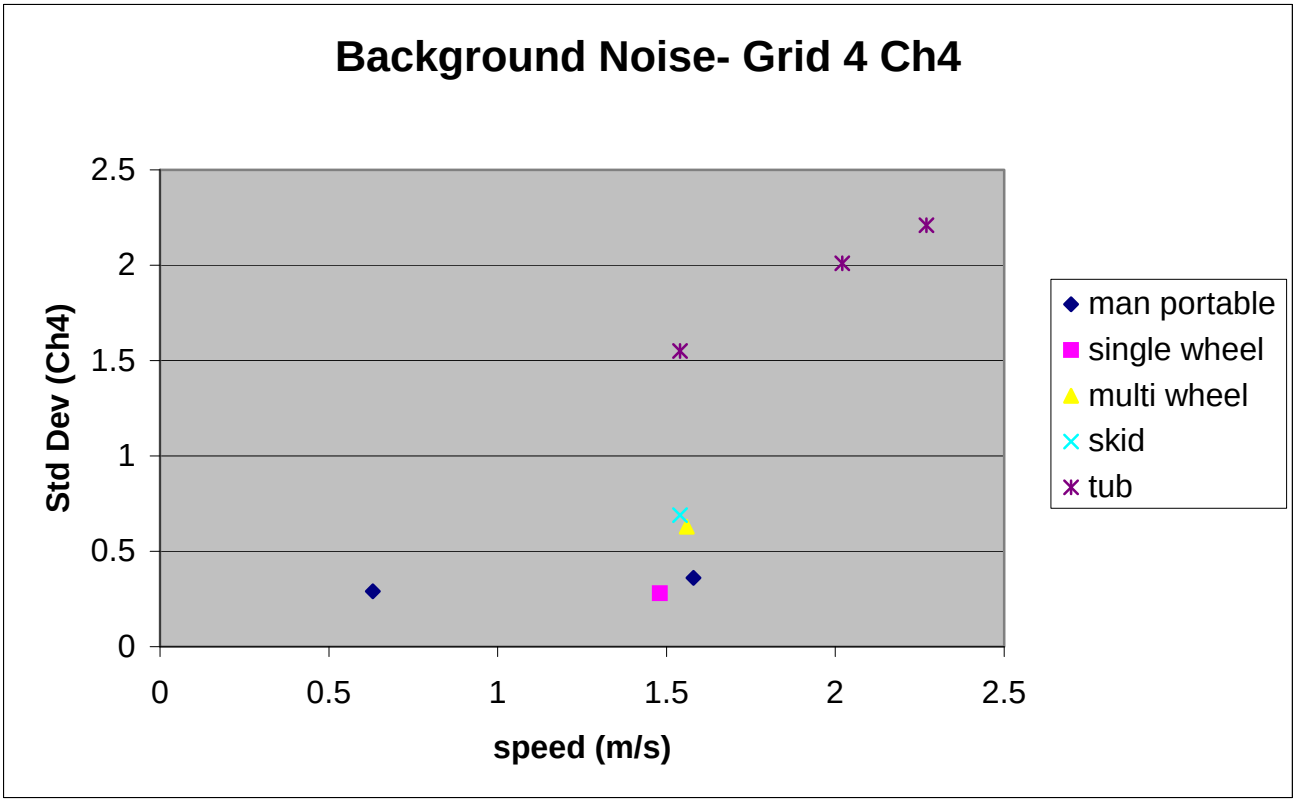

Background Noise - Grid 1 Ch2
Std Dev (Ch2)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
speed (m/s)
man Portable
single wheel
multi wheel
skid
tub
multi wheel loose

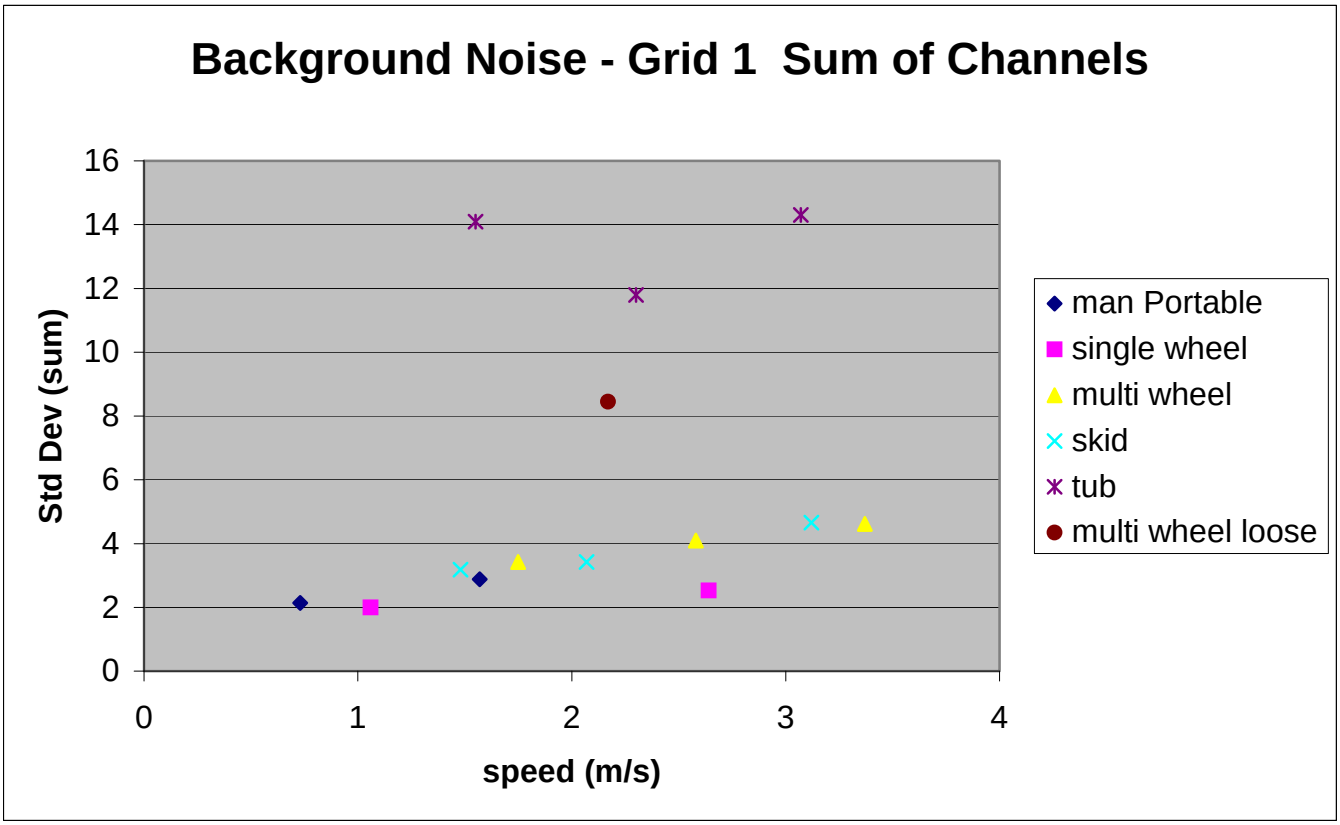

Background Noise- Grid 4 Ch2
Std Dev (Ch2)
speed (m/s)
0
1
2
3
4
5
6
7
8
9
0
0.5
1
1.5
2
2.5
man portable
single wheel
multi wheel
skid
tub

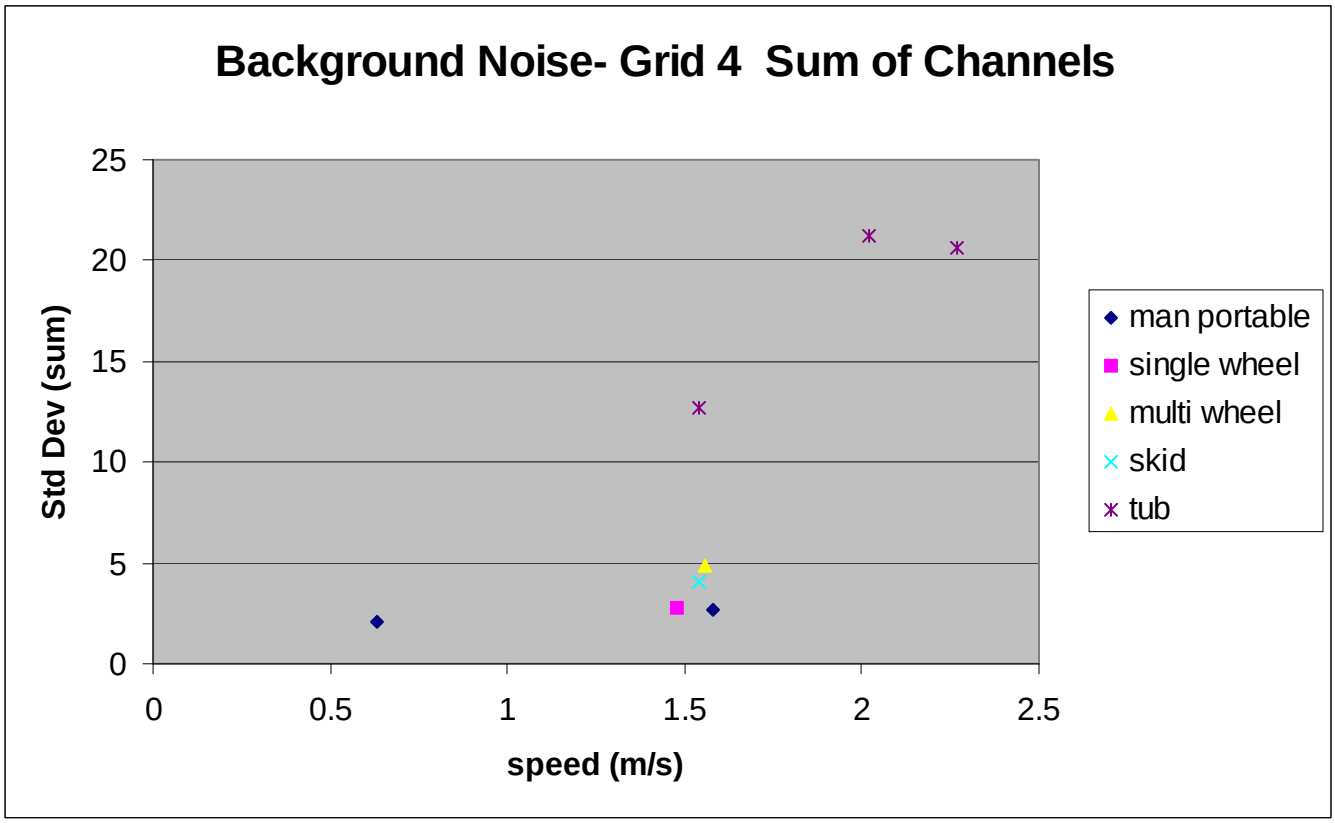

Background Noise - Grid 1 Ch3
Std Dev (Ch3)
speed (m/s)
0
0.5
1
1.5
2
2.5
3
0
1
2
3
4
man Portable
single wheel
multi wheel
skid
tub
multi wheel loose


Background Noise- Grid 4 Ch3
Std Dev (Ch3)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
speed (m/s)
man portable
single wheel
multi wheel
skid
tub

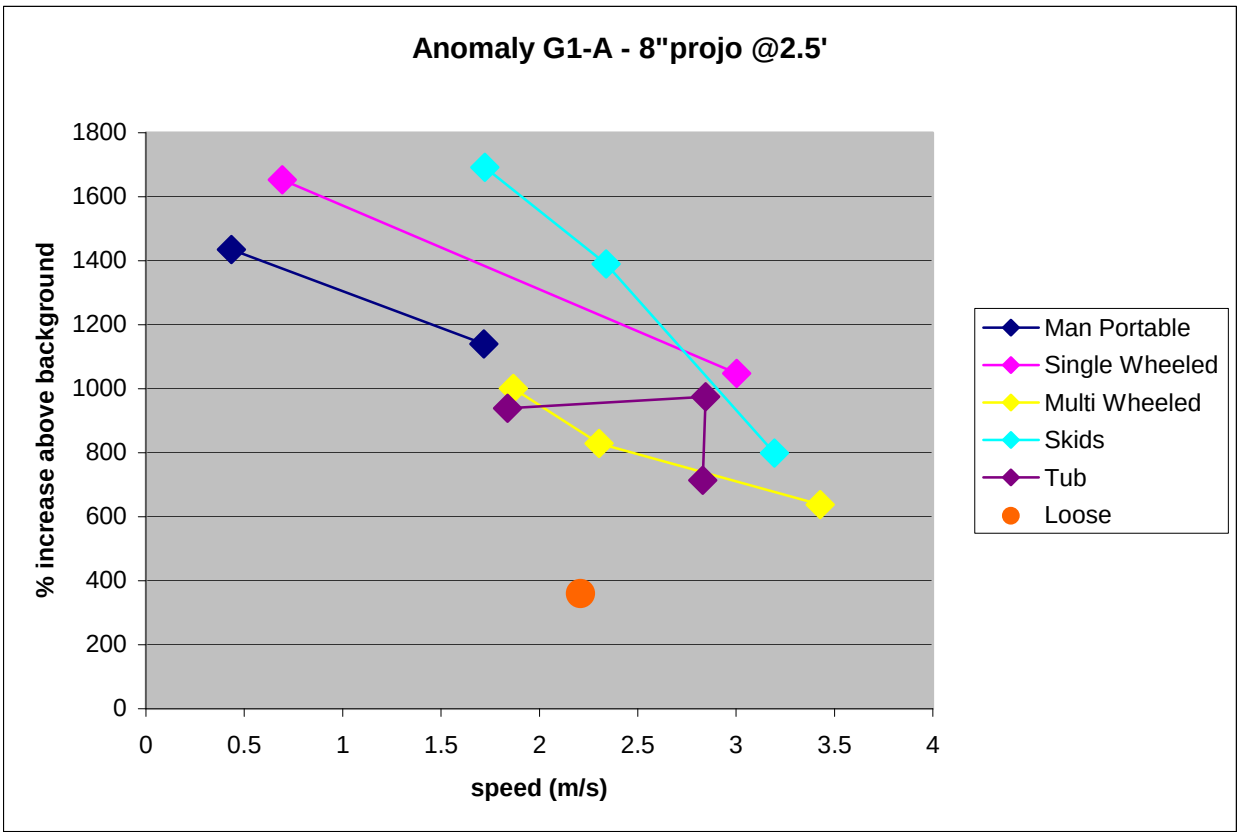

Background Noise - Grid 1 Ch4
Std Dev (Ch4)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
speed (m/s)
man Portable
single wheel
multi wheel
skid
tub
multi wheel loose

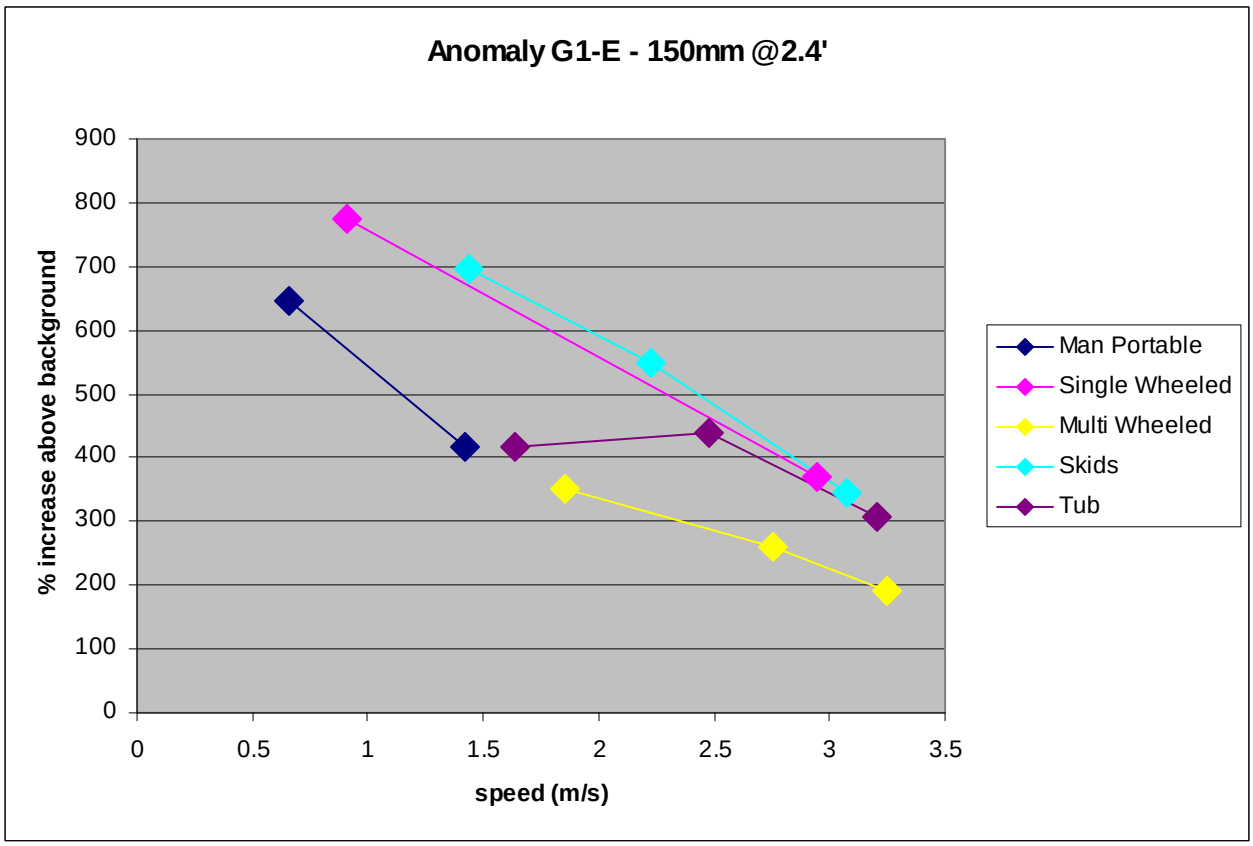

Background Noise- Grid 4 Ch4
Std Dev (Ch4)
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
speed (m/s)
man portable
single wheel
multi wheel
skid
tub

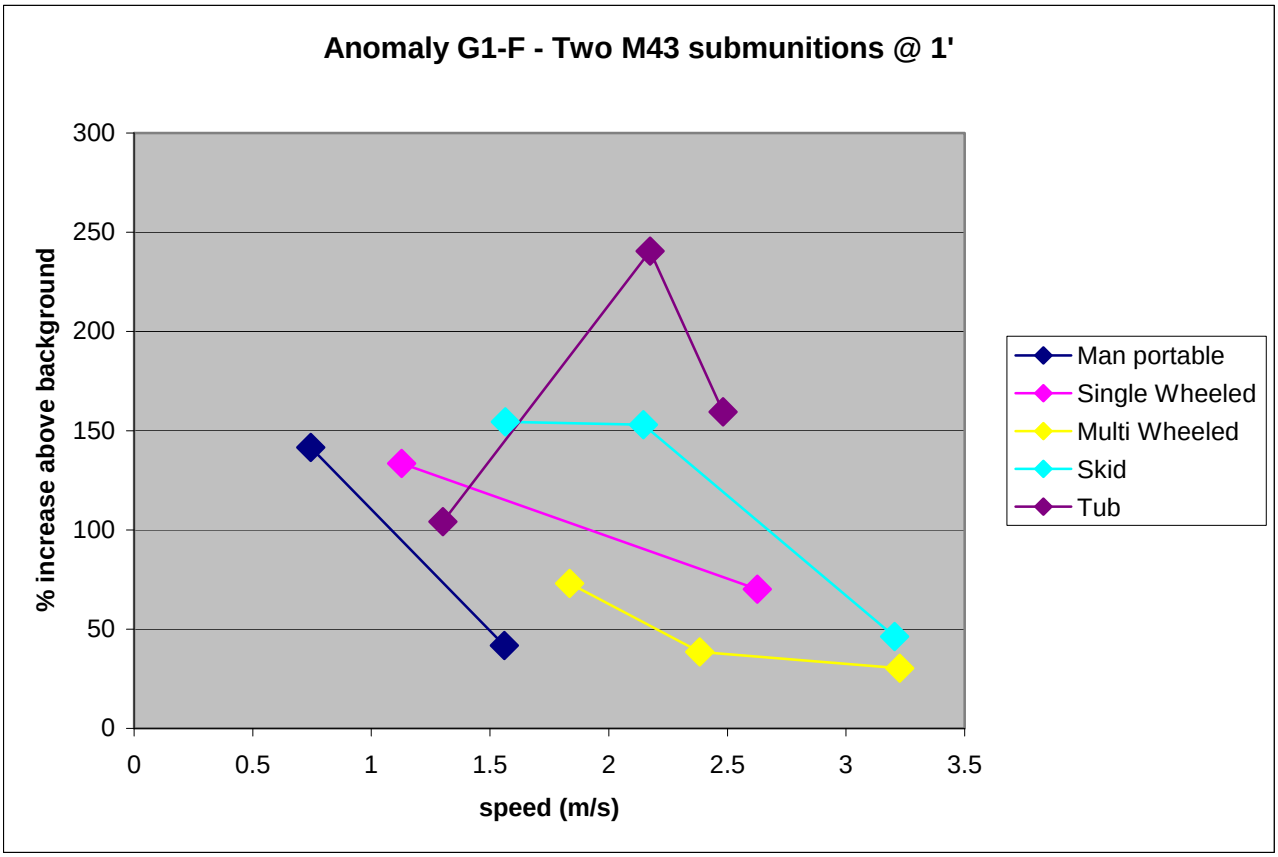

Background Noise - Grid 1 Sum of Channels
Std Dev (sum)
16
14
12
10
8
6
4
2
0
0
1
2
3
4
speed (m/s)
man Portable
single wheel
multi wheel
skid
tub
multi wheel loose

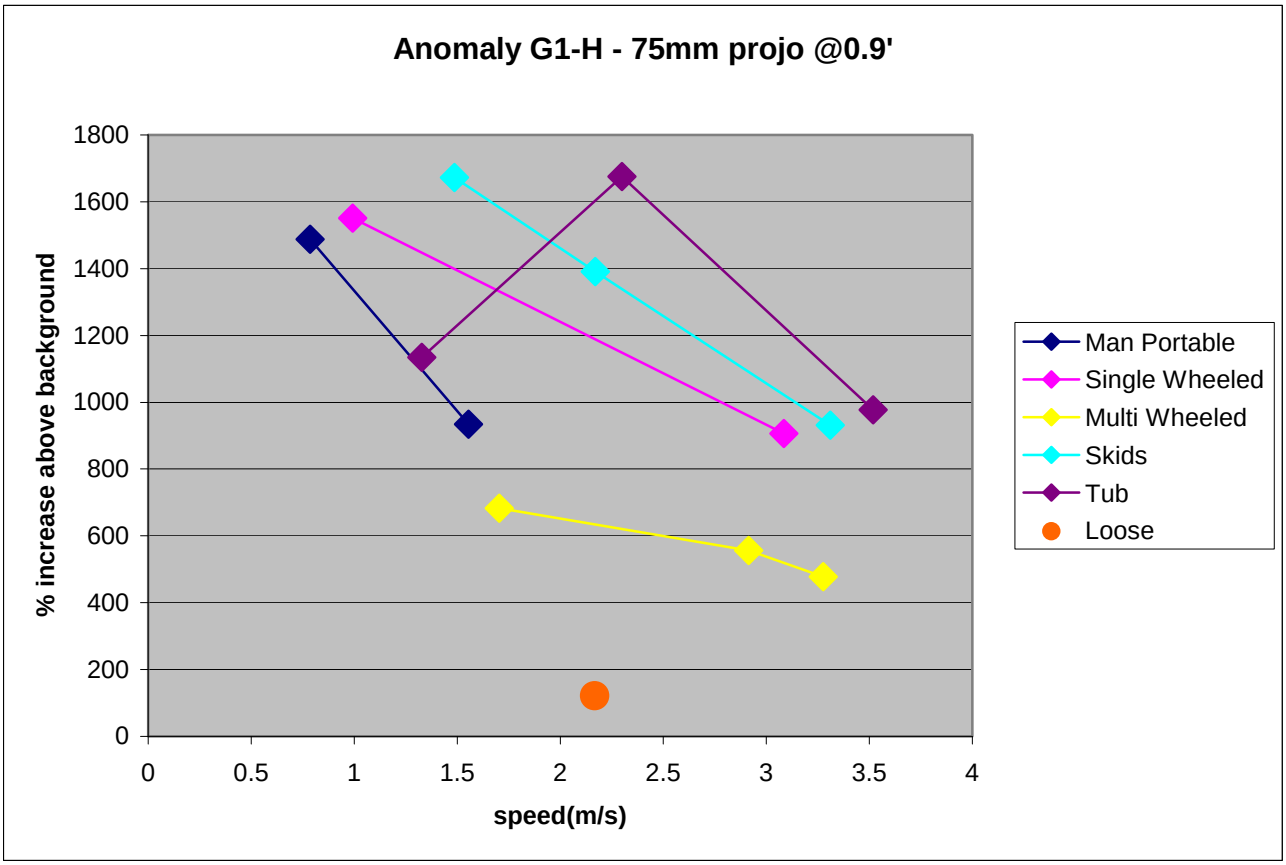

Background Noise- Grid 4 Sum of Channels
Std Dev (sum)
25
20
15
10
5
0
0
0.5
1
1.5
2
2.5
speed (m/s)
man portable
single wheel
multi wheel
skid
tub

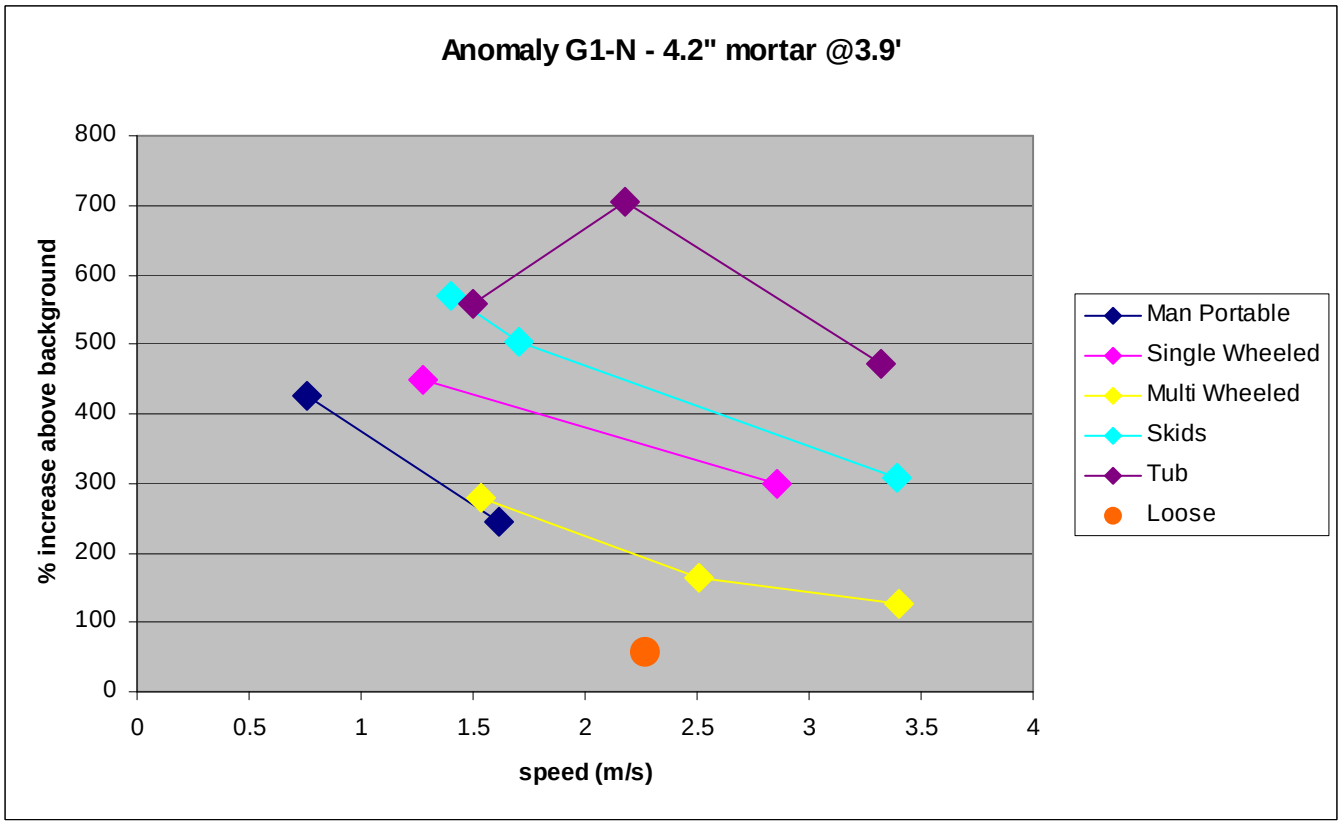
Appendix D: Seed Item Peak Response Percentage Increase Above Background (Sum of 4 Time Gates)

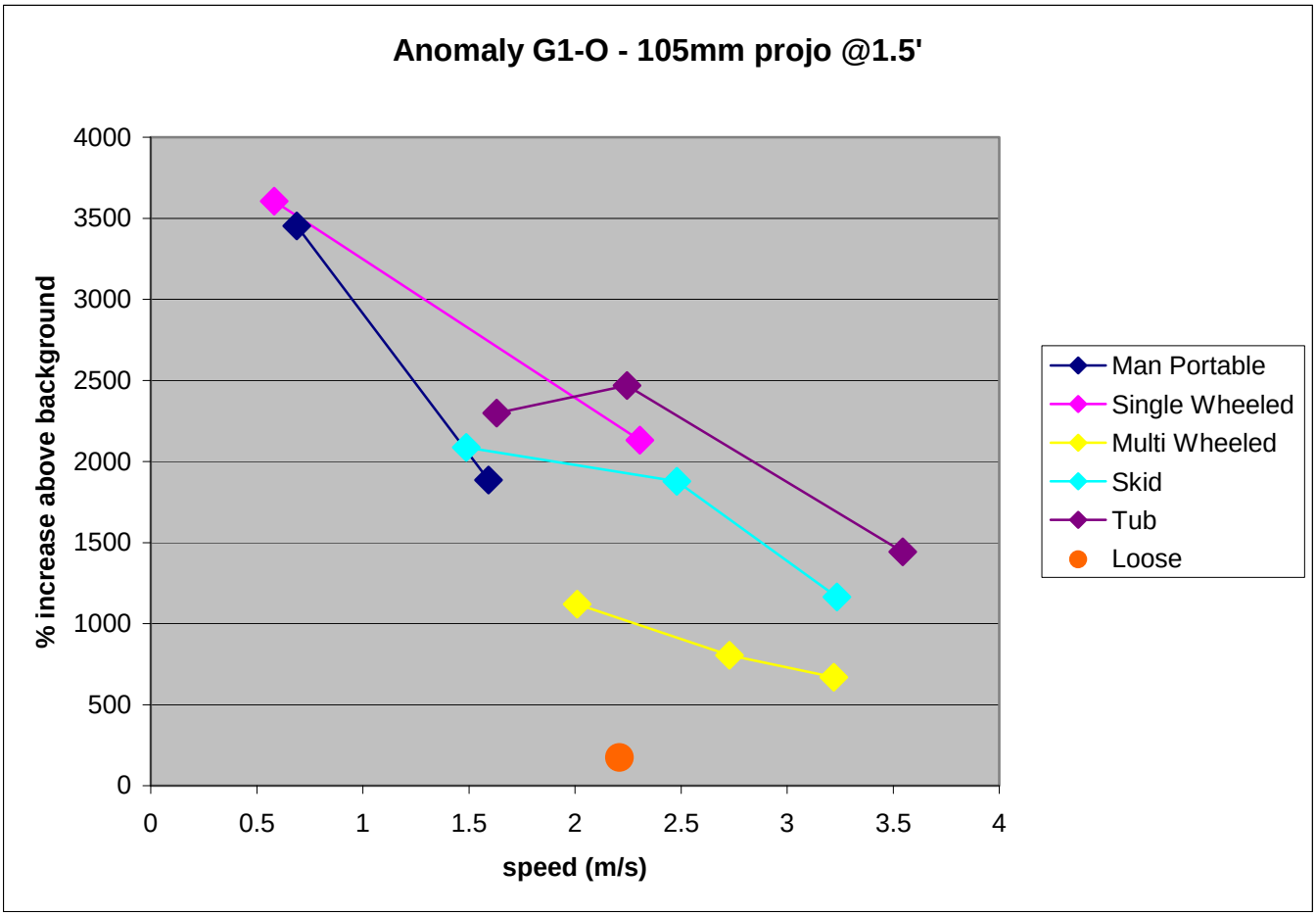

Anomaly G1-A - 8"projo @2.5'
% increase above background
speed (m/s)
0
200
400
600
800
1000
1200
1400
1600
1800
0
0.5
1
1.5
2
2.5
3
3.5
4
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

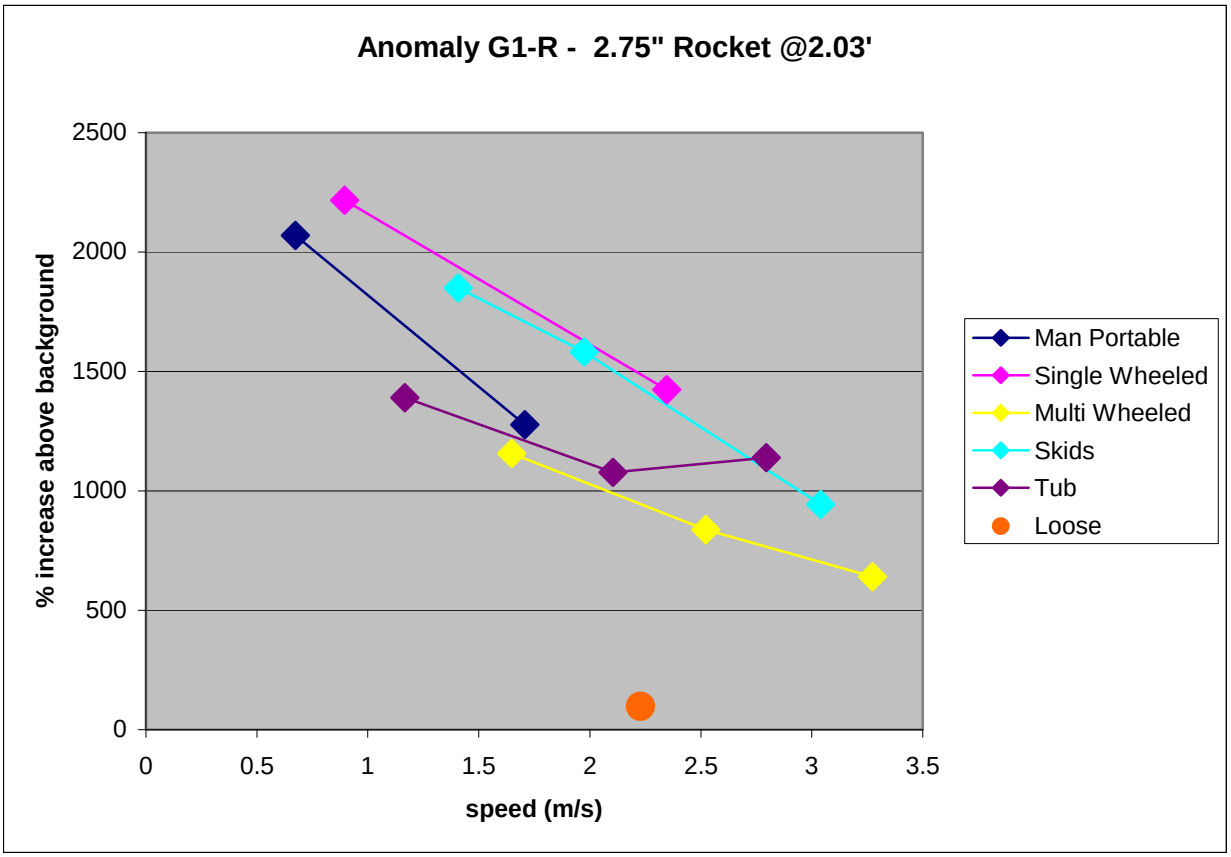

Anomaly G1-E - 150mm @2.4'
% increase above background
speed (m/s)
0
100
200
300
400
500
600
700
800
900
0
0.5
1
1.5
2
2.5
3
3.5
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub

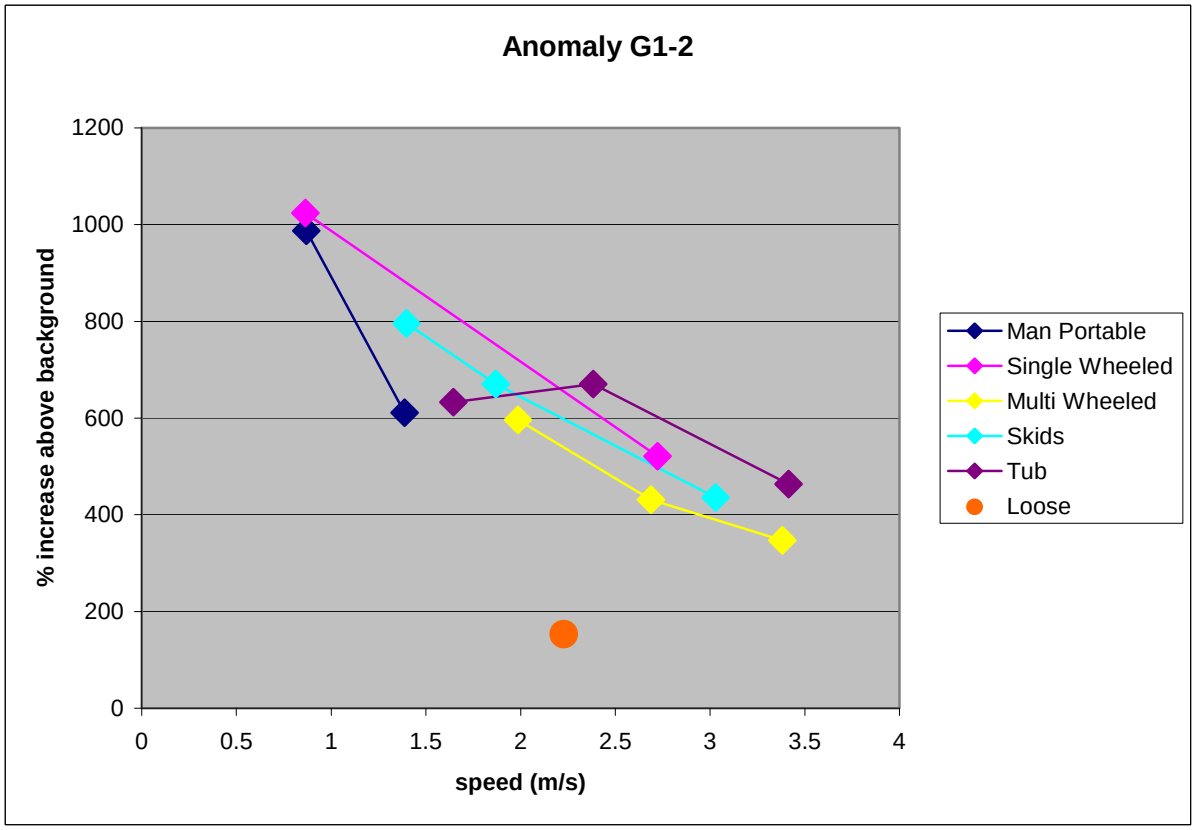

Anomaly G1-F - Two M43 submunitions @ 1'
% increase above background
300
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
speed (m/s)
Man portable
Single Wheeled
Multi Wheeled
Skid
Tub

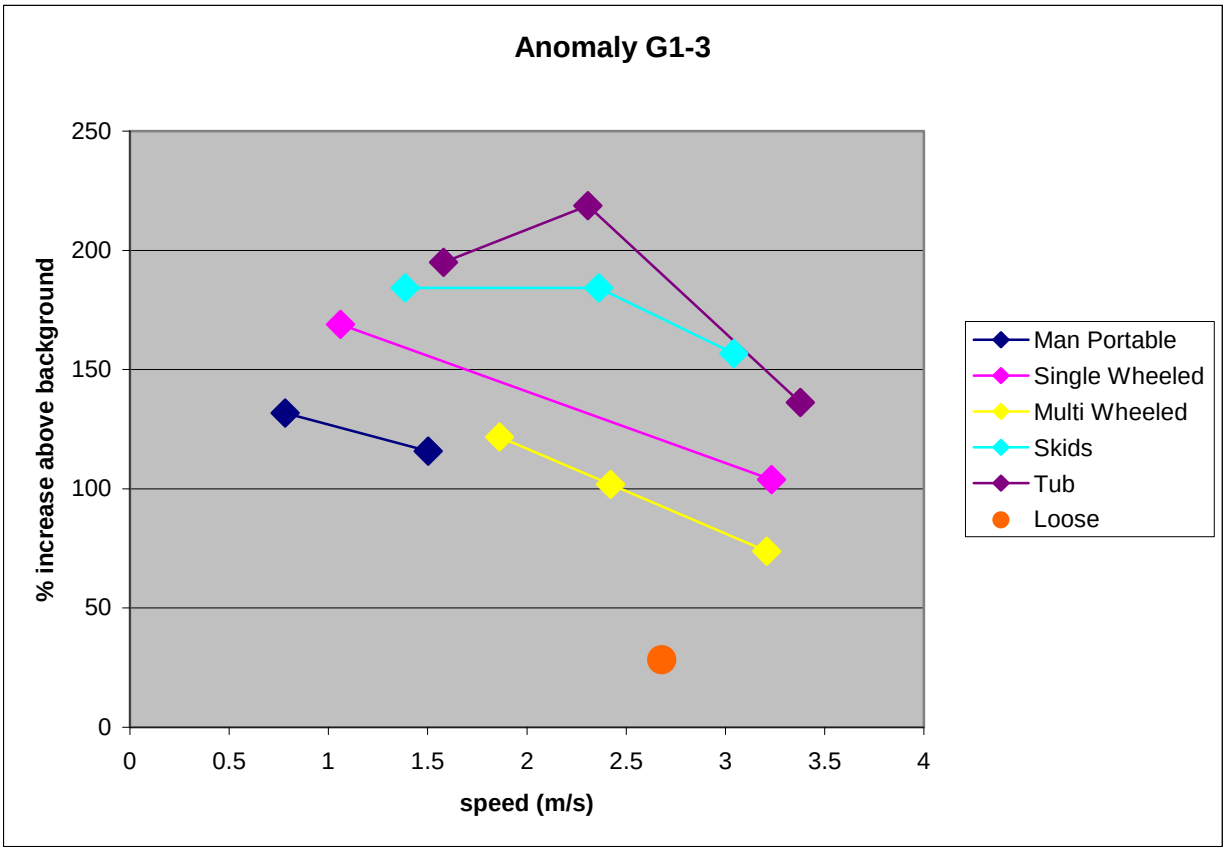

Anomaly G1-H - 75mm projo @0.9'
% increase above background
speed(m/s)
0
200
400
600
800
1000
1200
1400
1600
1800
0
0.5
1
1.5
2
2.5
3
3.5
4
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

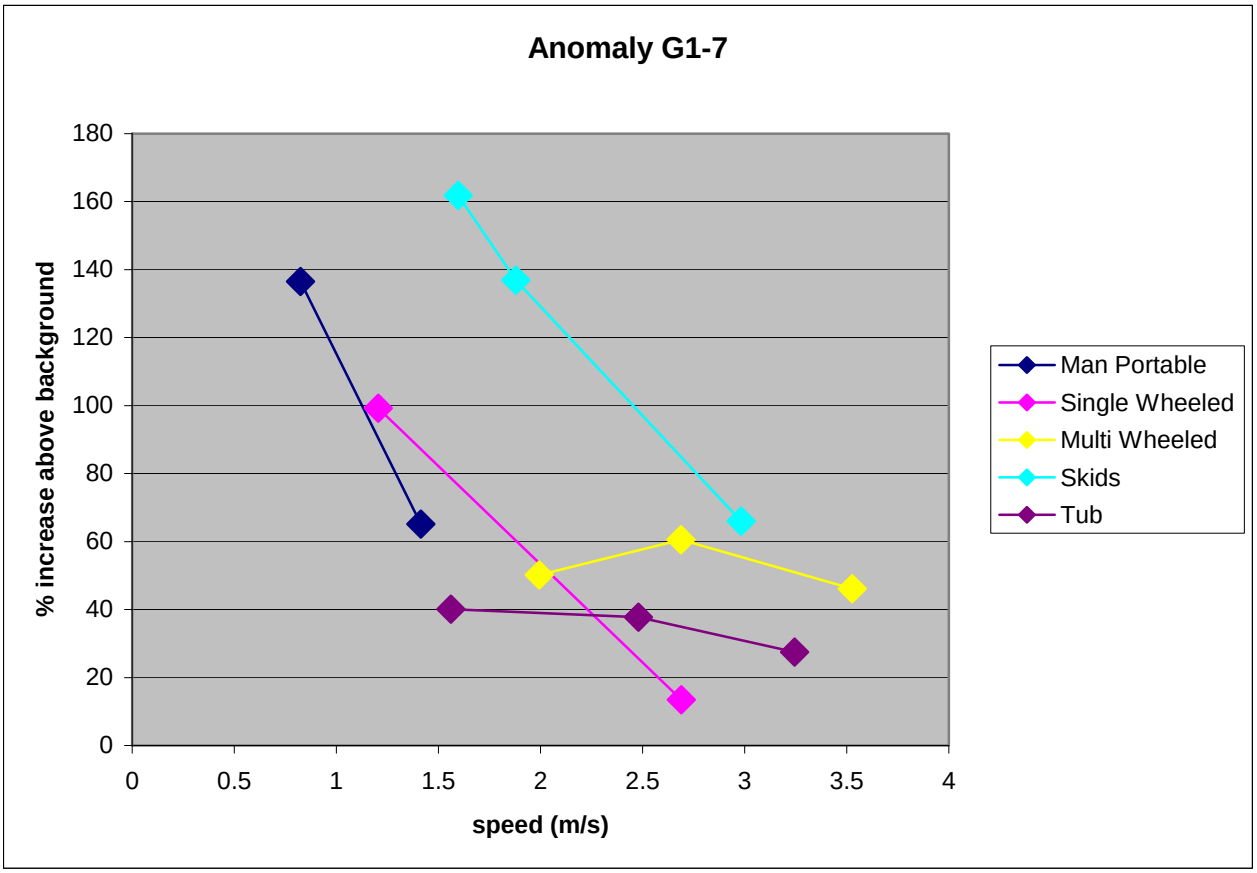

Anomaly G1-N - 4.2" mortar @3.9'
% increase above background
speed (m/s)
0
100
200
300
400
500
600
700
800
0
0.5
1
1.5
2
2.5
3
3.5
4
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

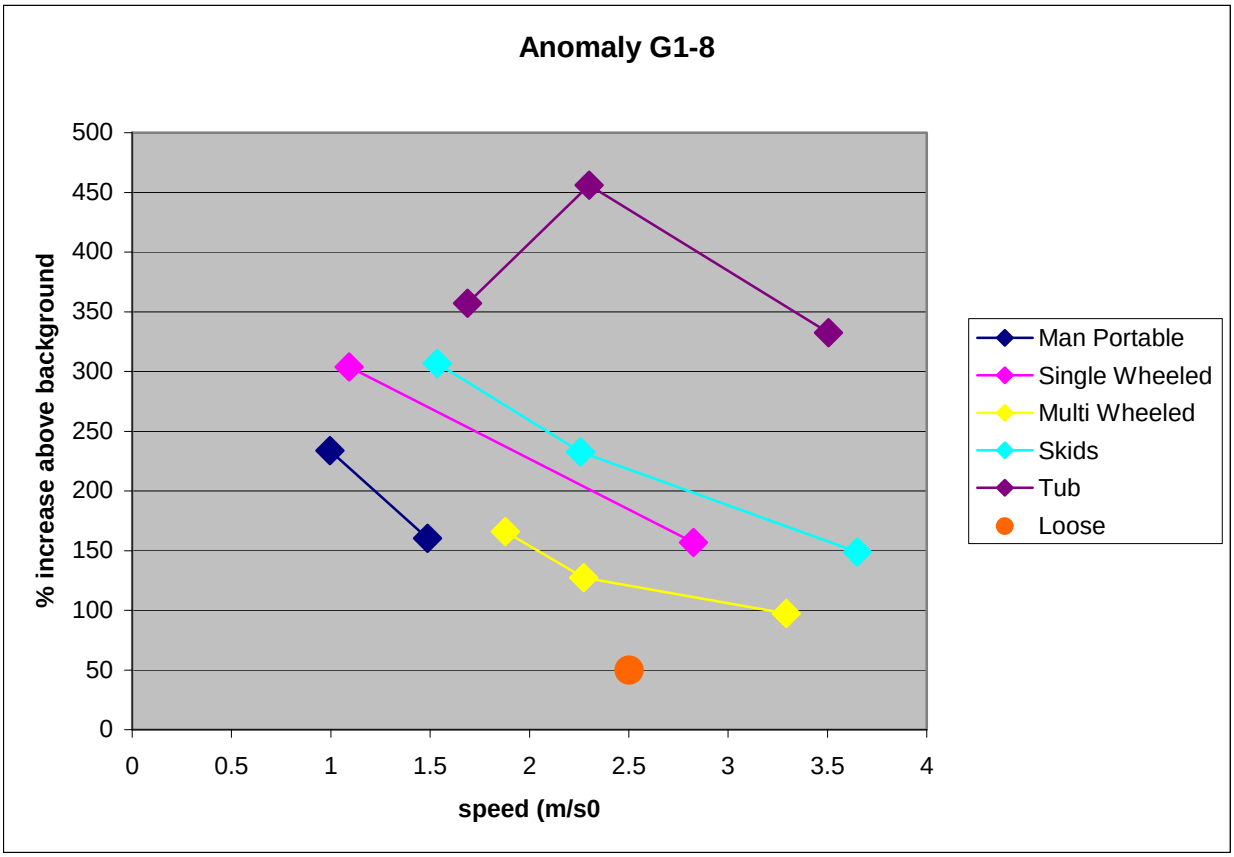

Anomaly G1-O - 105mm projo @1.5'
% increase above background
speed (m/s)
4000
3500
3000
2500
2000
1500
1000
500
0
0
0.5
1
1.5
2
2.5
3
3.5
4
Man Portable
Single Wheeled
Multi Wheeled
Skid
Tub
Loose

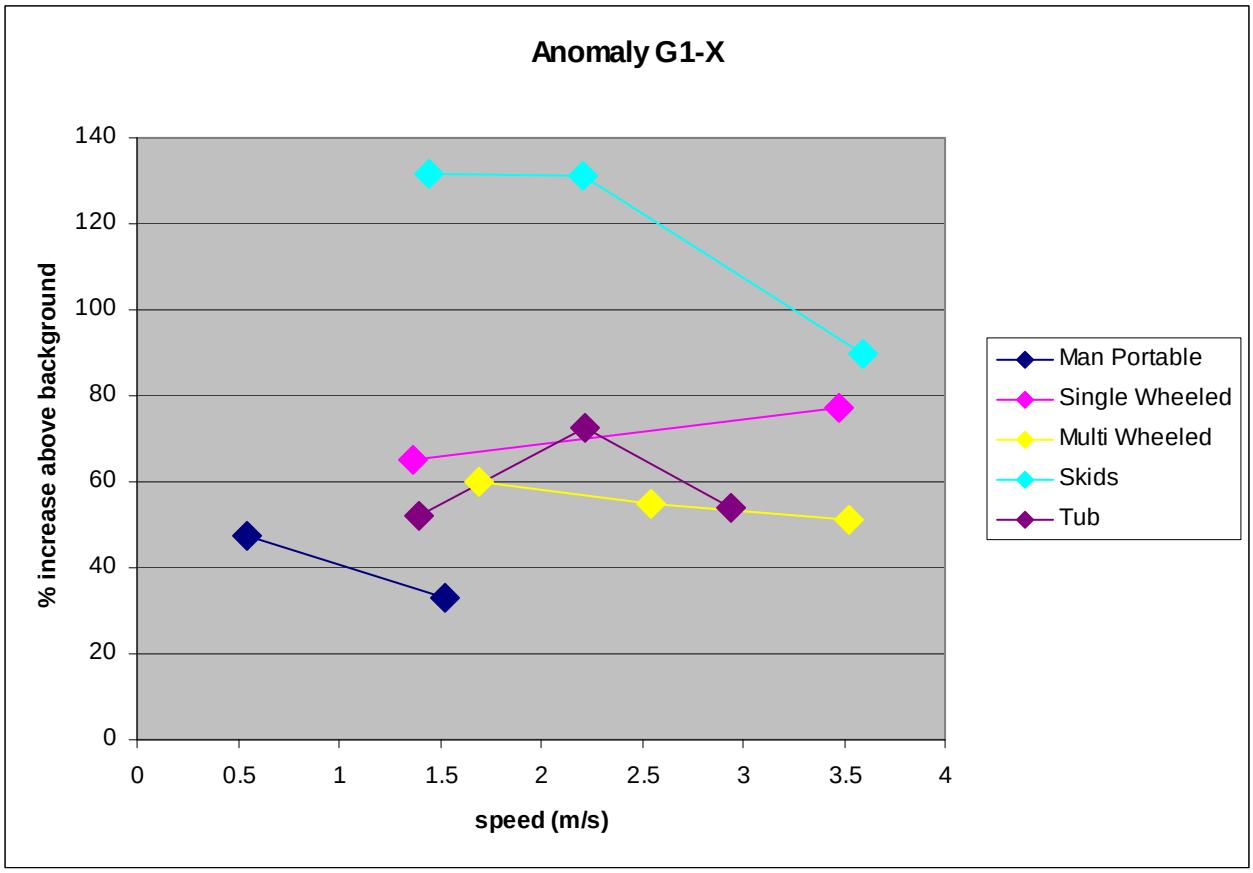

Anomaly G1-R - 2.75" Rocket @2.03'
% increase above background
2500
2000
1500
1000
500
0
0
0.5
1
1.5
2
2.5
3
3.5
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

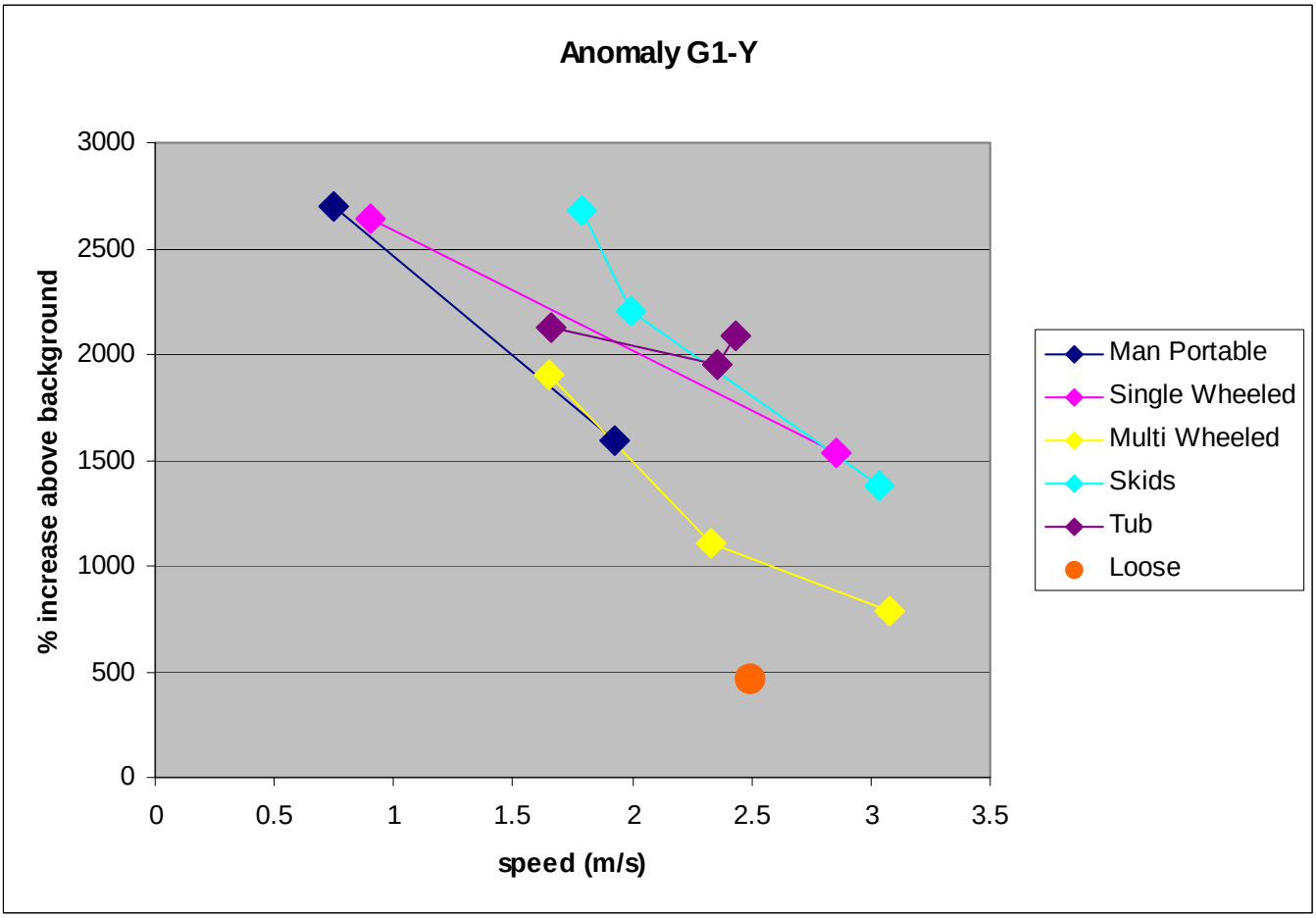

Anomaly G1-2
% increase above background
1200
1000
800
600
400
200
0
0
0.5
1
1.5
2
2.5
3
3.5
4
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose


Anomaly G1-3
% increase above background
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
4
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose


Anomaly G1-7
% increase above background
speed (m/s)
0
20
40
60
80
100
120
140
160
180
0
0.5
1
1.5
2
2.5
3
3.5
4
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub

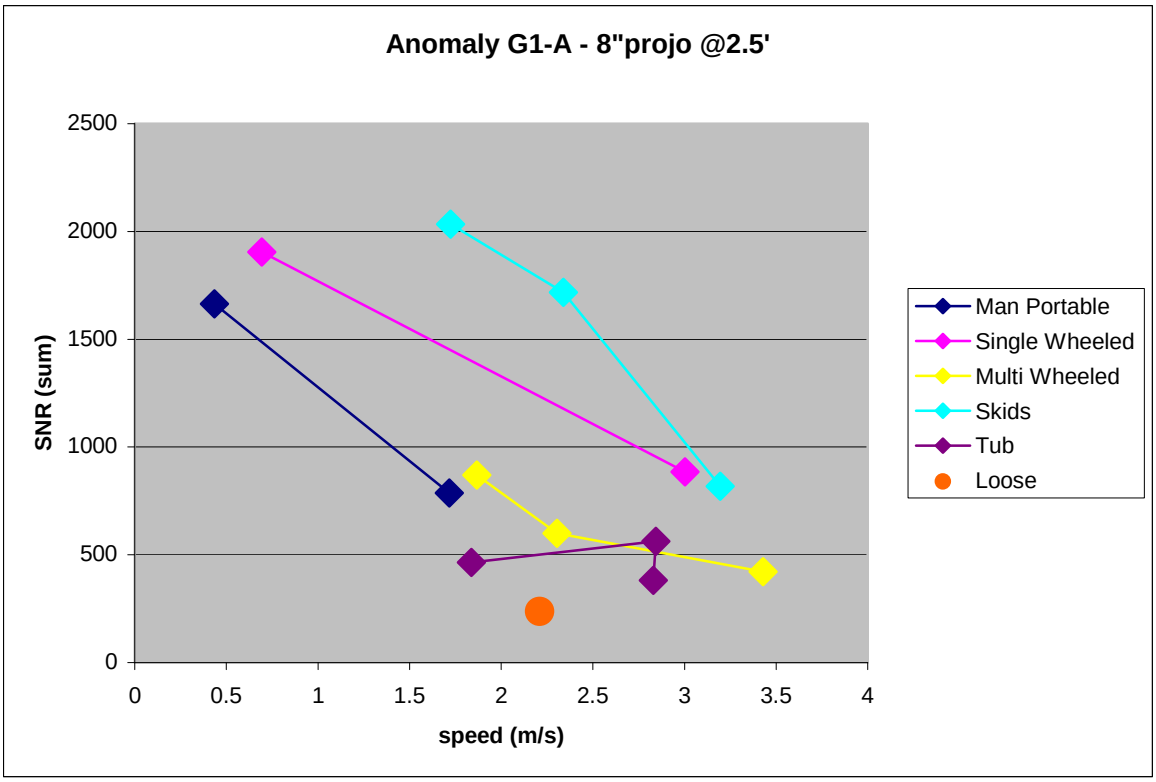

Anomaly G1-8
% increase above background
500
450
400
350
300
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
4
speed (m/s0
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

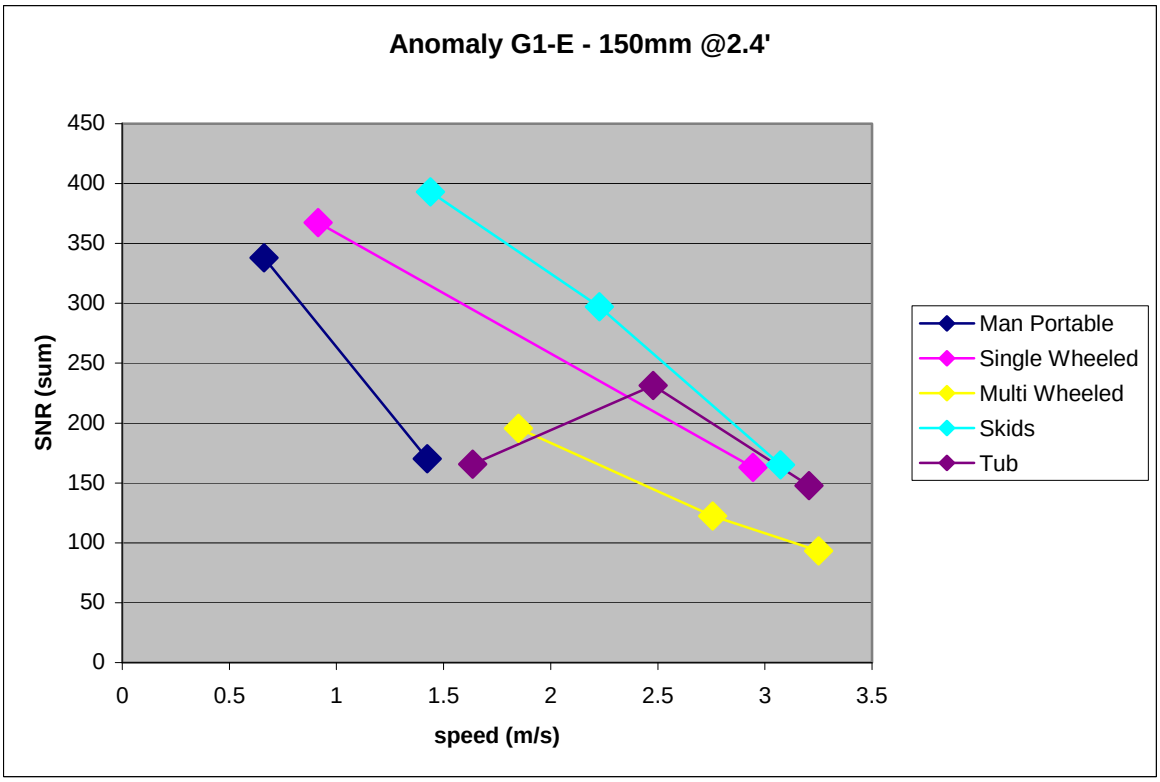

Anomaly G1-X
% increase above background
speed (m/s)
0
20
40
60
80
100
120
140
0
0.5
1
1.5
2
2.5
3
3.5
4
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub

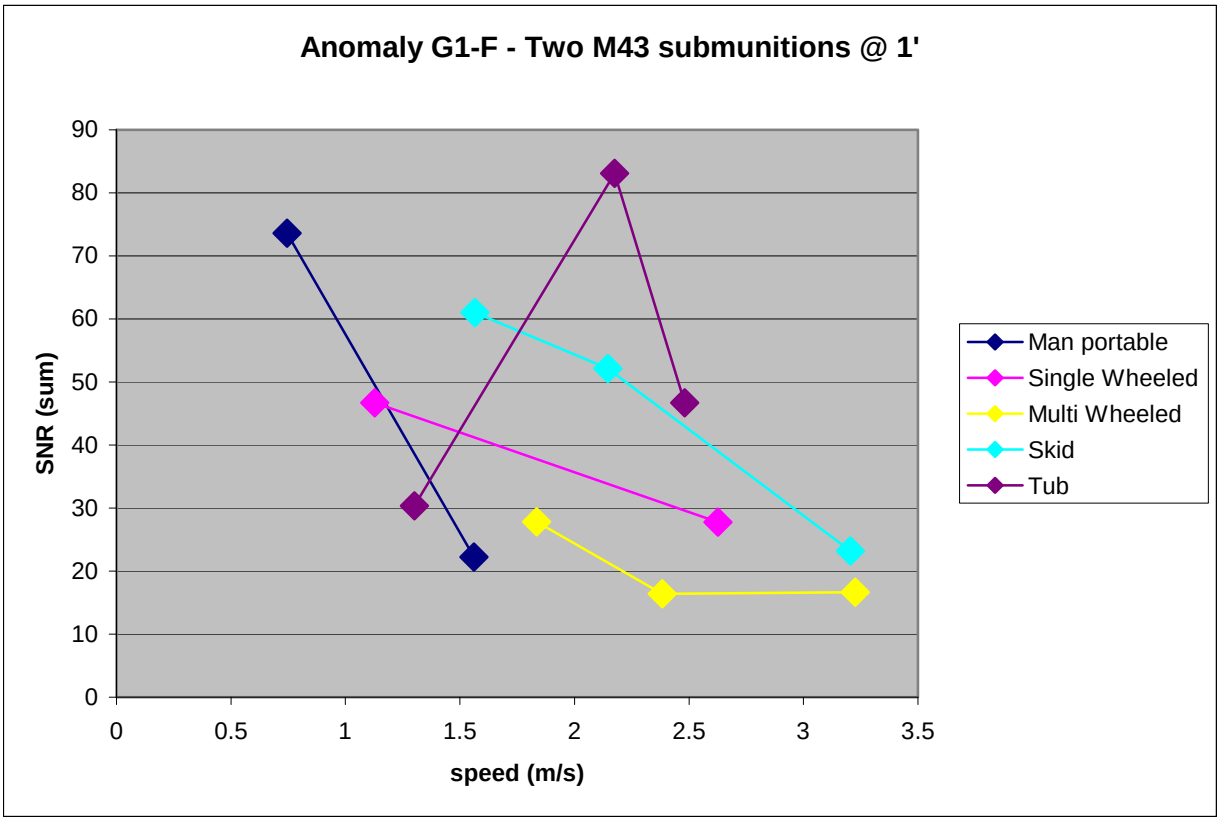

Anomaly G1-Y
% increase above background
3000
2500
2000
1500
1000
500
0
0
0.5
1
1.5
2
2.5
3
3.5
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

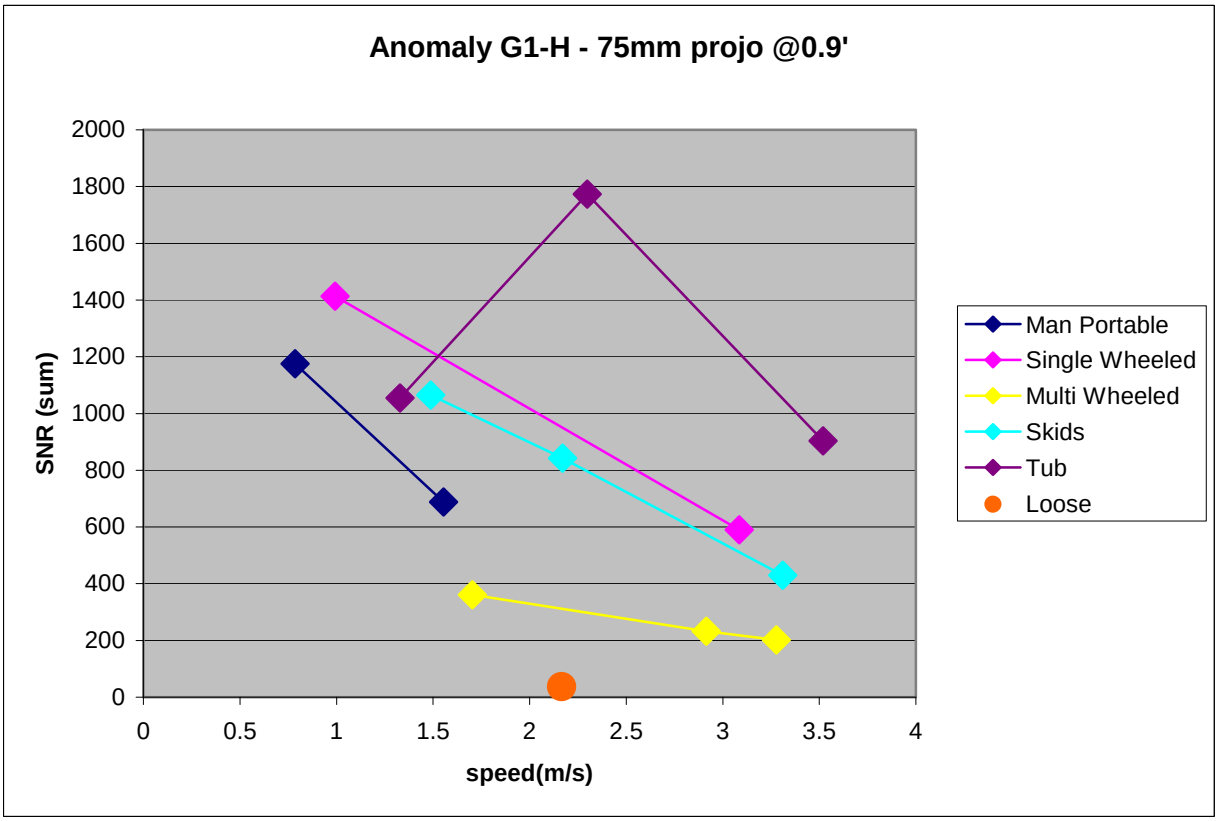
Appendix E: Seed Item SNRs

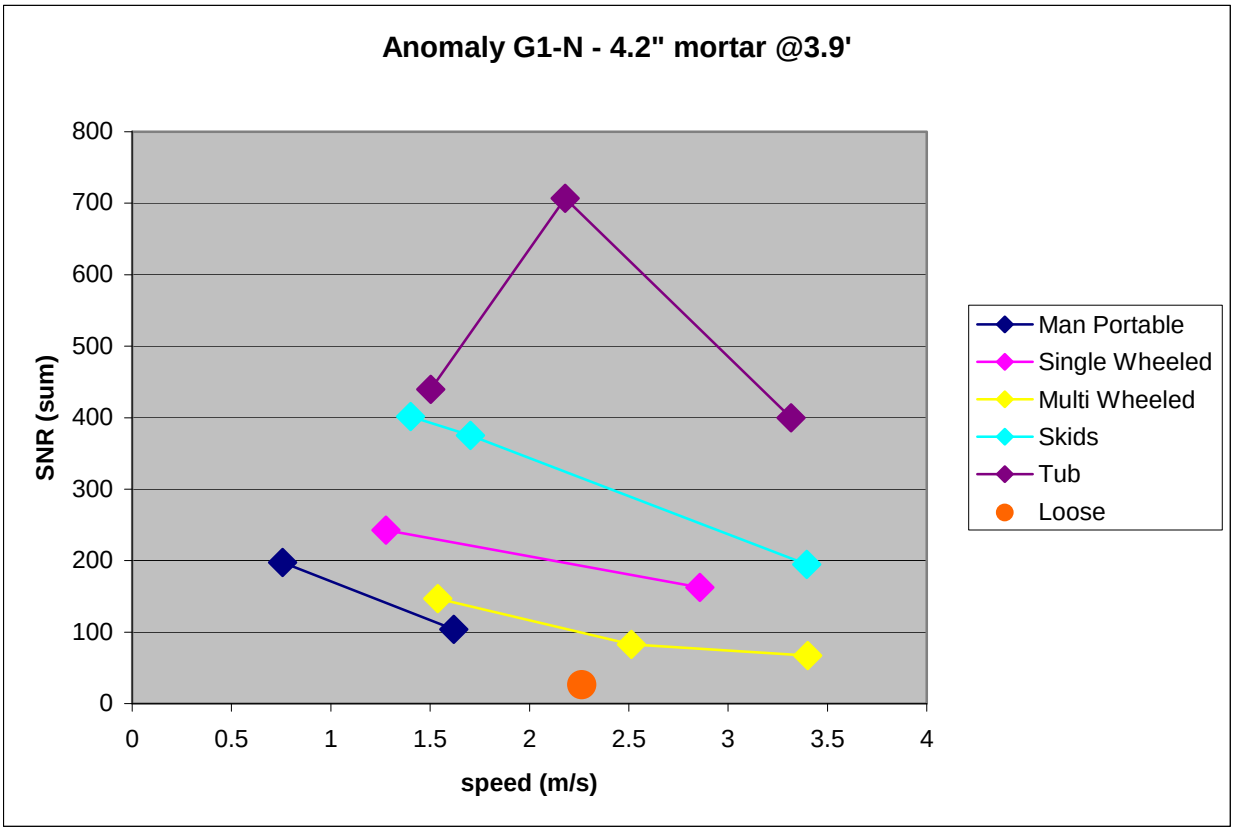
SUM OF 4 CHANNELS

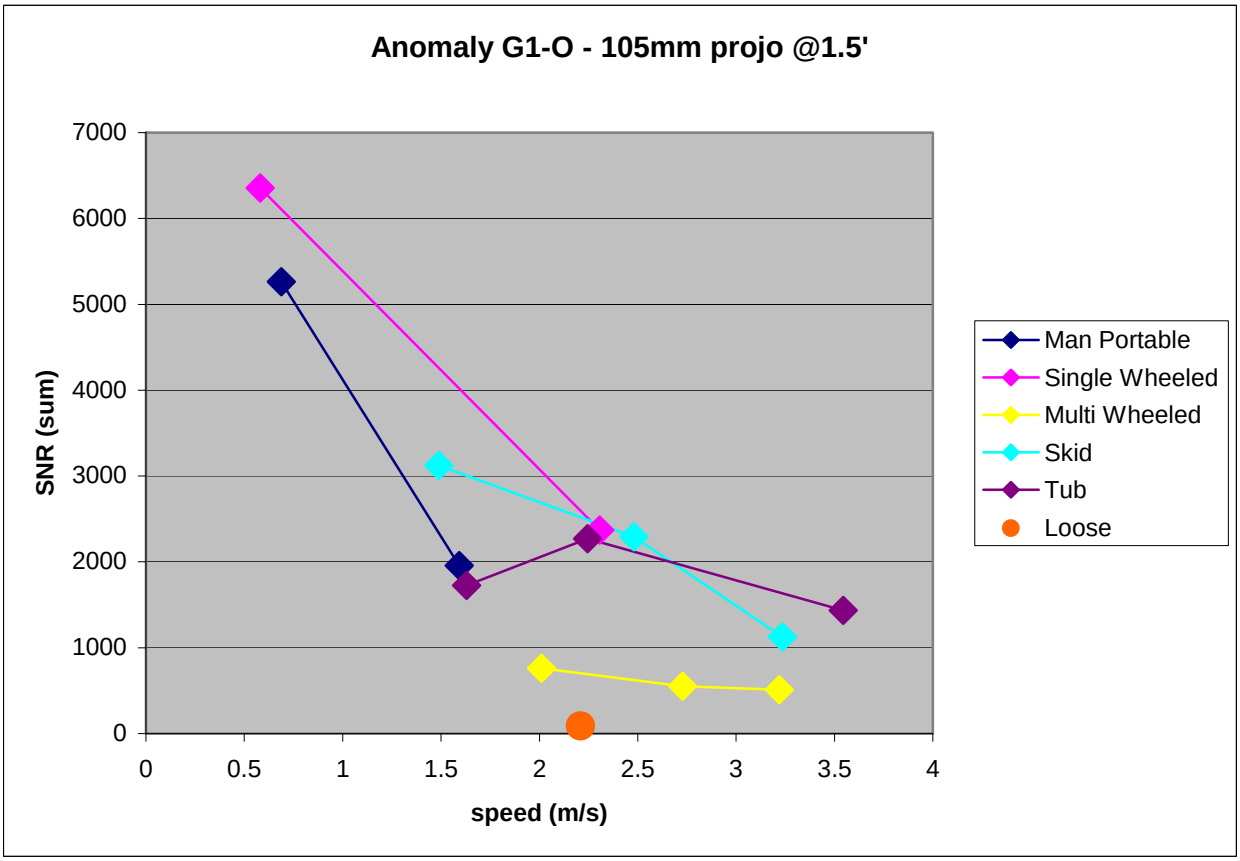


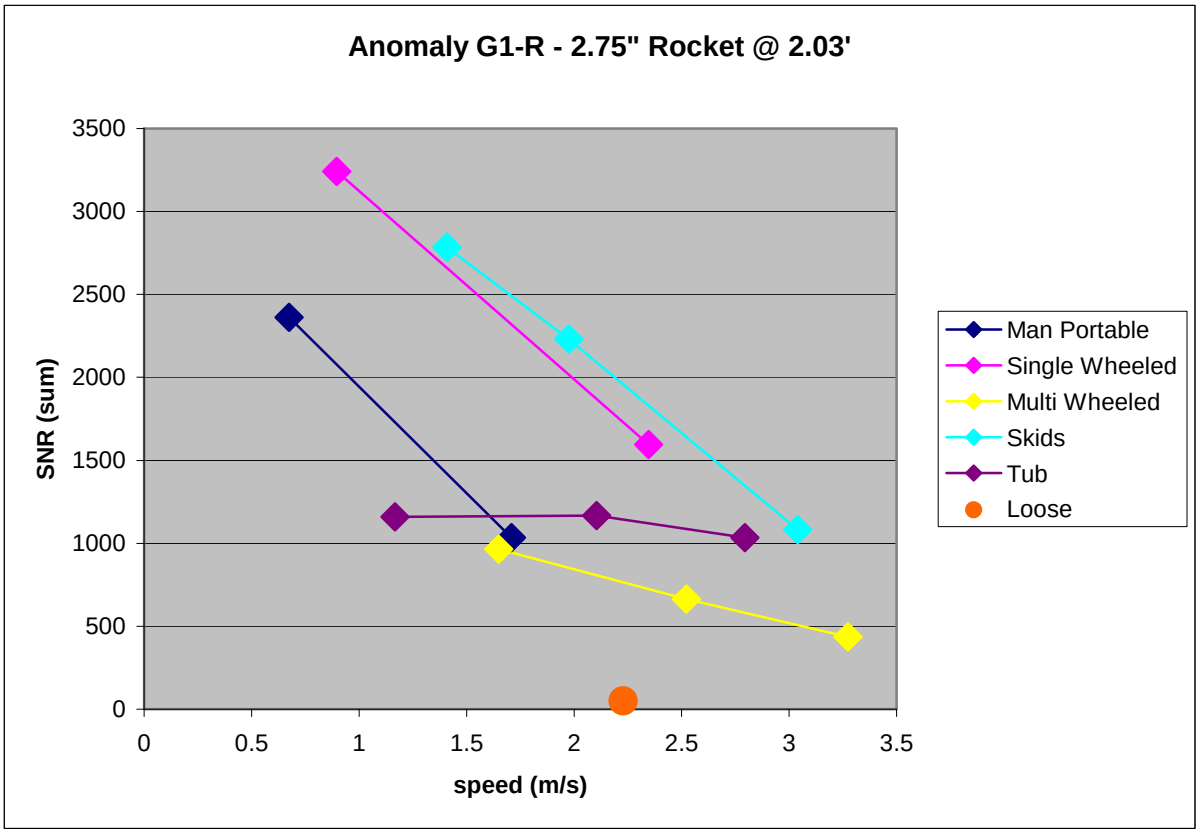


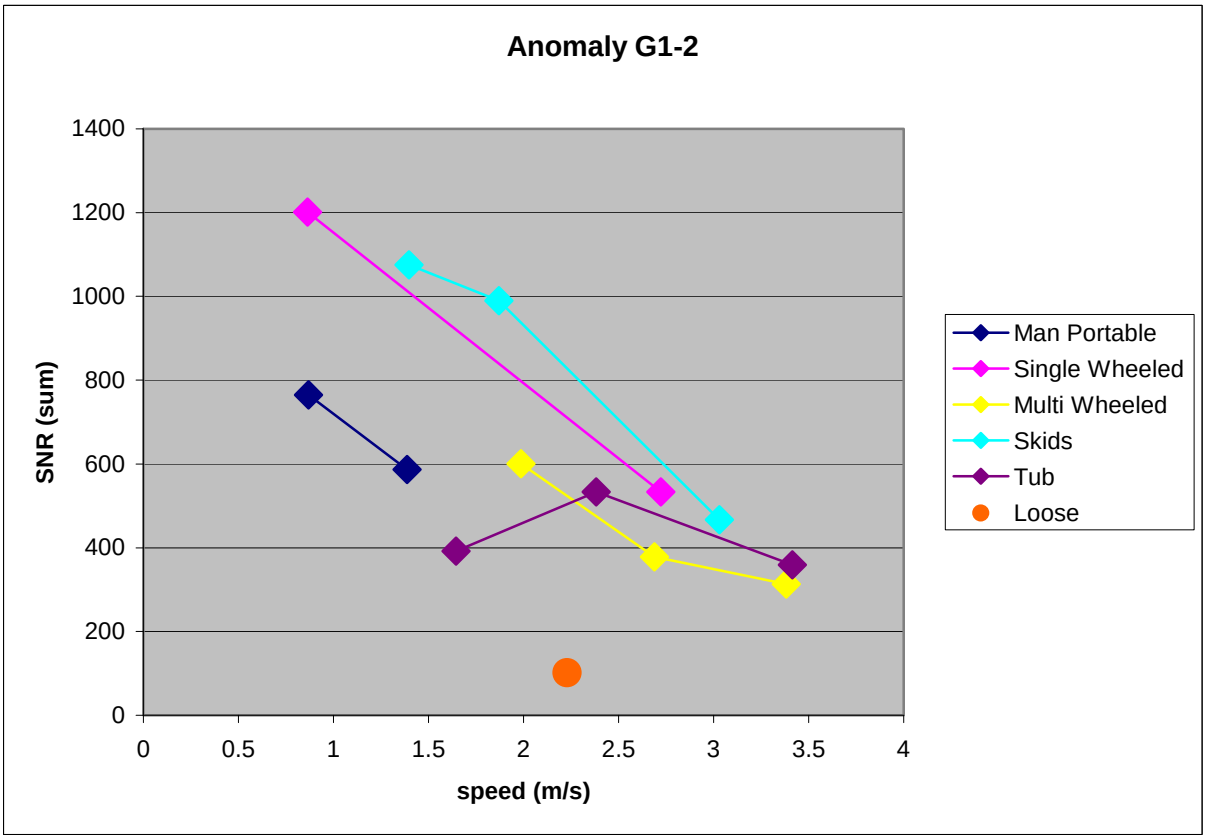

Anomaly G1-F - Two M43 submunitions @ 1'
SNR (sum)
speed (m/s)
0
10
20
30
40
50
60
70
80
90
0
0.5
1
1.5
2
2.5
3
3.5
Man portable
Single Wheeled
Multi Wheeled
Skid
Tub

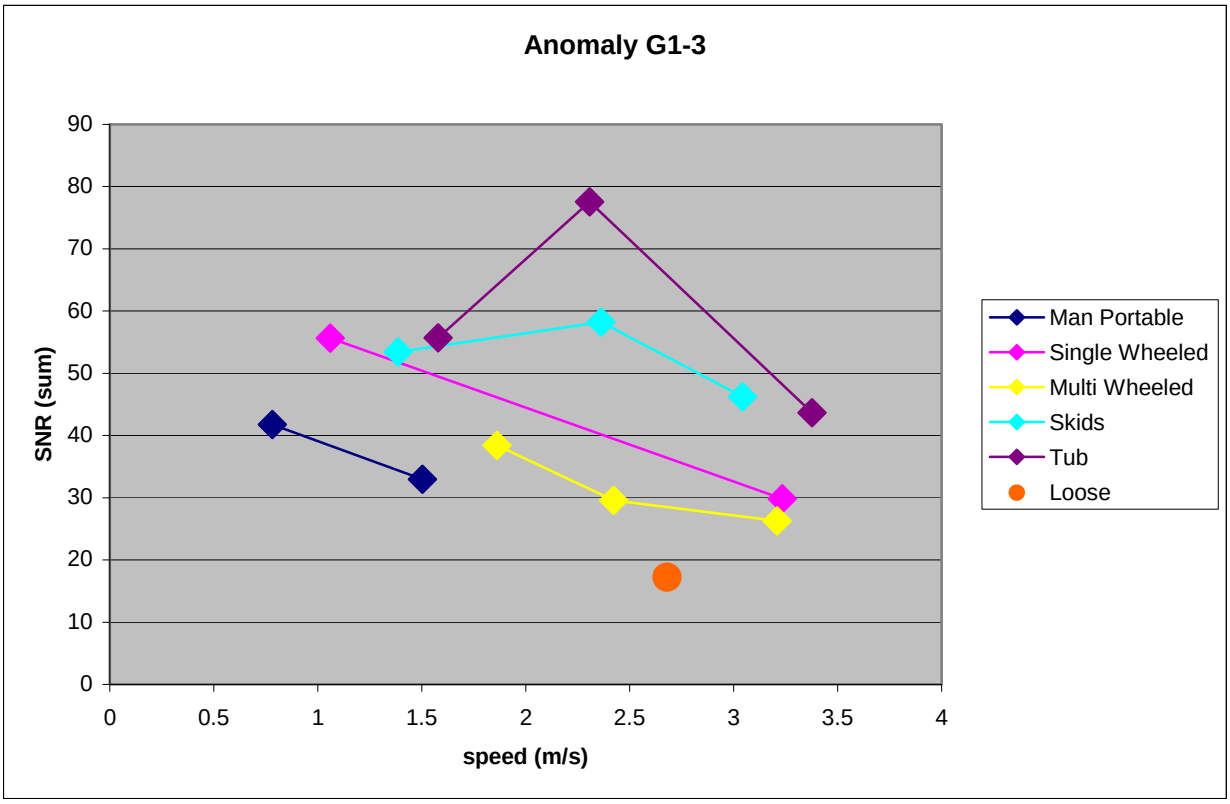

Anomaly G1-H - 75mm projo @0.9'
SNR (sum)
speed(m/s)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
0.5
1
1.5
2
2.5
3
3.5
4
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

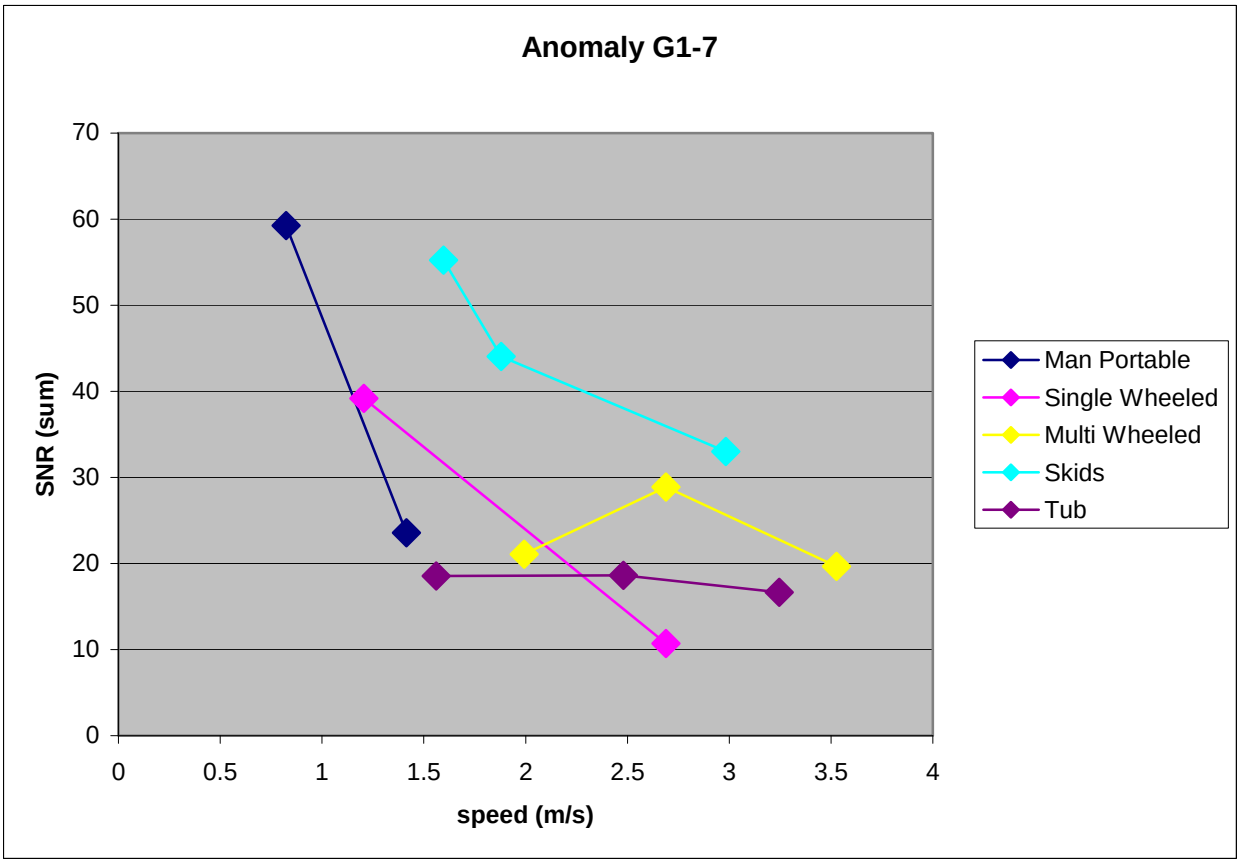

Anomaly G1-N - 4.2" mortar @3.9'
SNR (sum)
speed (m/s)
0
100
200
300
400
500
600
700
800
0
0.5
1
1.5
2
2.5
3
3.5
4
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

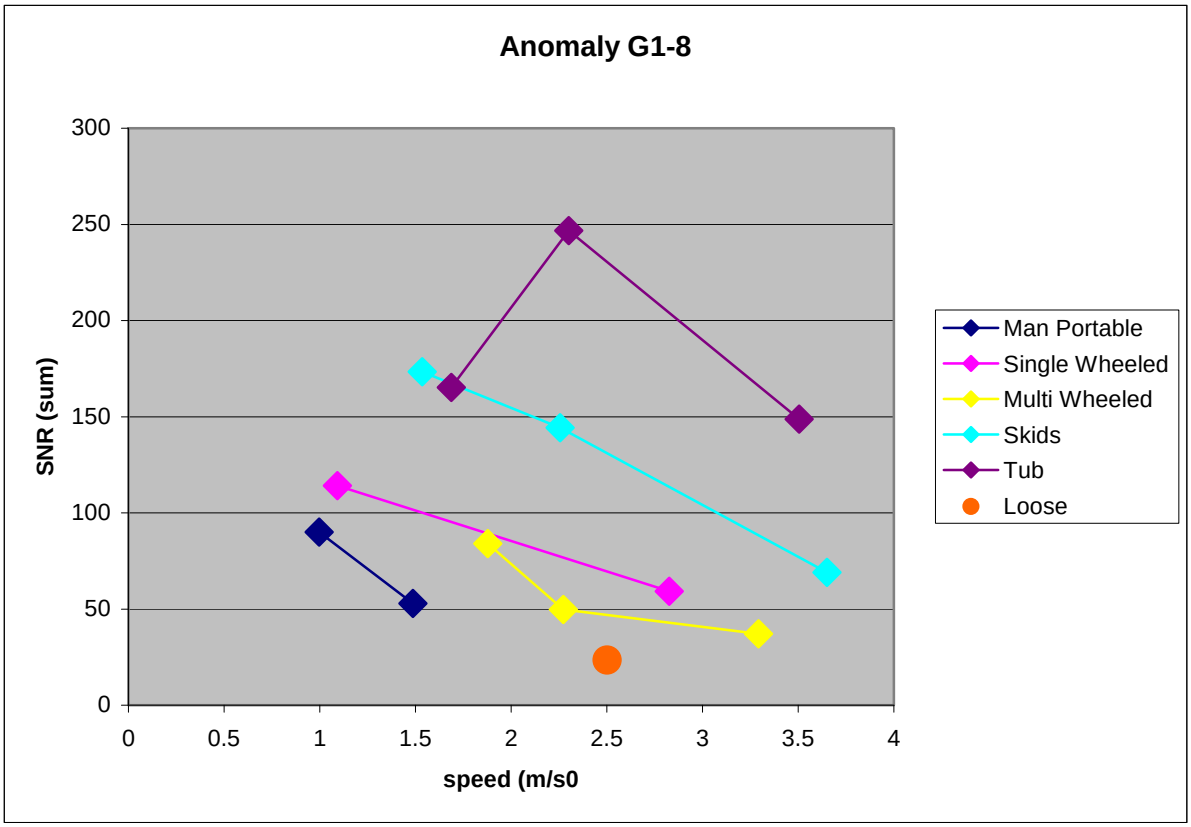

Anomaly G1-O - 105mm projo @1.5'
SNR (sum)
speed (m/s)
0
1000
2000
3000
4000
5000
6000
7000
0
0.5
1
1.5
2
2.5
3
3.5
4
Man Portable
Single Wheeled
Multi Wheeled
Skid
Tub
Loose

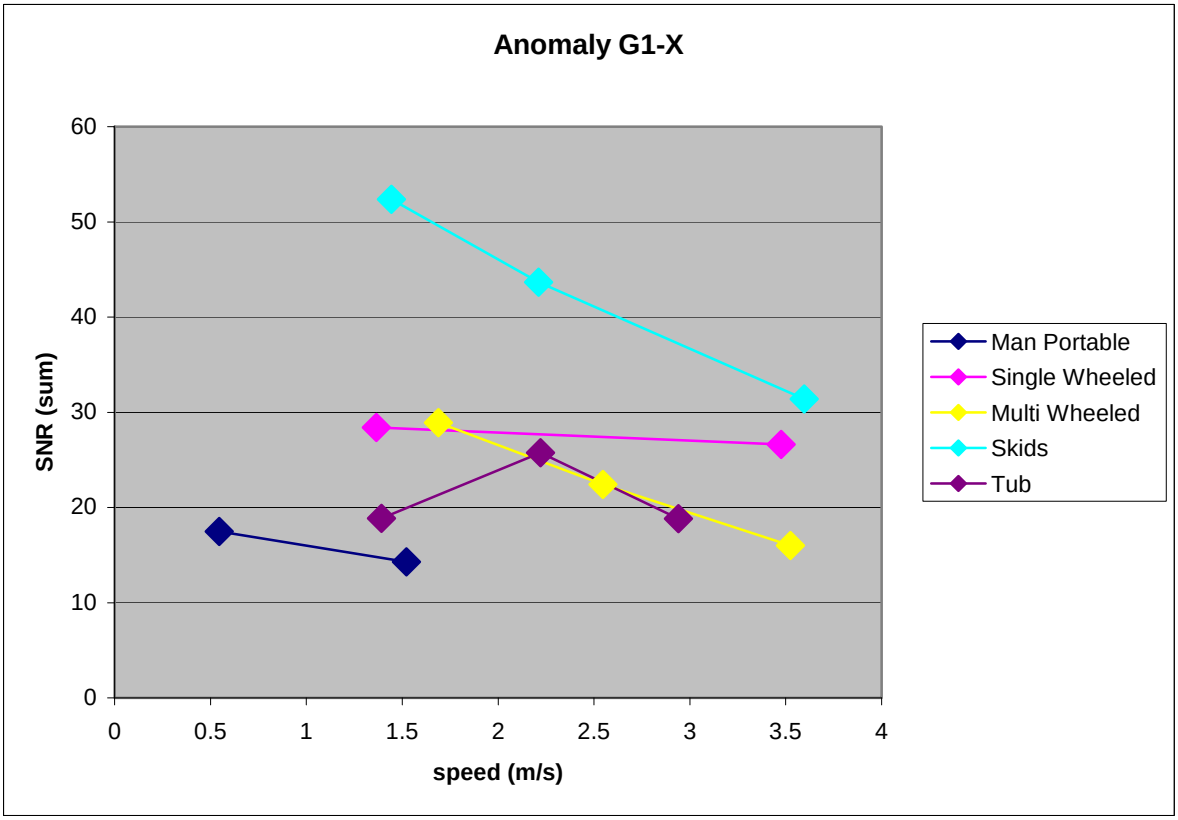

Anomaly G1-R - 2.75" Rocket @ 2.03'
SNR (sum)
speed (m/s)
3500
3000
2500
2000
1500
1000
500
0
0
0.5
1
1.5
2
2.5
3
3.5
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

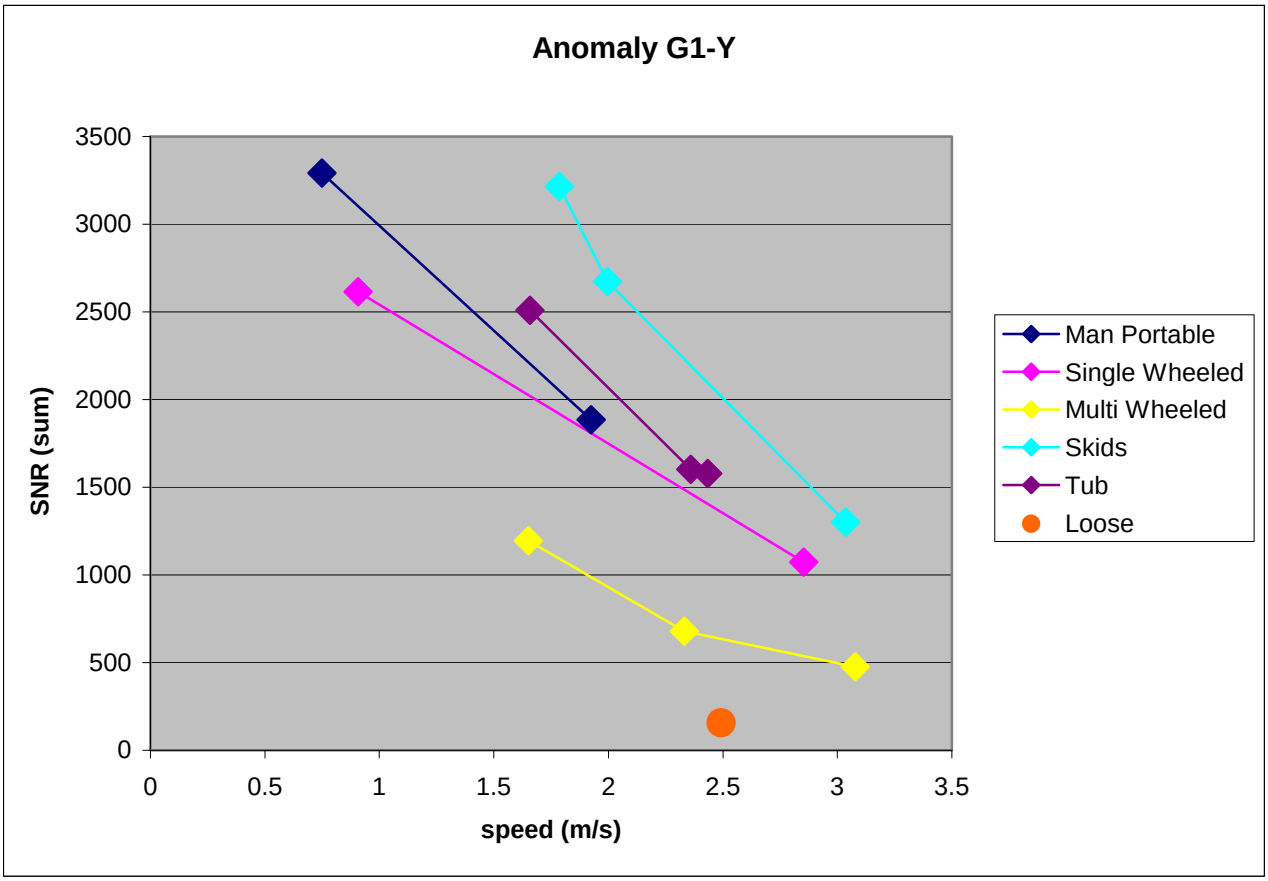

Anomaly G1-2
SNR (sum)
speed (m/s)
1400
1200
1000
800
600
400
200
0
0
0.5
1
1.5
2
2.5
3
3.5
4
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose


Anomaly G1-3
SNR (sum)
speed (m/s)
0
10
20
30
40
50
60
70
80
90
0
0.5
1
1.5
2
2.5
3
3.5
4
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

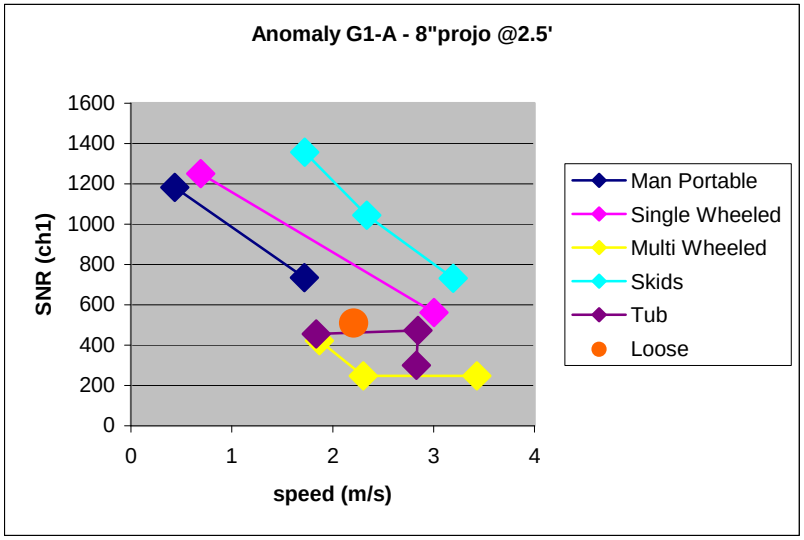

Anomaly G1-7
SNR (sum)
speed (m/s)
0
10
20
30
40
50
60
70
0
0.5
1
1.5
2
2.5
3
3.5
4
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub

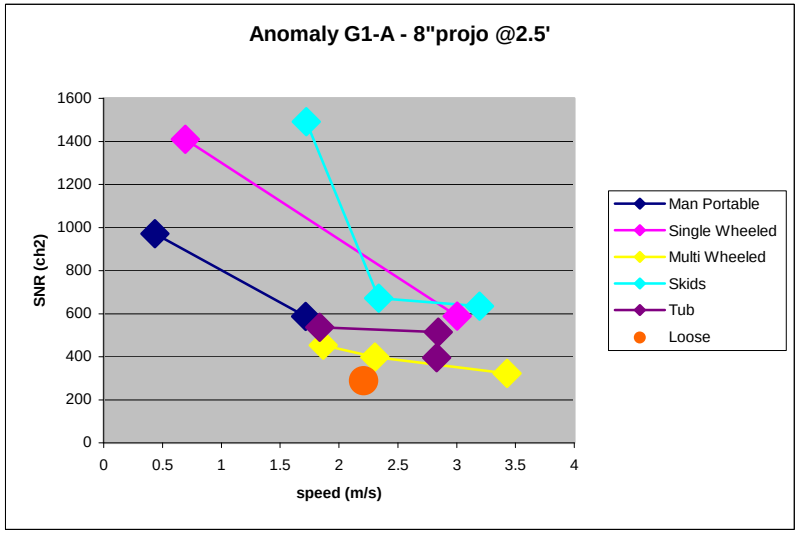

Anomaly G1-8
SNR (sum)
300
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
4
speed (m/s0
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

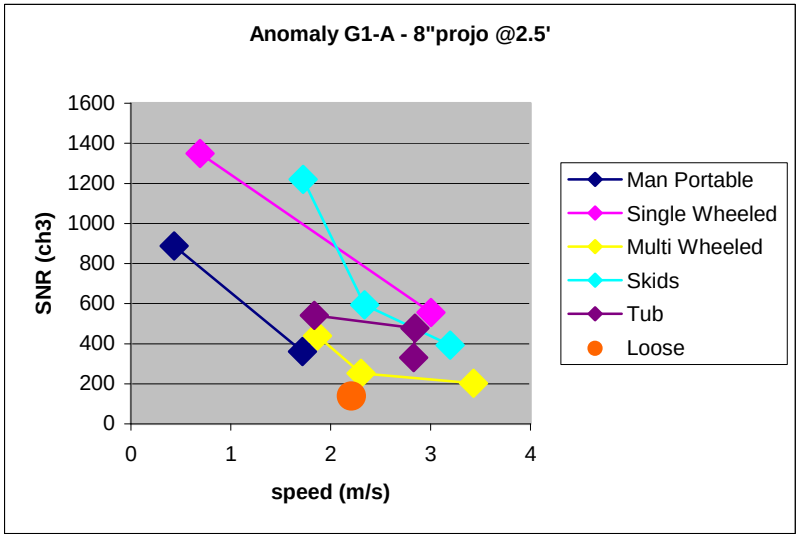

Anomaly G1-X
SNR (sum)
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
3.5
4
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub

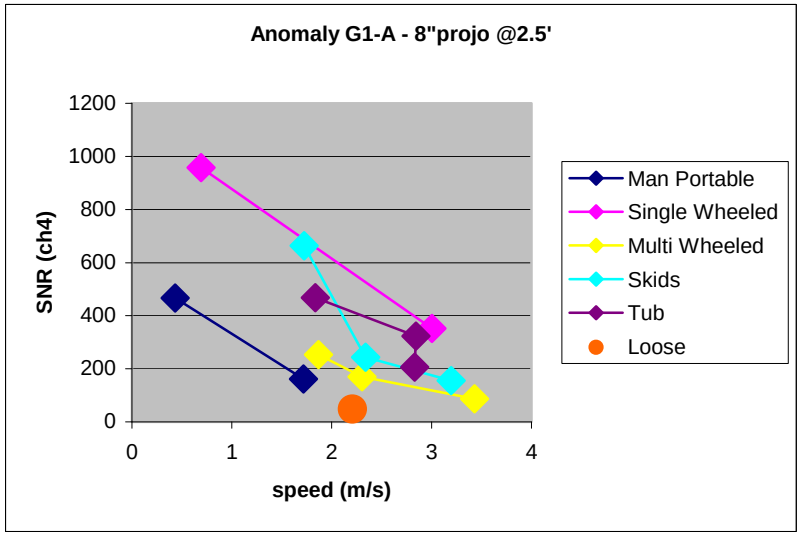

Anomaly G1-Y
SNR (sum)
3500
3000
2500
2000
1500
1000
500
0
0
0.5
1
1.5
2
2.5
3
3.5
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

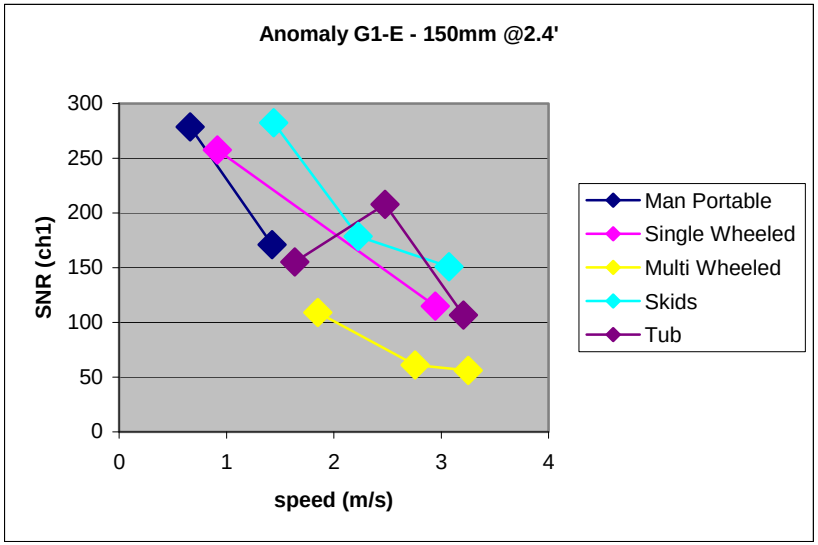
ALL 4 CHANNELS

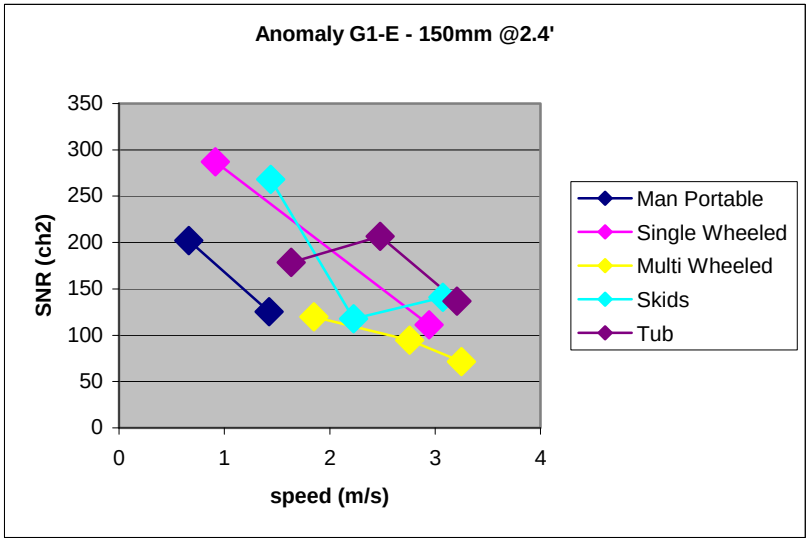


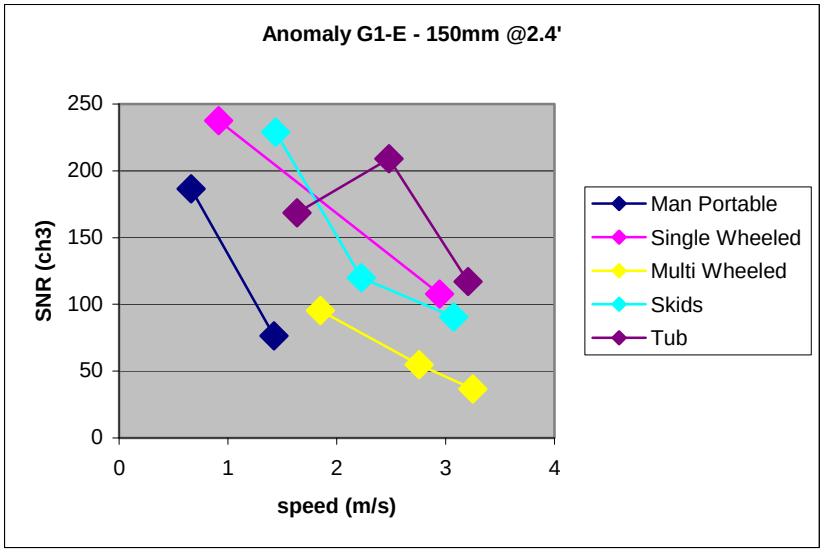


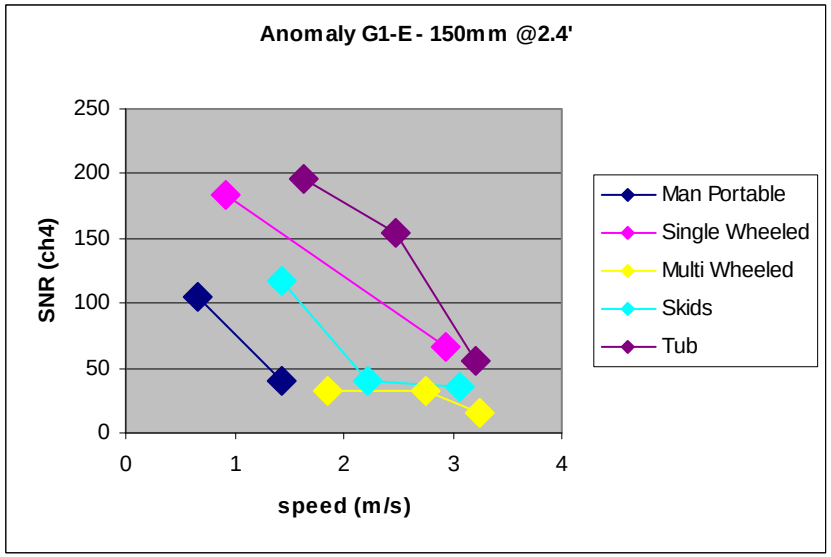


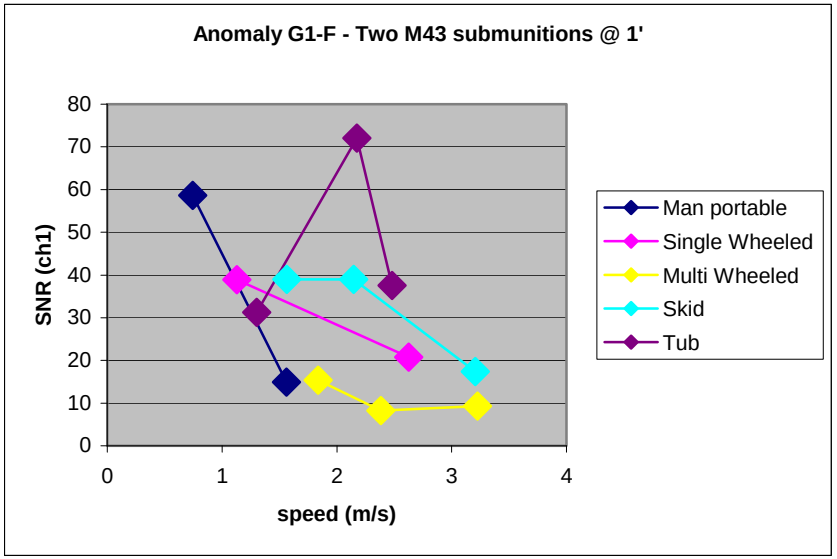


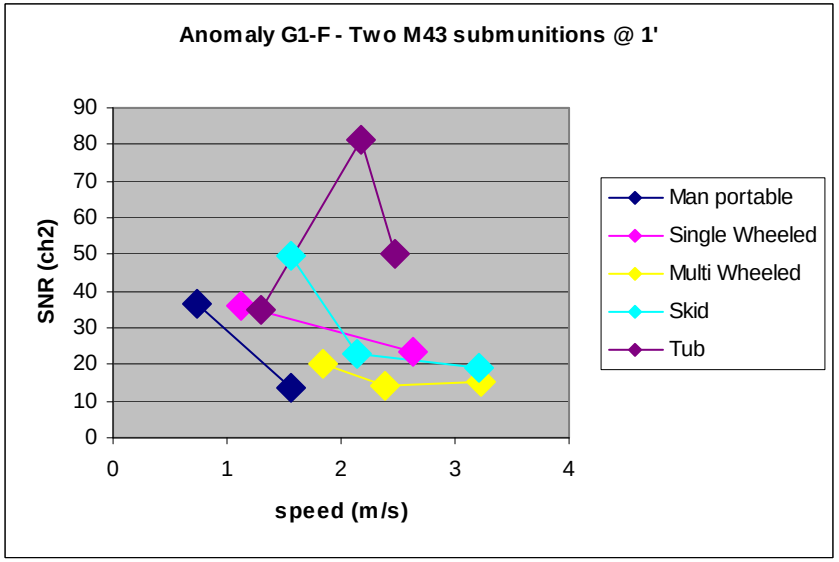

Anomaly G1-E - 150mm @2.4'
SNR (ch1)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub

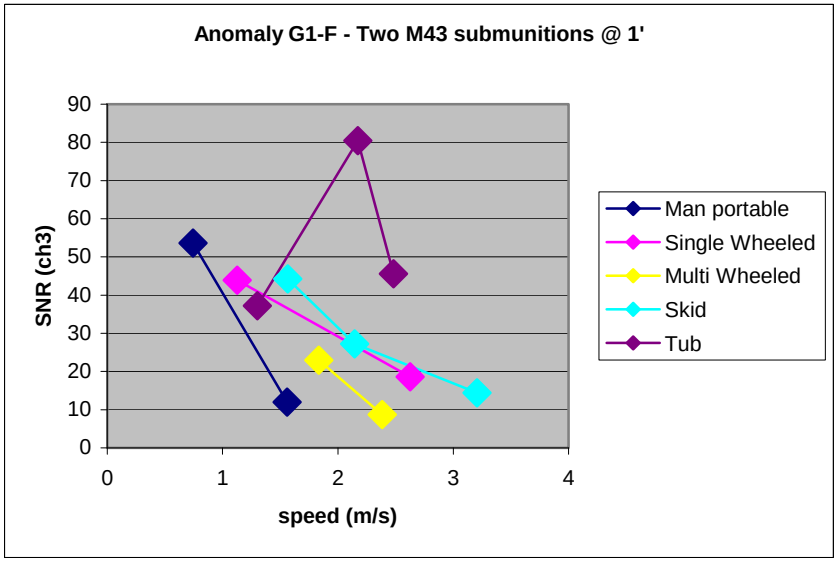

Anomaly G1-E - 150mm @2.4'
SNR (ch2)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub

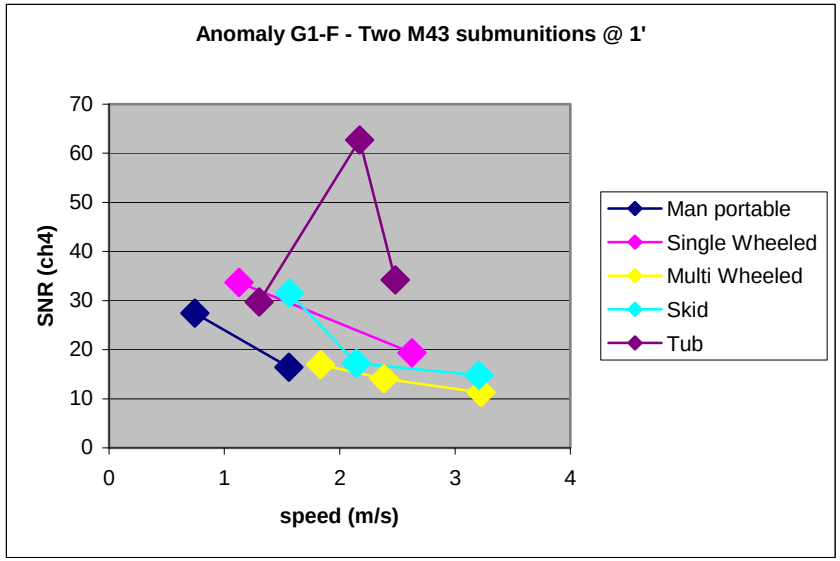

Anomaly G1-E - 150mm @2.4'
SNR (ch3)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub

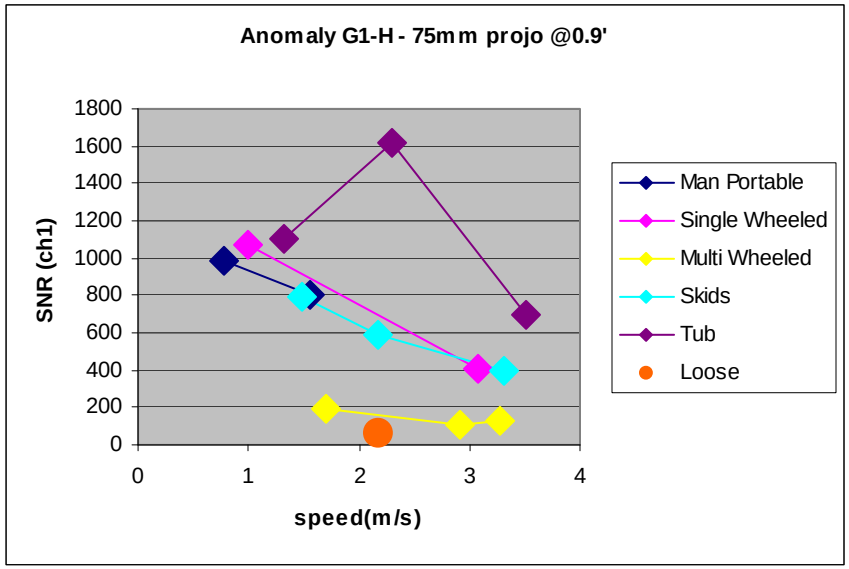

Anomaly G1-E - 150mm @2.4'
SNR (ch4)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub

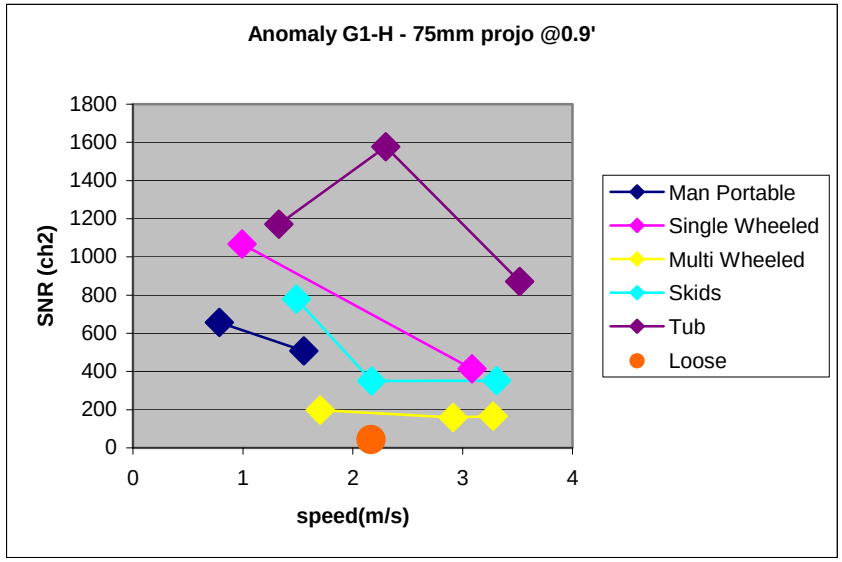

Anomaly G1-F - Two M43 submunitions @ 1'
SNR (ch1)
speed (m/s)
Man portable
Single Wheeled
Multi Wheeled
Skid
Tub

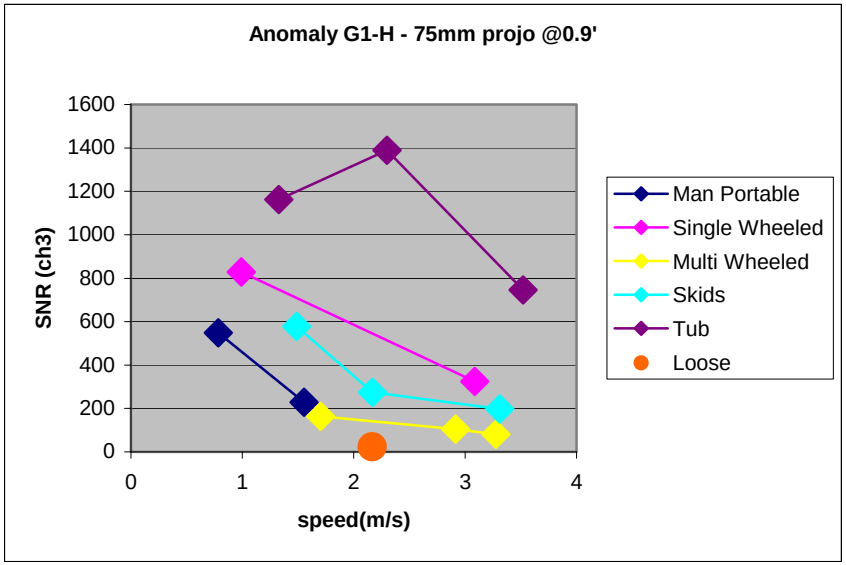

Anomaly G1-F - Two M43 submunitions @ 1'
SNR (ch2)
speed (m/s)
Man portable
Single Wheeled
Multi Wheeled
Skid
Tub

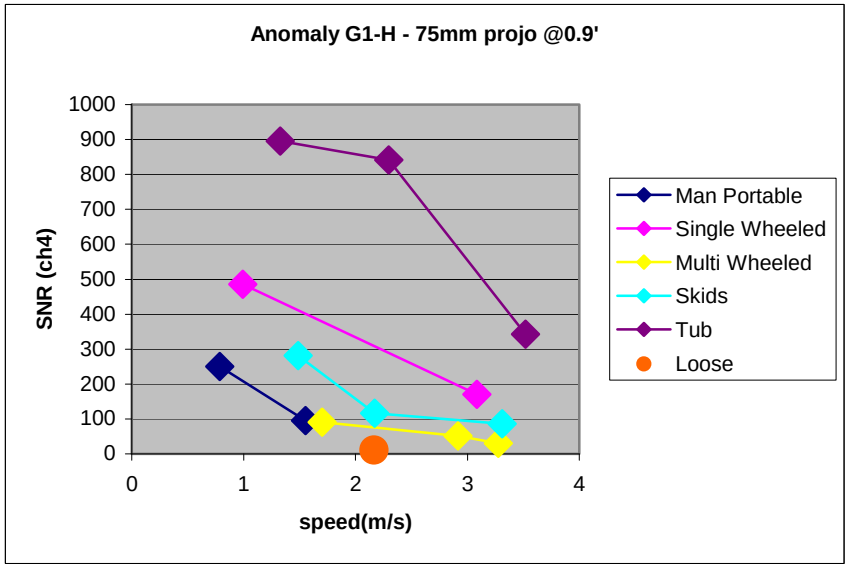

Anomaly G1-F - Two M43 submunitions @ 1'
SNR (ch3)
speed (m/s)
Man portable
Single Wheeled
Multi Wheeled
Skid
Tub

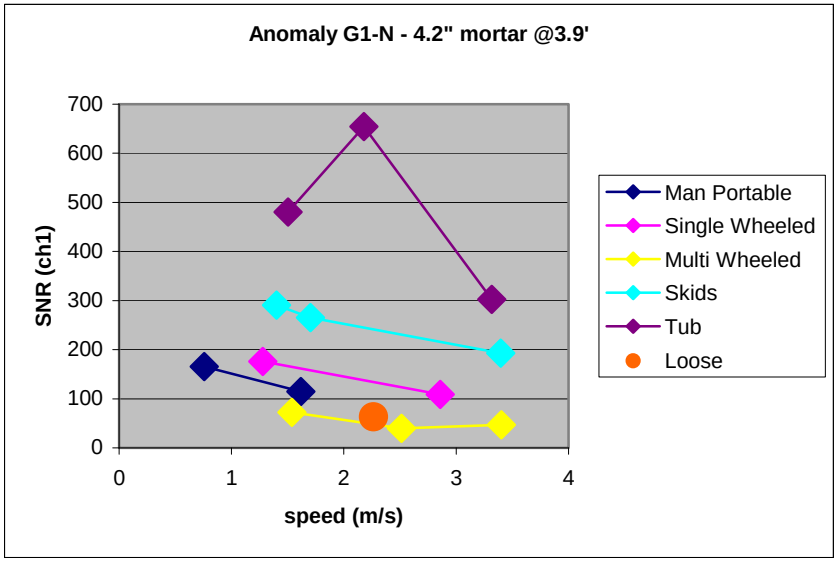

Anomaly G1-F - Two M43 submunitions @ 1'
SNR (ch4)
speed (m/s)
Man portable
Single Wheeled
Multi Wheeled
Skid
Tub

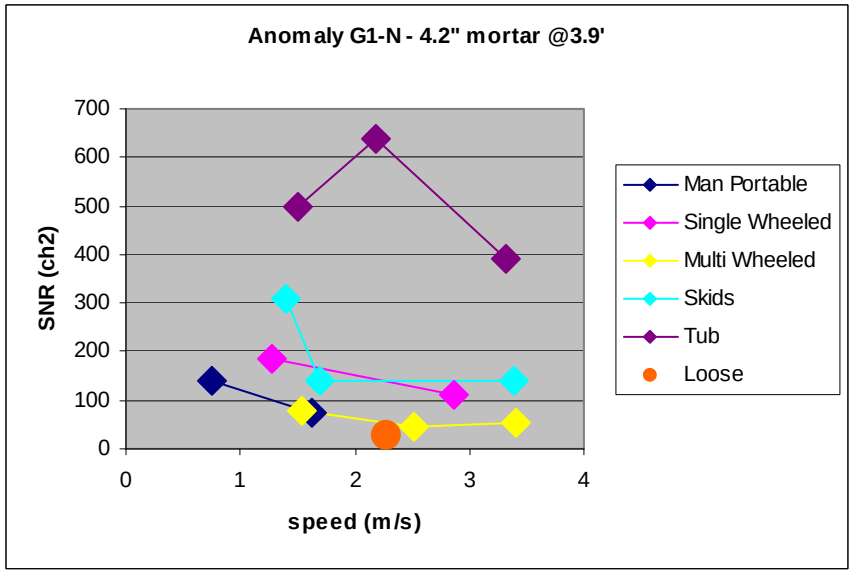

Anomaly G1-H - 75mm projo @0.9'
SNR (ch1)
speed(m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

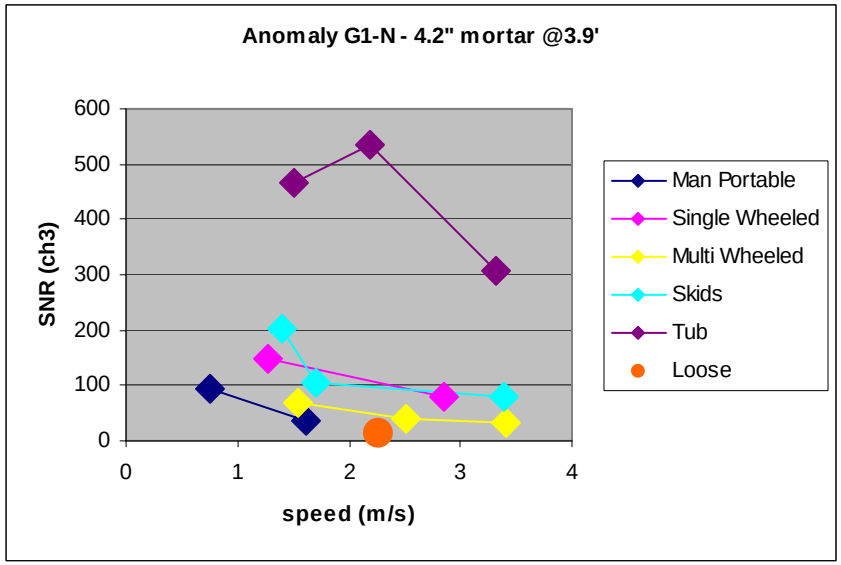

Anomaly G1-H - 75mm projo @0.9'
SNR (ch2)
speed(m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

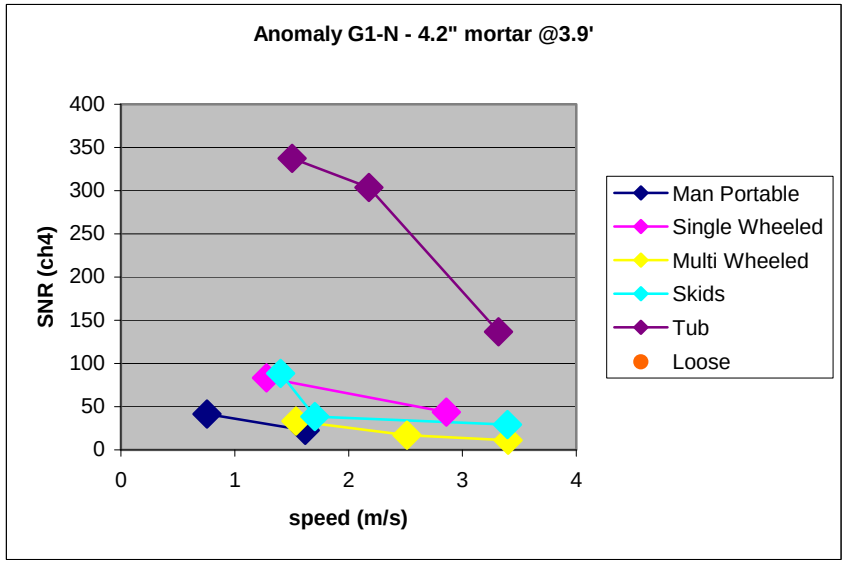

Anomaly G1-H - 75mm projo @0.9'
SNR (ch3)
speed(m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

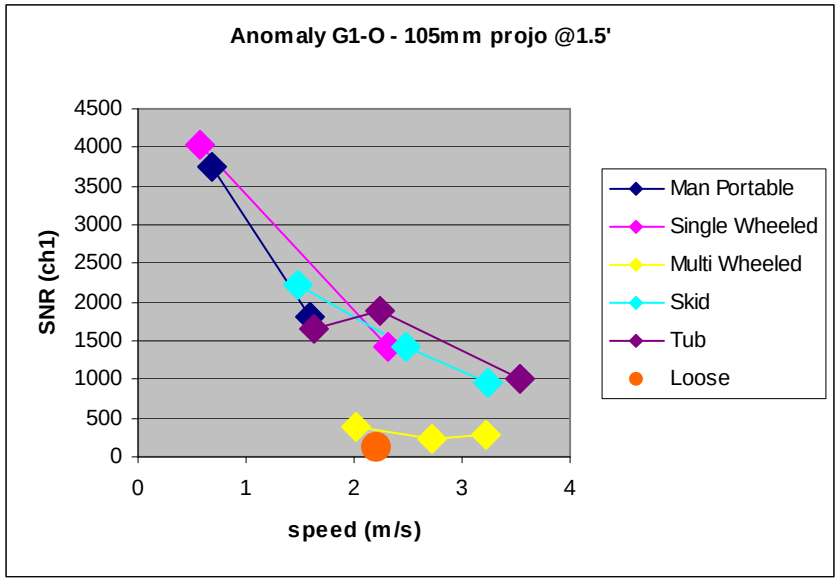

Anomaly G1-H - 75mm projo @0.9'
SNR (ch4)
speed(m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

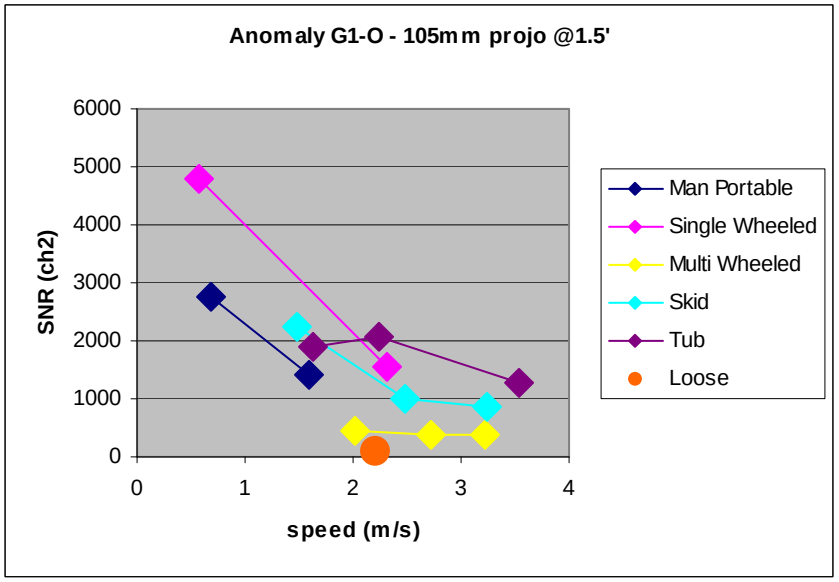

Anomaly G1-N - 4.2" mortar @3.9'
SNR (ch1)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

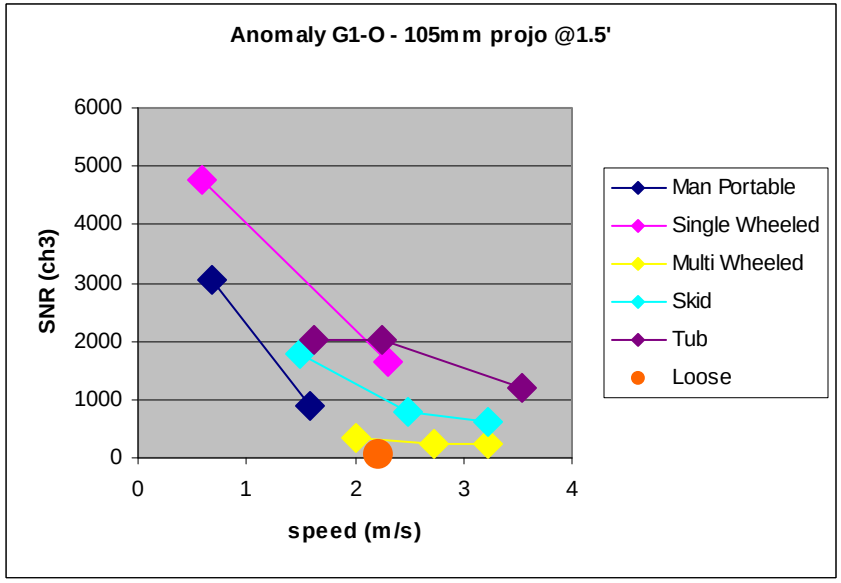

Anomaly G1-N - 4.2" mortar @3.9'
SNR (ch2)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

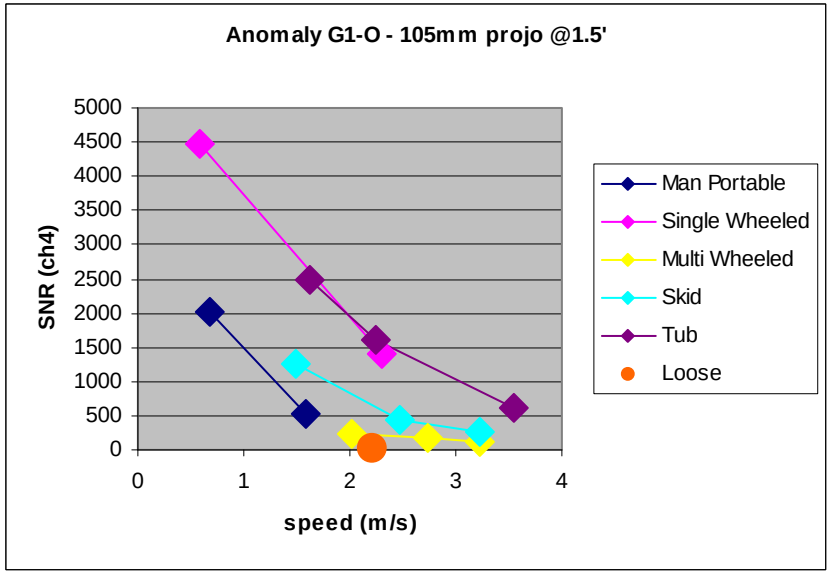

Anomaly G1-N - 4.2" mortar @3.9'
SNR (ch3)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

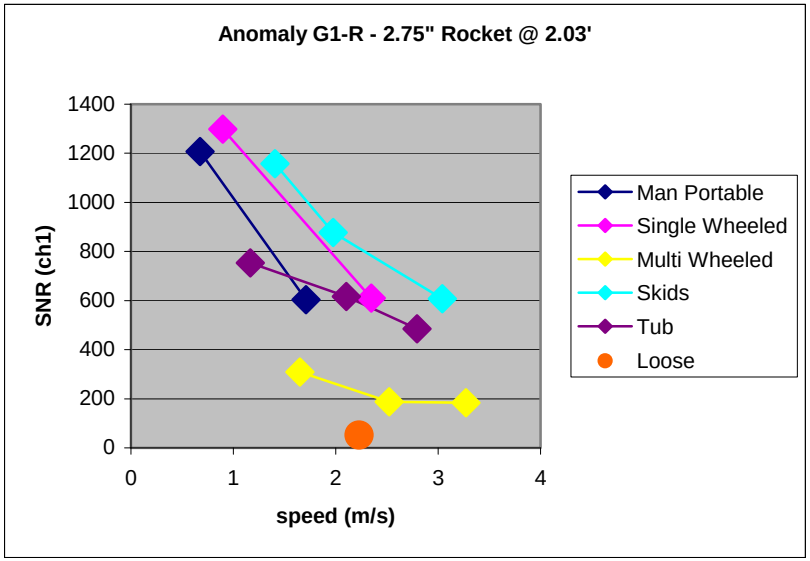

Anomaly G1-N - 4.2" mortar @3.9'
SNR (ch4)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

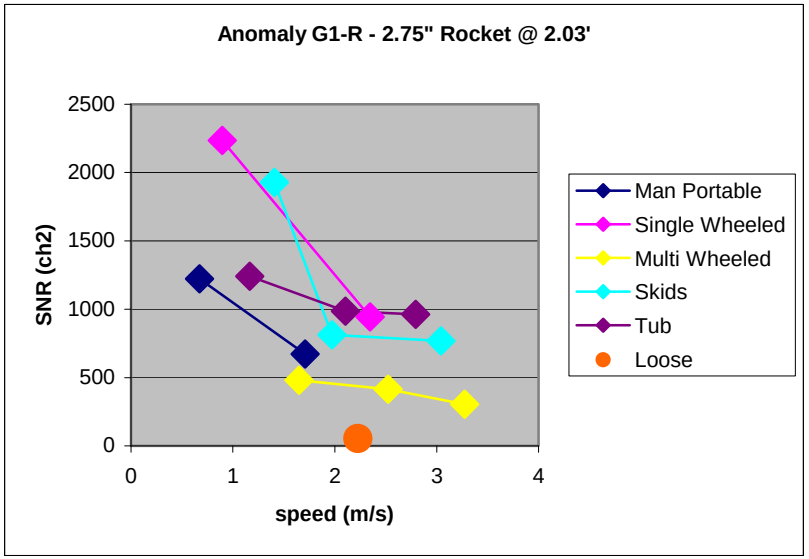

Anomaly G1-O - 105mm projo @1.5'
SNR (ch1)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skid
Tub
Loose

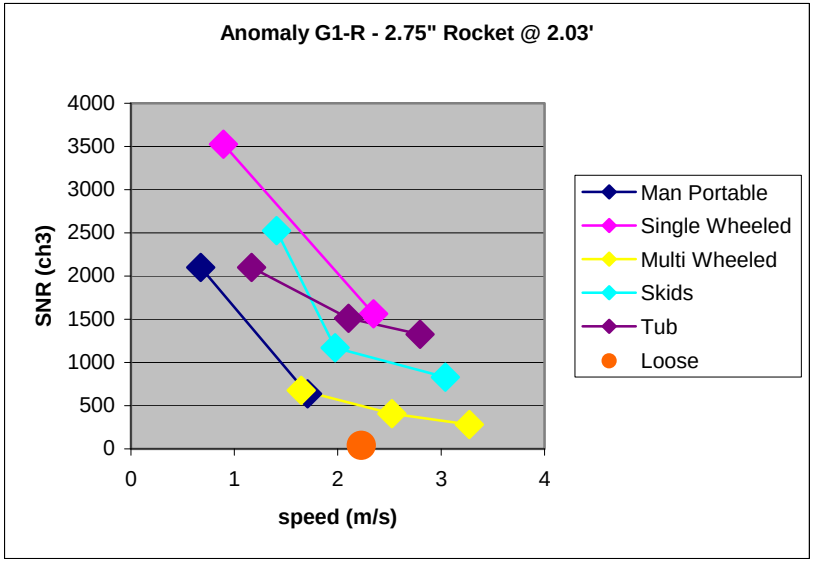

Anomaly G1-O - 105mm projo @1.5'
SNR (ch2)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skid
Tub
Loose

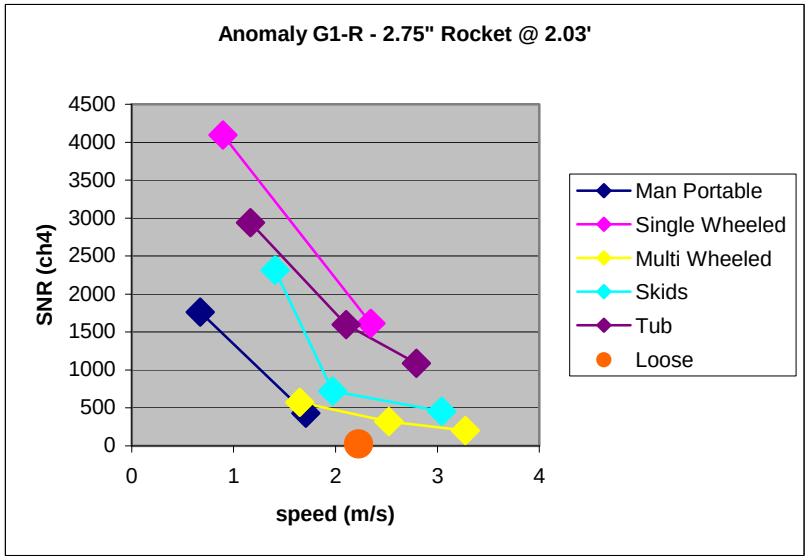

Anomaly G1-O - 105mm projo @1.5'
SNR (ch3)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skid
Tub
Loose

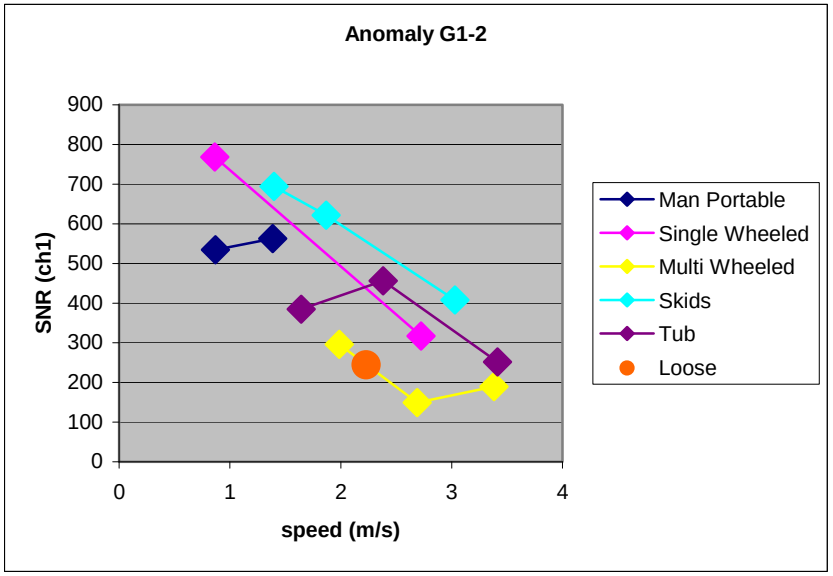

Anomaly G1-O - 105mm projo @1.5'
SNR (ch4)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skid
Tub
Loose

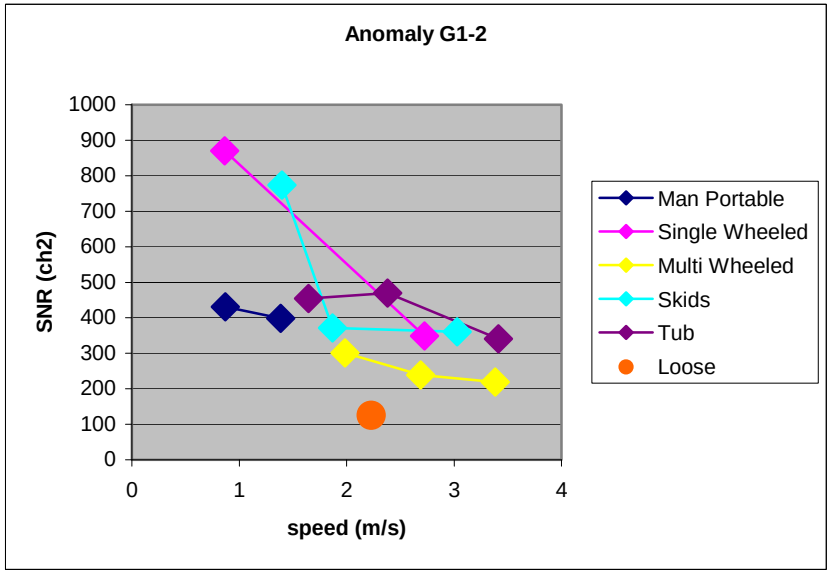

Anomaly G1-R - 2.75" Rocket @ 2.03'
SNR (ch1)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

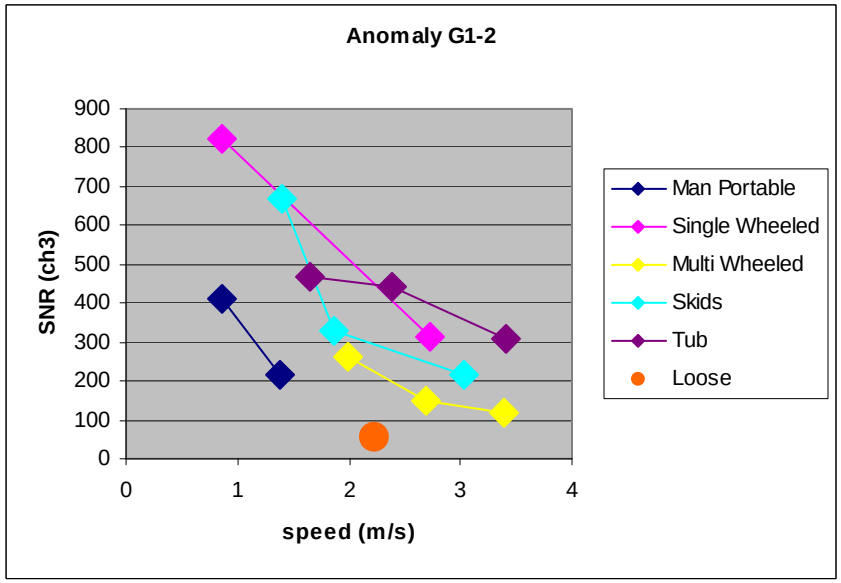

Anomaly G1-R - 2.75" Rocket @ 2.03'
SNR (ch2)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

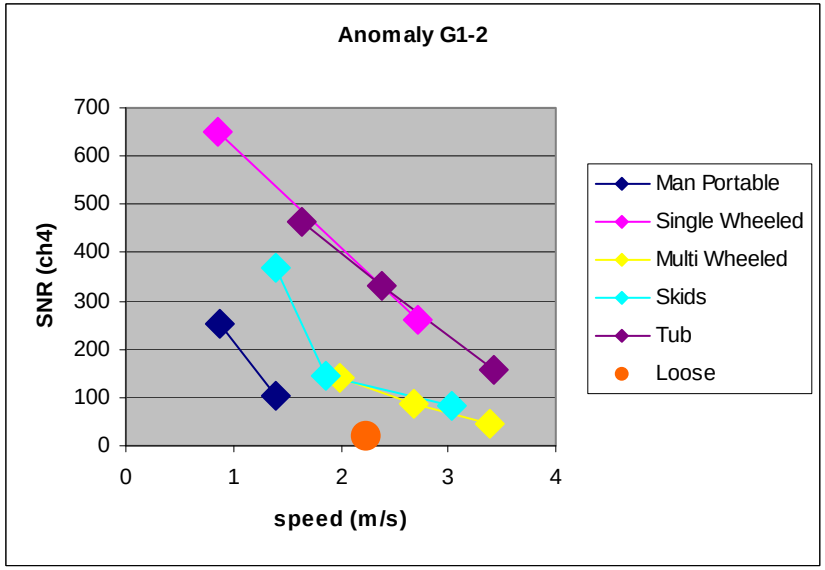

Anomaly G1-R - 2.75" Rocket @ 2.03'
SNR (ch3)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

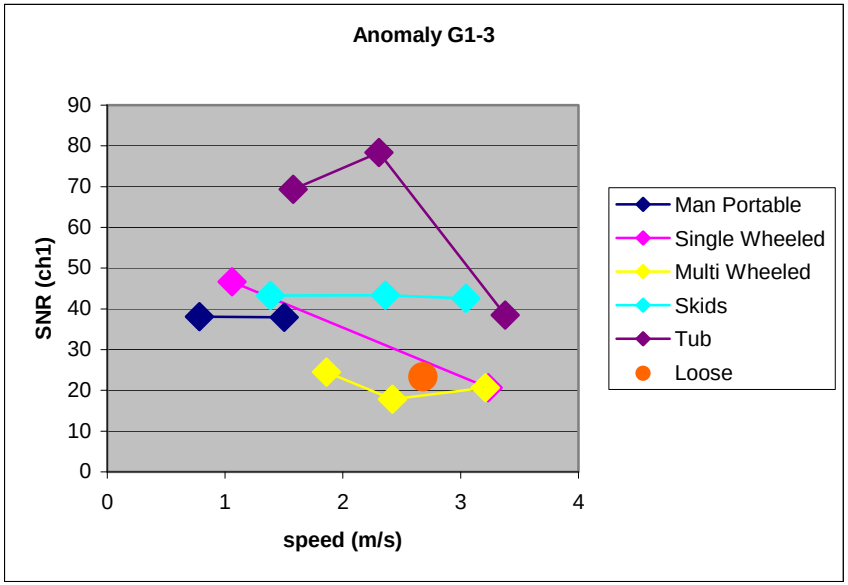

Anomaly G1-R - 2.75" Rocket @ 2.03'
SNR (ch4)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

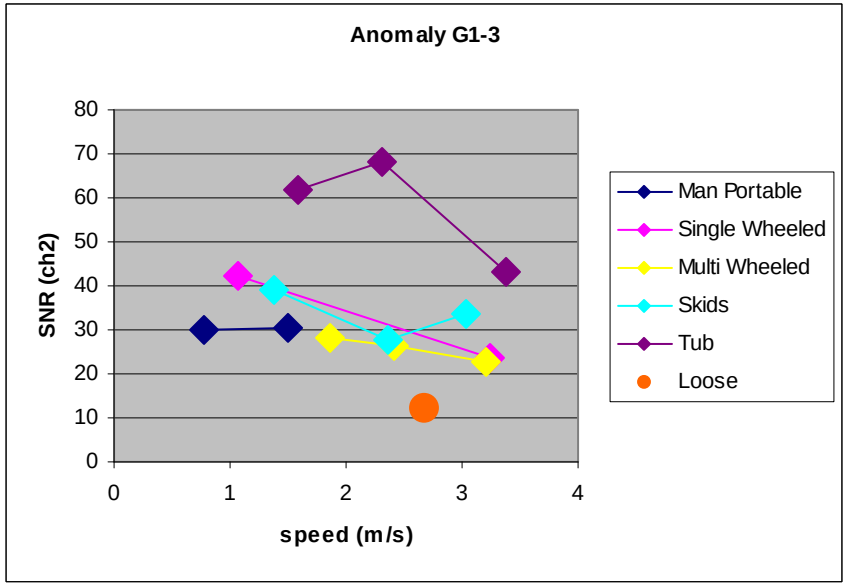

Anomaly G1-2
SNR (ch1)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

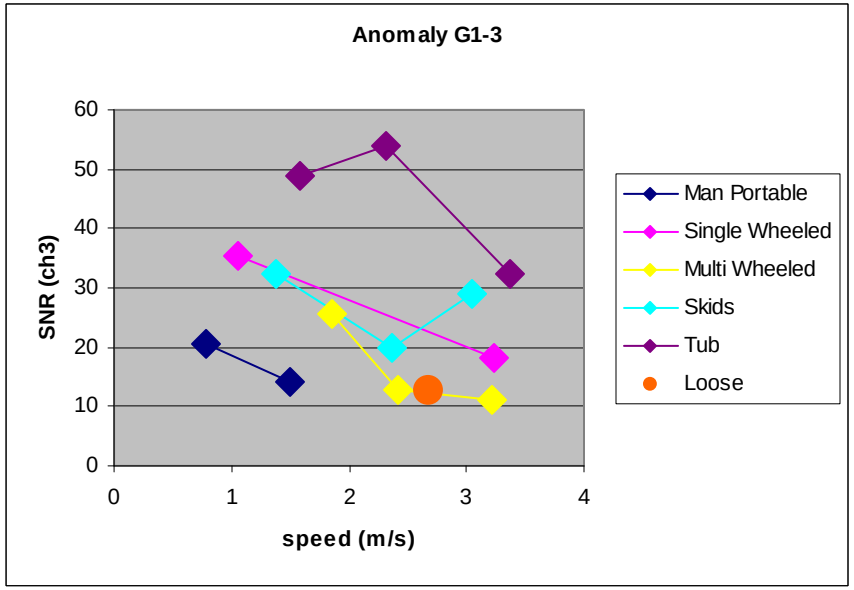

Anomaly G1-2
SNR (ch2)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

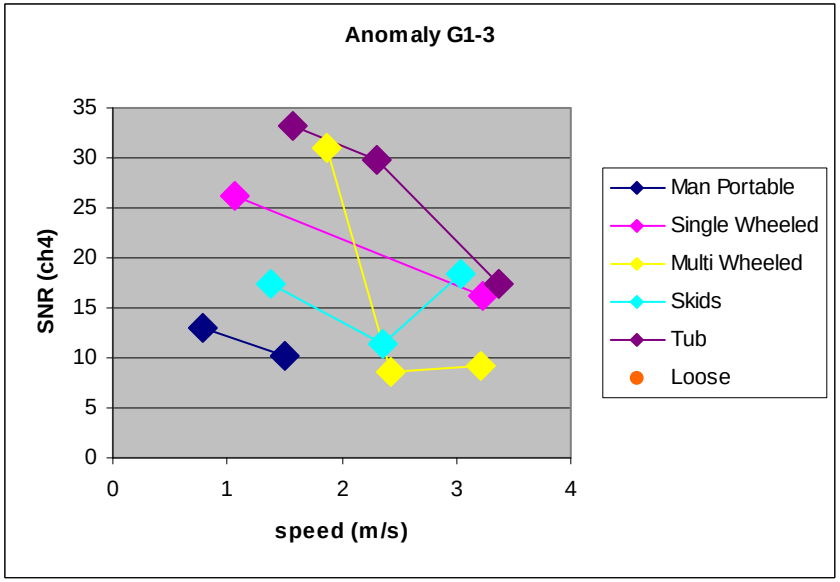

Anomaly G1-2
SNR (ch3)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

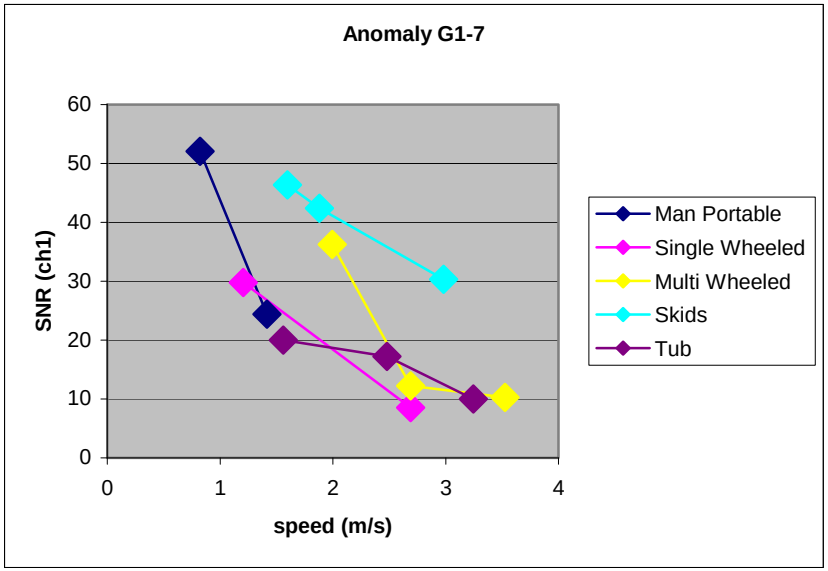

Anomaly G1-2
SNR (ch4)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

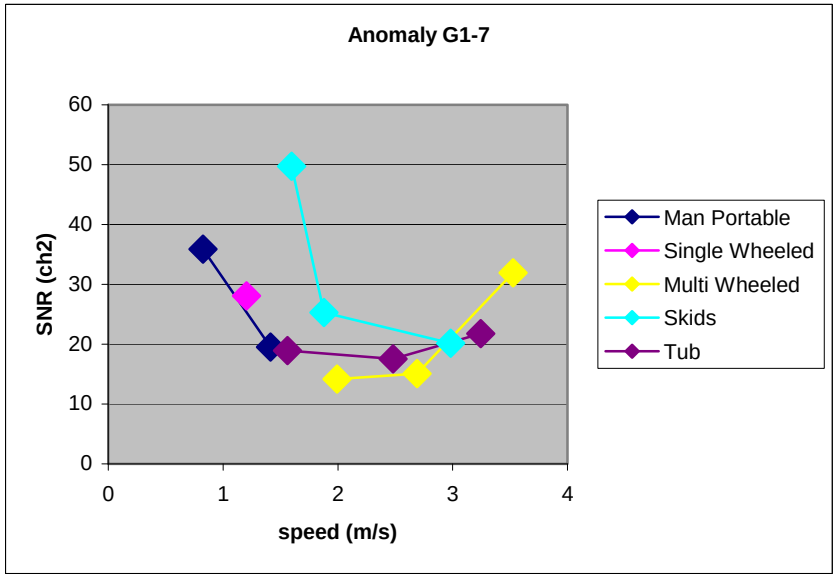

Anomaly G1-3
SNR (ch1)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

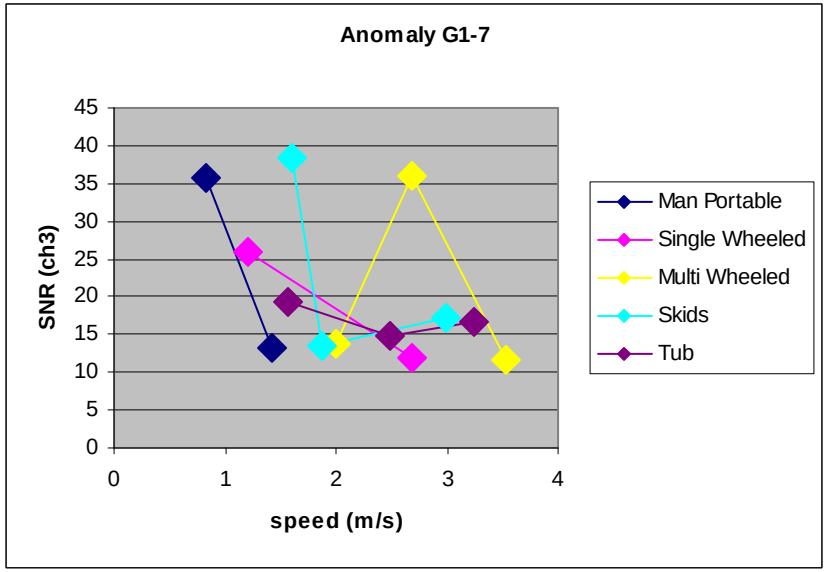

Anomaly G1-3
SNR (ch2)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

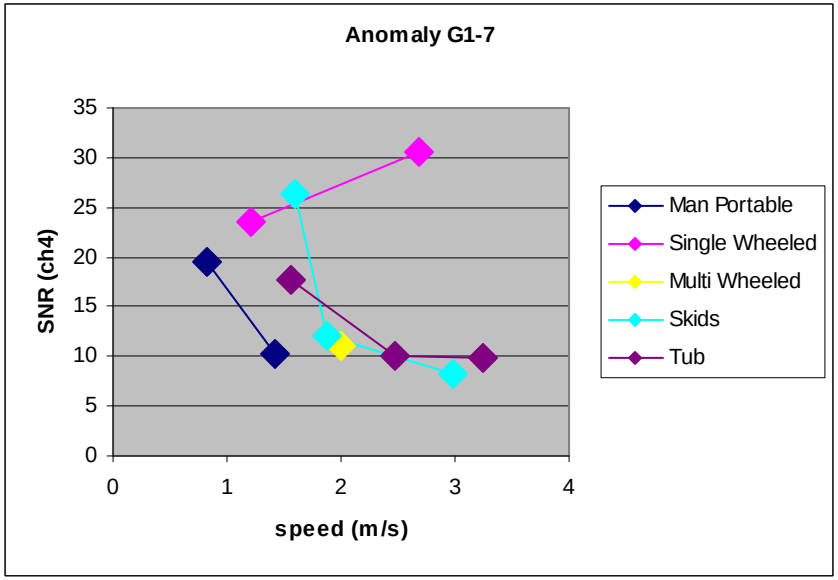

Anomaly G1-3
SNR (ch3)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

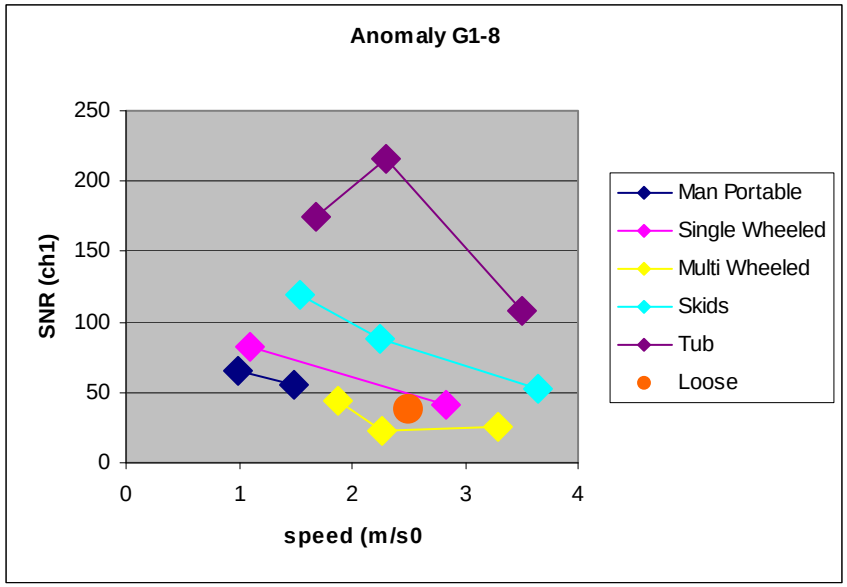

Anomaly G1-3
SNR (ch4)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

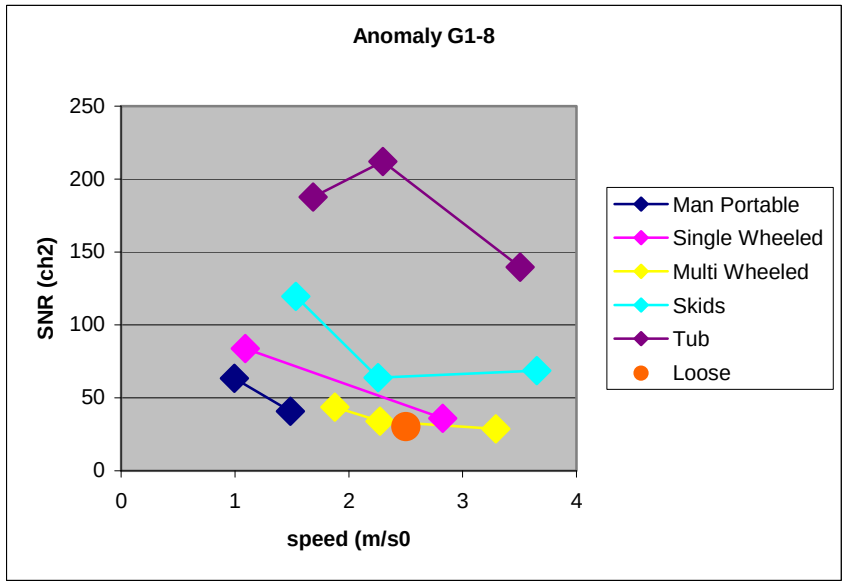

Anomaly G1-7
SNR (ch1)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub

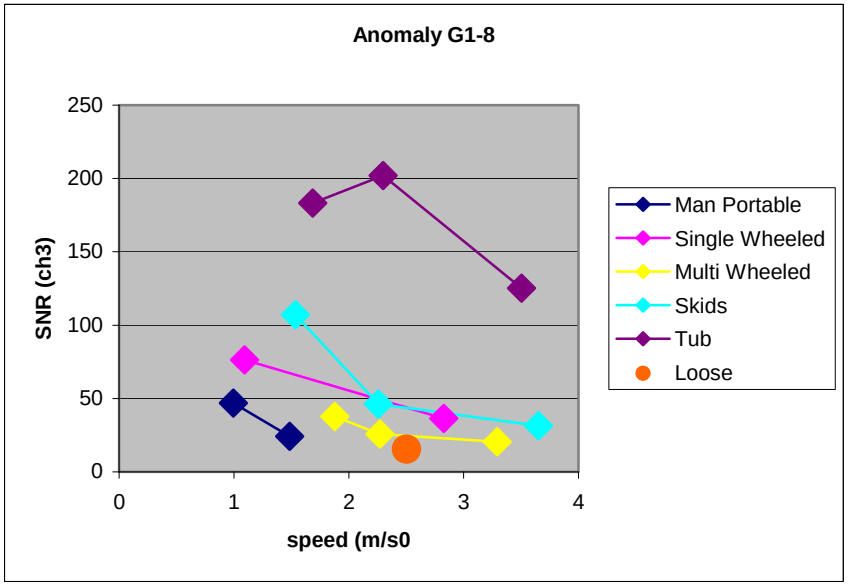

Anomaly G1-7
SNR (ch2)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub

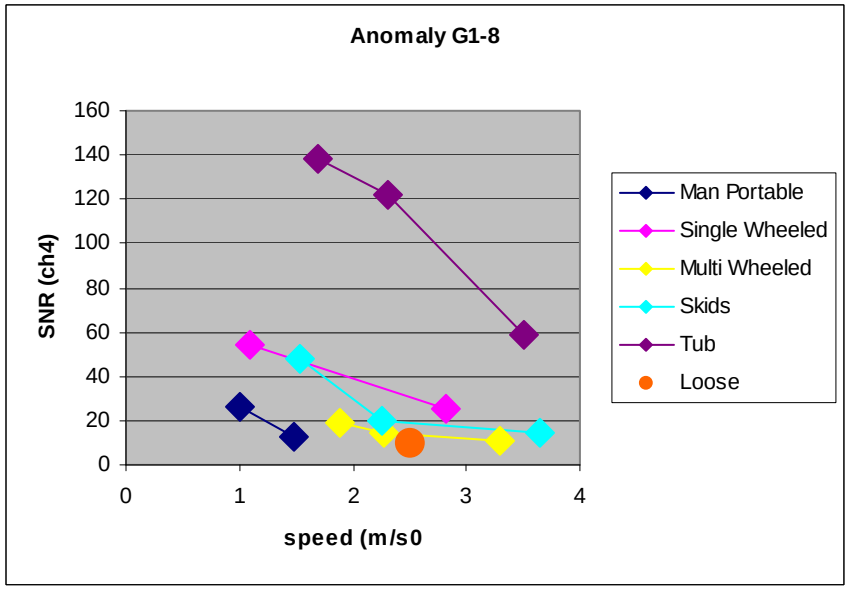

Anomaly G1-7
SNR (ch3)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub

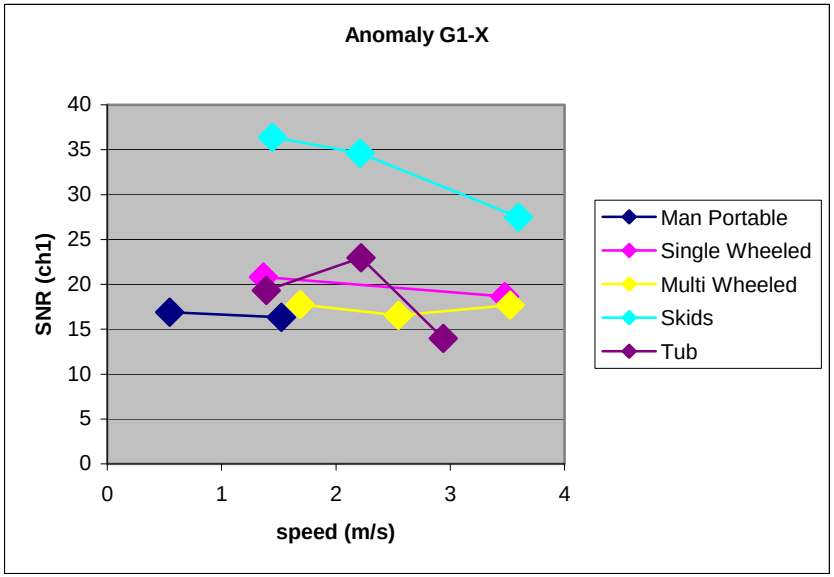

Anomaly G1-7
SNR (ch4)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub

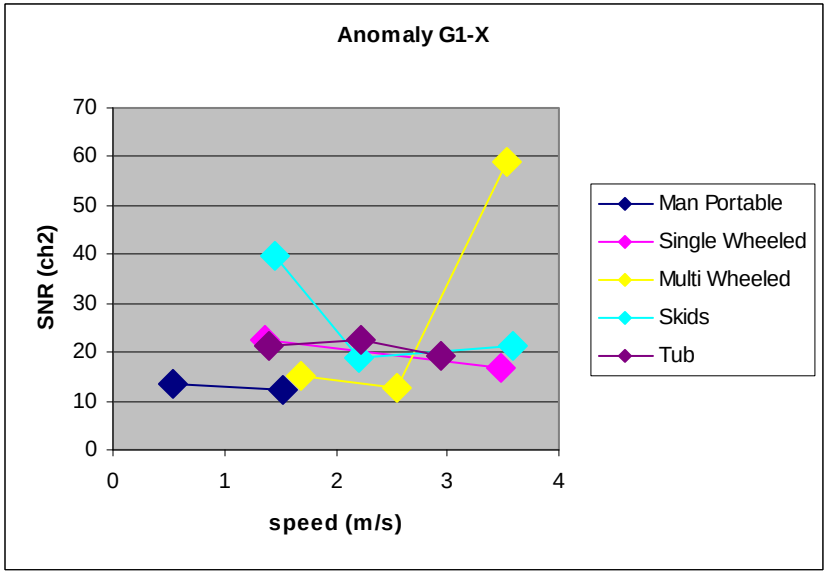

Anomaly G1-8
SNR (ch1)
250
200
150
100
50
0
0
1
2
3
4
speed (m/s0
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

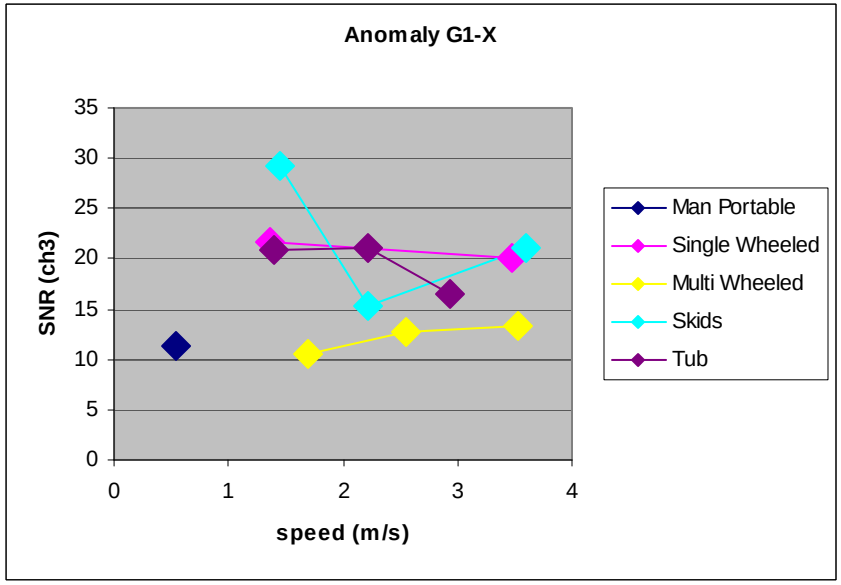

Anomaly G1-8
SNR (ch2)
250
200
150
100
50
0
0
1
2
3
4
speed (m/s0
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

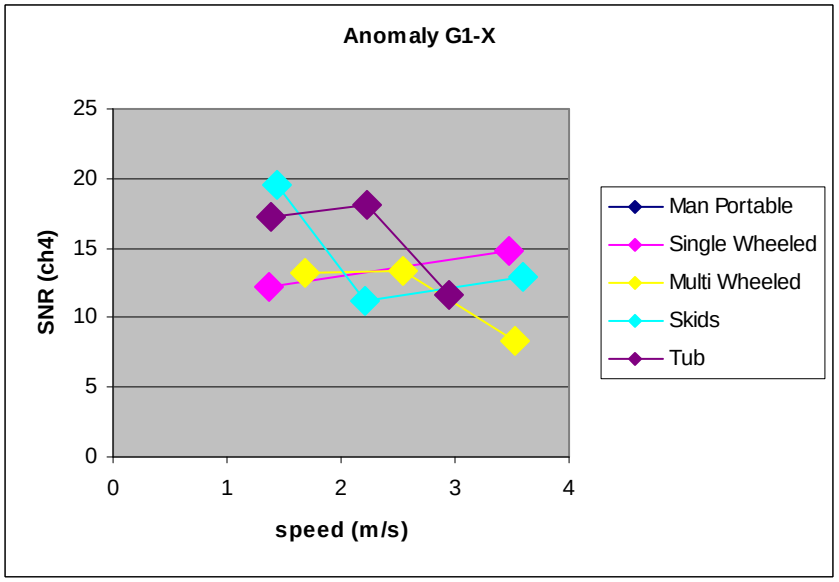

Anomaly G1-8
SNR (ch3)
250
200
150
100
50
0
0
1
2
3
4
speed (m/s0
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

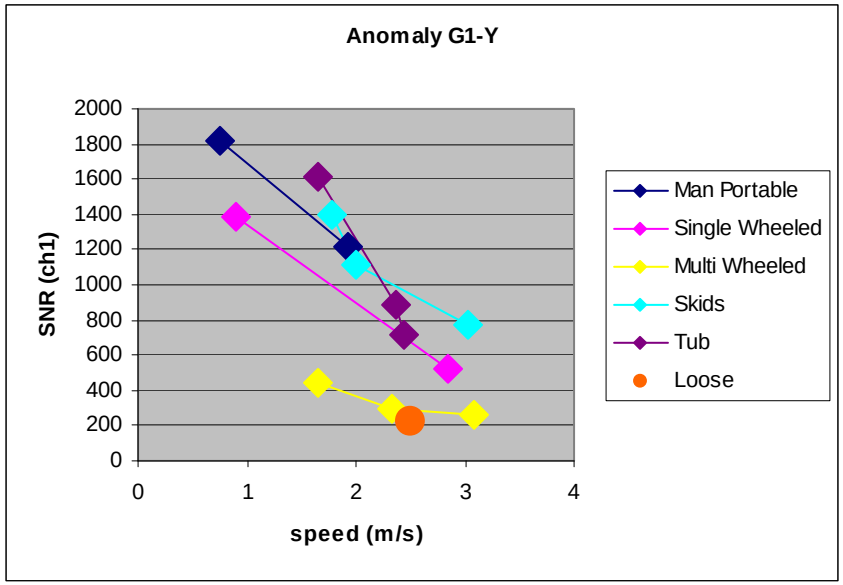

Anomaly G1-8
SNR (ch4)
160
140
120
100
80
60
40
20
0
0
1
2
3
4
speed (m/s0
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

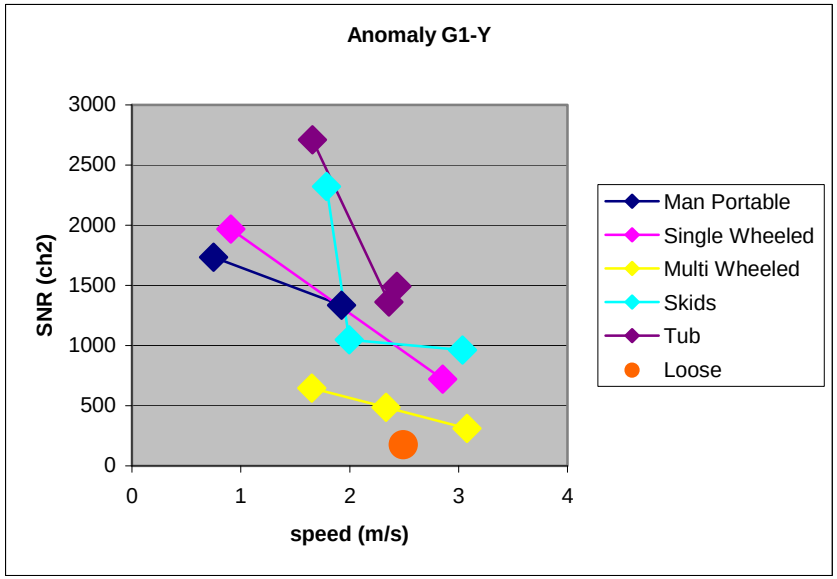

Anomaly G1-X
SNR (ch1)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub

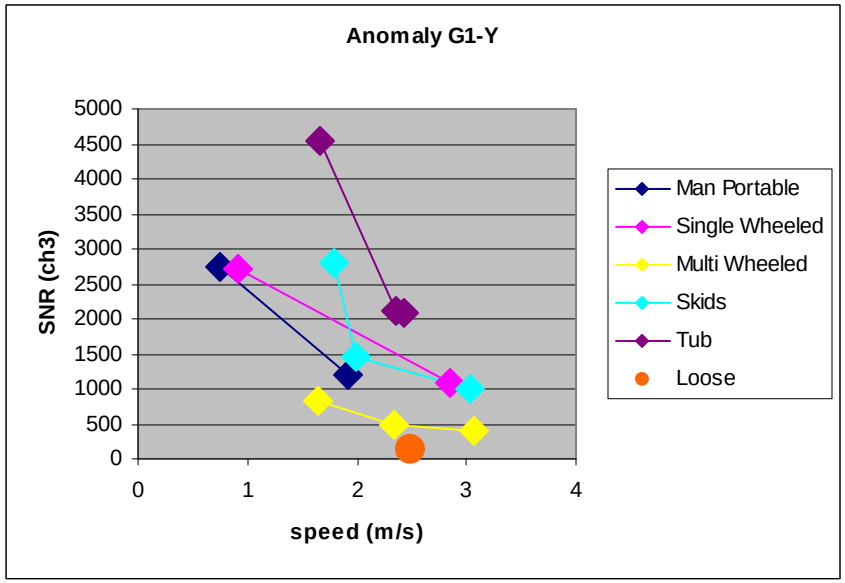

Anomaly G1-X
SNR (ch2)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub

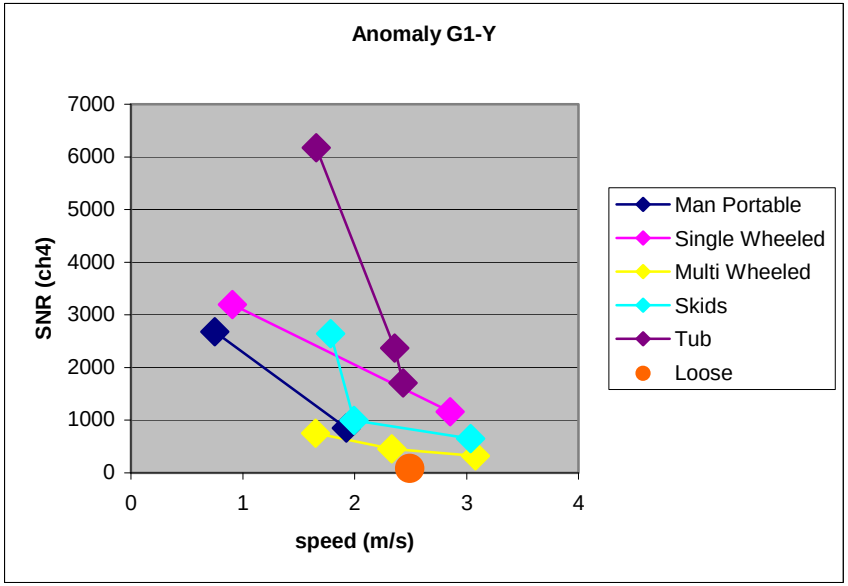

Anomaly G1-X
SNR (ch3)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub


Anomaly G1-X
SNR (ch4)
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub


Anomaly G1-Y
SNR (ch1)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
1
2
3
4
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose


Anomaly G1-Y
SNR (ch2)
3000
2500
2000
1500
1000
500
0
0
1
2
3
4
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose


Anomaly G1-Y
SNR (ch3)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
1
2
3
4
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose


Anomaly G1-Y
SNR (ch4)
7000
6000
5000
4000
3000
2000
1000
0
0
1
2
3
4
speed (m/s)
Man Portable
Single Wheeled
Multi Wheeled
Skids
Tub
Loose

Appendix F: Anomaly Sizes

ID	Item	Depth (m)	Size (m)												
			Man-port, single, wheels, slow	**Man-port, single, wheels, normal**	**Towed, single coil, wheels, normal**	**Towed, single coil, wheels, fast**	**Towed, dual coil, wheels, normal**	**Towed, dual coil, wheels, fast**	**Towed, dual coil, wheels, X-fast**	**Towed, dual coil, skids, normal**	**Towed, dual coil, skids, fast**	**Towed, dual coil, skids, X-fast**	**Towed, dual coil, in tub, normal**	**Towed, dual coil, in tub, fast**	**Towed, dual coil, in tub, X-fast**
I	2 - 105mm Projectile	1.49	2.8	2.56	2.39	2.55				2.17	2.71	3.16			
E	150mm Projectile	0.72	3	3.1	2.77	3.05	3.05	3.04	3.05	2.81	2.76	2.8	2.17	2.5	2.81
O	105mm Projectile	0.47	3.32	3.15	3.04	3.44	3.16	3.26	3.25	2.97	3.36	3.35	2.53	2.8	3.47
A	8 inch Projectile	0.77	4.15	4.19	3.9	4.37	4.11	4.23	4.55	3.95	4.1	4.22	2.95	3.35	3.54
F	2 - M43 Submunitions	0.33	1.32	1.44	1.45	2.1	1.93	2.6	2.28	1.77	2.11	2.77	2.1	2.16	2.42
Q	155mm Projectile	1.04	3.48	2.98	2.16	2.5	2.81	2.77	2.8	2.98	2.91	3.3	3.69	3.7	3.42
M	3- 155mm Projectiles	2.89	2.2	2.15	2	2.45	2.99	2.54	2.75	3.42	3.71	3.93	4.17	4.04	4.38
R	2.75” Rocket w/ Fins	0.62	3.05	3.2	2.6	3.09	2.43	3.2	3.36	2.84	3.36	3.61	1.98	2.17	2.59
H	75mm Projectile HE plus Case	0.28	2.87	3.15	2.95	3.57	4.7	4.28	4.65	4.55	4.68	4.59	3.98	4.25	4.24
D	250 lb GP Bomb	2.97	2.38	2.13	2.38	2.56	3.08	2.71	2.72	2.31	2.66	2.05	3.3	3.61	3.62
SW	Nail	-		1.88	1.85	2.67	1.72	2.58	2.81	1.77	2.1	2.67	1.79	2.38	3.05
SE	Nail	-	1.6	1.99	1.78	2.33	1.88	2.38	2.72	1.83	1.82	2.44	1.72	2.39	2.78
NE	Nail	-	1.78	2.04	1.66	2.61	1.88	2.43	2.42	1.68	2.11	3	2.28	2.38	2.87
NW	Nail	-		1.93	1.65	2.54	1.84	2.37	2.09	1.89	2.05	2.85	1.82	2.22	2.83
C	Nail	-	2	1.83	1.93	2.57	1.95	2.55	3.08	1.6	2.24	2.95	2.39	2.44	2.9
AVG			**2.51**	**2.50**	**2.31**	**2.69**	**2.61**	**2.84**	**3.00**	**2.51**	**2.78**	**3.06**	**2.60**	**2.78**	**3.10**

Appendix G: Blind Seed Item Results

Only Government personnel are to have access to this Appendix.