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Personnel and Vehicle Data Collection at Aberdeen Proving Ground (APG) and its Distribution for Research

by Sylvester M Nabritt, Thyagaraju Damarla, and Gary Chatters

NOTICES

Disclaimers

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14. ABSTRACT

The US Army Research Laboratory's (ARL) Networked Sensing and Fusion Branch continually strives to develop next generation unattended ground sensors (UGSs) and other sensing platforms. In support of these goals, it is a requirement to have access to seismic, acoustic, magnetic, and other sensor signatures of vehicle and people. These signature databases allow researchers to develop cutting-edge detection algorithms that detect and classify 1 or more vehicles or persons. These algorithms will be geared toward current and new UGS applications. For this effort, a team was deployed to Spesutie Island at Aberdeen Proving Ground, Maryland, to collect signatures of personnel and vehicles from July 27–30, 2015.

15. SUBJECT TERMS

Acoustic, Seismic, magnetic, footstep, vehicle, magnetometer, geophone, unattended ground sensor (UGS)

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1. Introduction

The US Army Research Laboratory's (ARL) Networked Sensing and Fusion Branch continually strives to develop next generation unattended ground sensors (UGSs) and other sensing platforms. In support of these goals, it is a requirement to have access to seismic, acoustic, magnetic, and other sensor signatures of vehicle and people. These signature databases allow researchers to develop cutting-edge detection algorithms that detect and classify 1 or more vehicles or persons. These algorithms will be geared toward current and new UGS applications.

For this effort, a team was deployed to Spesutie Island at Aberdeen Proving Ground, Maryland, to collect signatures of personnel and vehicles from July 27–30, 2015.

2. Data Collection Setup

The team set up several data collection nodes comprised of seismic, acoustic, and magnetic sensors, where 1 node did not have the 3-axis geophone or the 3-microphone array. The layout for the specific sensors is shown in Fig. 1. The team spent the first day setting up all the data acquisition equipment and Garmin VIRB high definition (HD) cameras were set up around the perimeter to record all activity. The blue dots indicate an UGS suite consisting of a single microphone and a z-axis seismic sensor; a red dot indicates an UGS system consisting of a 5-inch-diameter circular array of microphones and a 3-axis seismic sensor; and a black dot indicates a 3-axis magnetic sensor placed closer to the middle of 20 m by 20 m square grid shown with dotted lines. Five UGS systems from each corner of a 20 m by 20 m square and the magnetic sensors are connected to a data collection unit, which collects the data and stores them in a file. The data are collected for a stretch of 5 min at a time.

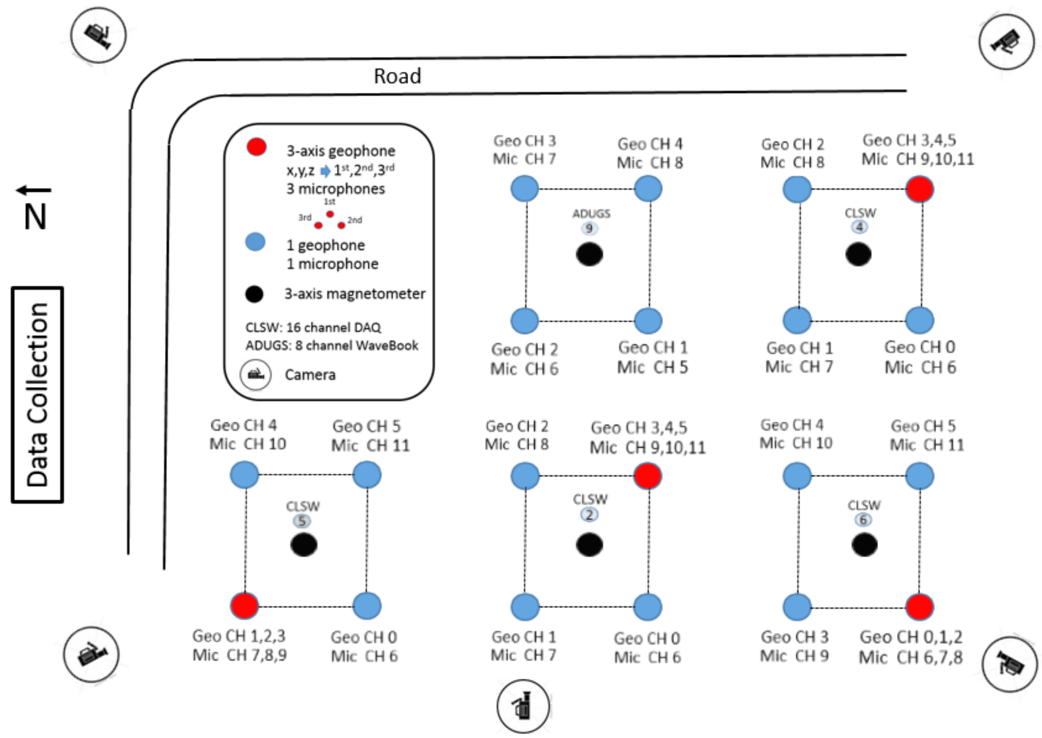

Fig. 1 Sensor layout grid

As mentioned earlier, the sensor layout placed the UGS systems 20 m away from each other in a grid pattern. The specific hardware and software used are given in Table 1.

Table 1 Data collection equipment

Name	Description/Manufacturer	No. Used
Geophone	Geospace GS-11D z-axis or 3-axis xyz configuration	28
Microphone	Behringer ECM8000 condenser microphone	28
Magnetometer	Applied Physics Model 1540-digital 3-axis fluxgate	5
Amplifiers	Alligator Technologies USBPGF-S1 programmable instrumentation amplifier	5
Data acquisition device 1	Measurement Computing (IOTECH) WaveBook/ 516E with option WBK13A	1
Data acquisition device 2	Measurement Computing (IOTECH) USB-1616HS-BNC	5
Laptop computers	Dell Latitude E6400 series	
Data recording software	DASYLab	5
Data recording software	WaveView	1
Global positioning system (GPS)	Garmin e Trex 20x	12
Camera	Garmin VIRB 010-01088-10	5
Cone penetrometer	Kessler DCP K-100	1

Actual photos of the equipment used for this data collection and their setup are shown in Fig. 2.

Fig. 2 Sensor suite used for data collection

3. Data Collection

Several people participated in the data collection to enact various scenarios. The list of participants and their weights are given in Table 2. Also, column 2 corresponds to the GPS receiver each participant carried while enacting a scenario, which tracked that person's location.

Table 2 Data collection participants

Participant (No.)	GPS No.	Weight (lb)
GC_1	4	150
TD_2	1	160
RF_3	5	160
RH_4	6	165
MN_5	8	195
GW_6	9	204
NS_7	3	170
SX_8	11	154
CH_9	10	200
TW_10	7,3	170
GW_11	2	204

The data were collected on 3 different days where the first 2 days were walkers ranging from 1–9 persons (Tables 3 and 4) in different formations, which are described later in this section. On the 3rd day, data were collected with different sets of civilian vehicles ranging from sedans to SUVs. Each sensor setup collected seismic, acoustic, and magnetic data. The data were collected at 4096 samples/s and video/GPS locations was recorded to provide ground truth for vehicles and walkers. These data will be used to verify the classification results of the algorithms being developed. To start out testing, a Kessler DCP K-100 cone penetrometer was used to provide a consistent impulse to calibrate the sensors. After calibration, collection of data was started; the activity, participants, and times for each event are outlined in Table 3.

Table 3 Day 2 walking participants

Activity	No.	Participants	Time
Seismic calibration	3 at10 flags	5,8	1320
1 person walking	9	1,4,5,6,7,8,9,10,11	1335–1428
9 persons walking	2	1,4,5,6,7,8,9,10,11	1430–1434, 1454–1459
2 persons walking	4	(10,11), (8,10), (4,5), (5,11)	1353–1357, 1400–1403, 1405–1408, 1410–1413
3 persons walking	2	(4,8,9), (1,6,10)	1415–1419, 1423–1427
4 persons walking	2	(4,8,9,11), (3,5,6,10)	1430–1433, 1438–1442

Table 4 Day 3 walking participants

Activity (No.)	Participants	Times
Heavy right wedge (1)	4,6,9,11	1017–1025
Diamond (2)	4,6,9,11	1028–1036
Zigzag (3)	4,6,9,11	1043–1050
Line (horizontal) (4)	4,6,9,11	1054–1101
Line (vertical) (5)	4,6,9,11	1115–1122
Double wedge (6)	1,5,6,8,9,11	1134–1138
Formation with diamond in front and 2 men behind (7)	1,5,6,8,9,11	1140–1143
Point man slack man (8)	1,5,6,8,9,11	1143–1147
Diamond leading wedge (9)	1,2,5,6,8,9,11	1340–1350
Diamond with staggered column (10)	1,2,5,6,8,9,11	1358–1409
Heavy left wedge with trailing wedge (11)	1,2,3,5,6,8,9,11	1420–1431
2 wedges in trail (12)	1,5,6,8,9,11	1500–1505
2 wedges in line (13)	1,5,6,8,9,11	1513–1515
2 wedges in line (14)	1,5,6,8,9,11	1519–1521

The path each person walked through the sensor field is illustrated in Fig. 3, where the red dotted line indicates the path and the green dot is a walker. There were up to 9 walkers spaced 3 m apart walking single file starting with 1 at a time.

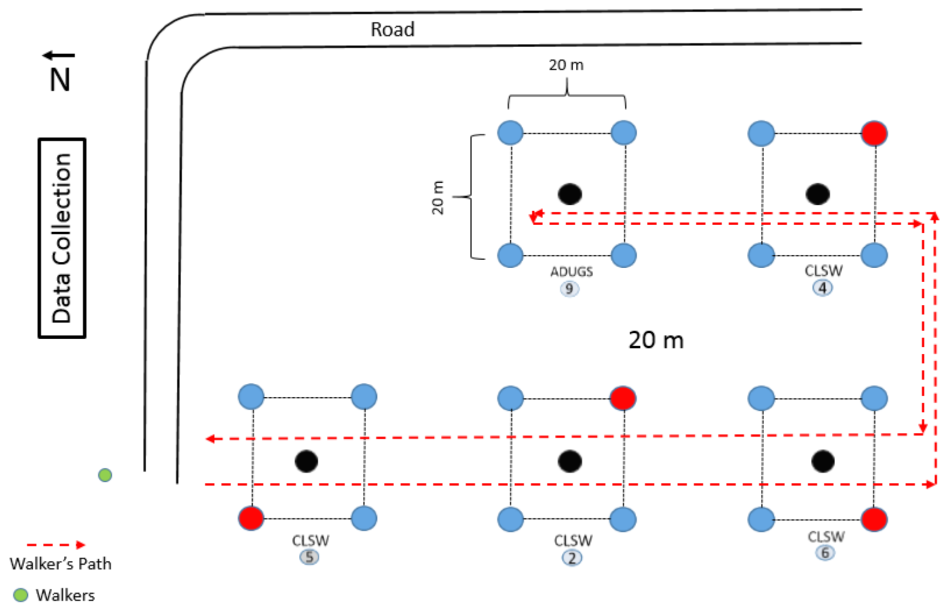

Fig. 3 Day 2 path for walkers 1–9

The second day of data collection consisted of many combinations of walkers each carrying a simulated M4 or M16. The activity, participants, and time for each event are shown in Table 4.

The paths each person walked through the sensor field for activities 1–5 are illustrated in Figs. 4–8, where the red dotted line indicates the path and the green dots indicates the walkers' pattern for each activity. The walkers are spaced approximately 5 m apart.

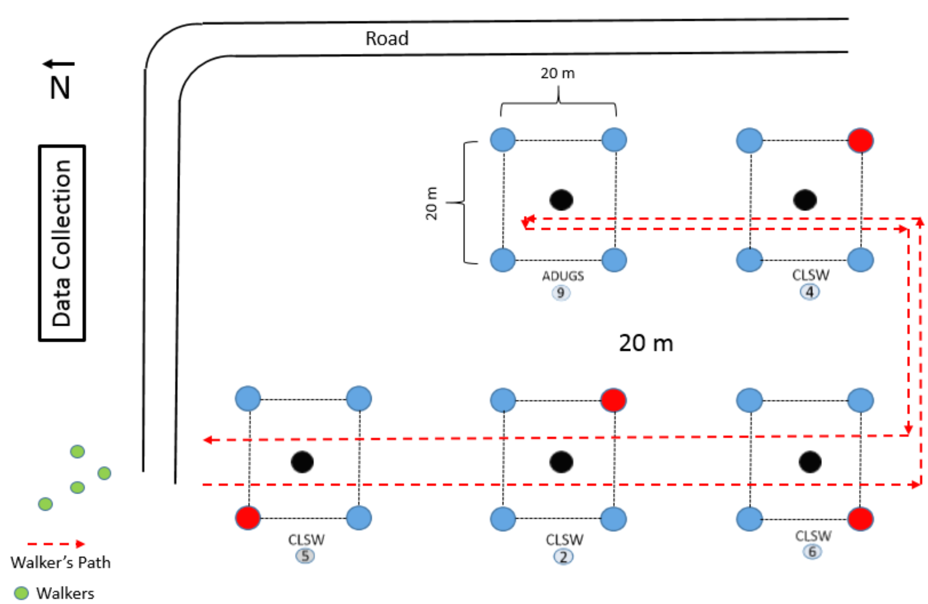

Fig. 4 Day 3 walker's heavy right wedge pattern

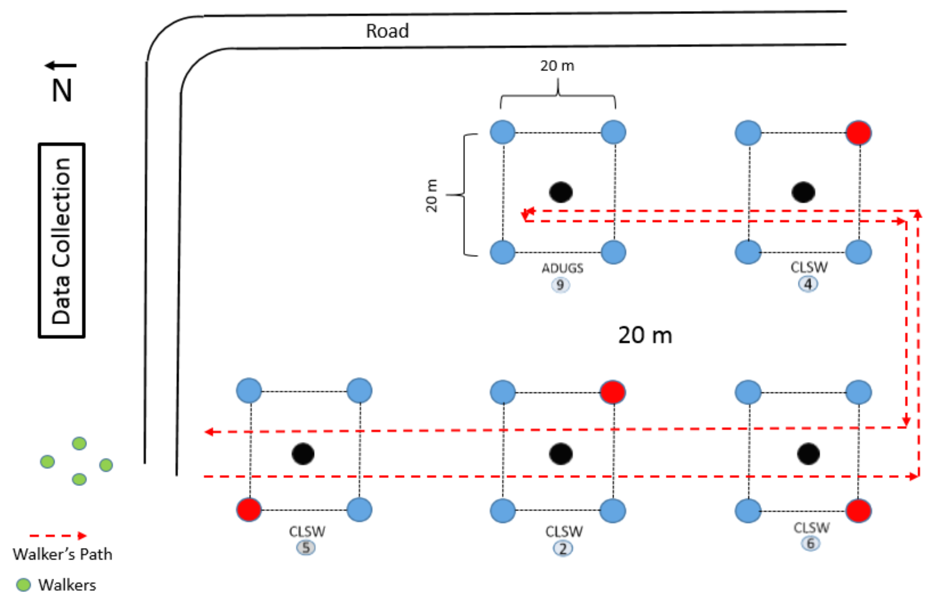

Fig. 5 Day 3 walker's diamond pattern

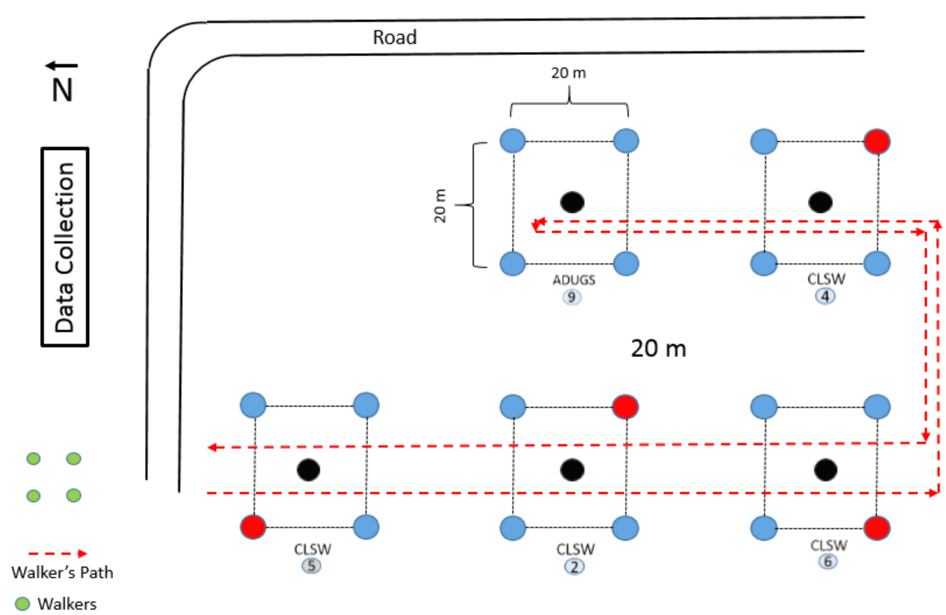

Fig. 6 Day 3 walker's zig zag pattern

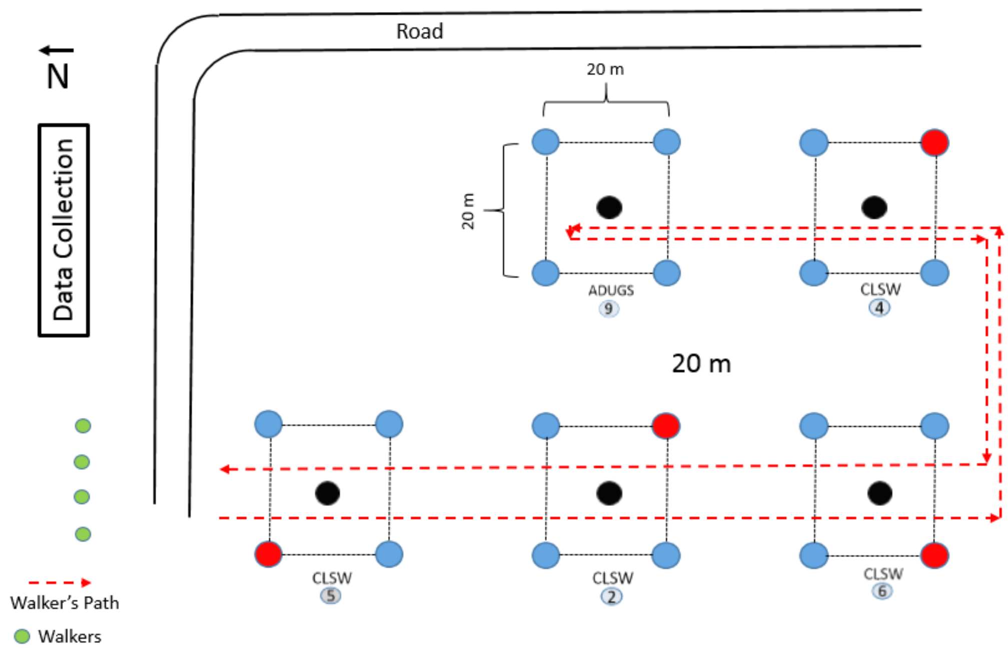

Fig. 7 Day 3 walker's line horizontal pattern

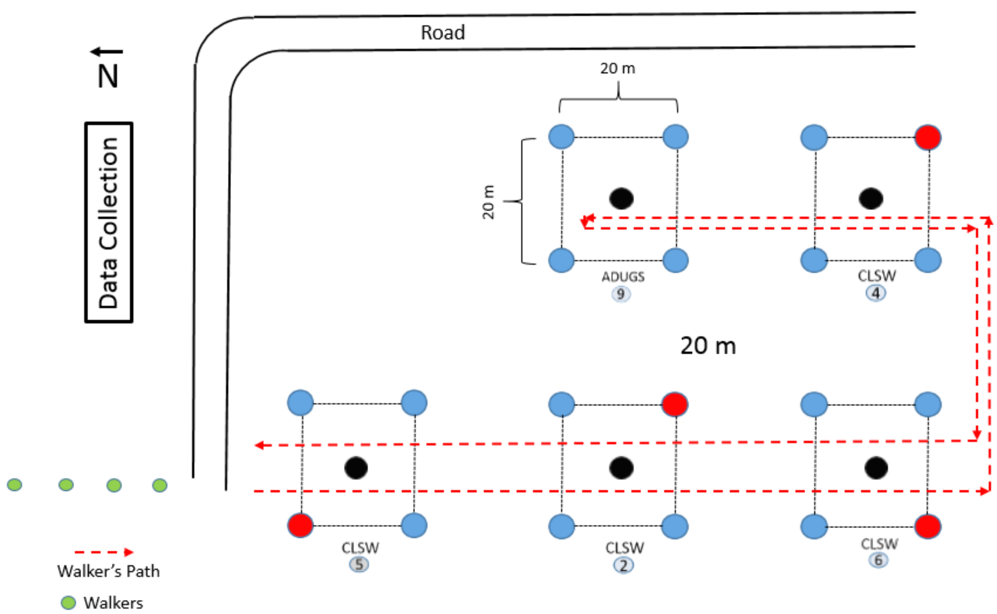

Fig. 8 Day 3 walker's line vertical pattern

The paths each person walked through the sensor field for activities 6, 7, and 8 are illustrated in Figs. 9–11, where the red dotted line indicates the path and the green dots indicate the walkers' pattern for each activity. Again, the walkers are spaced approximately 5 m apart.

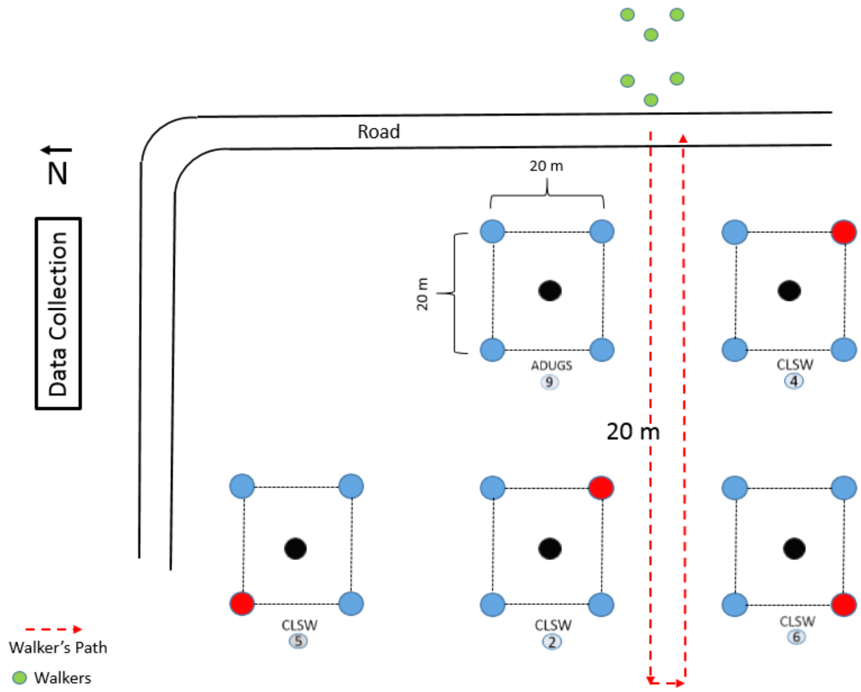

Fig. 9 **Day 3 walker's double wedge pattern**

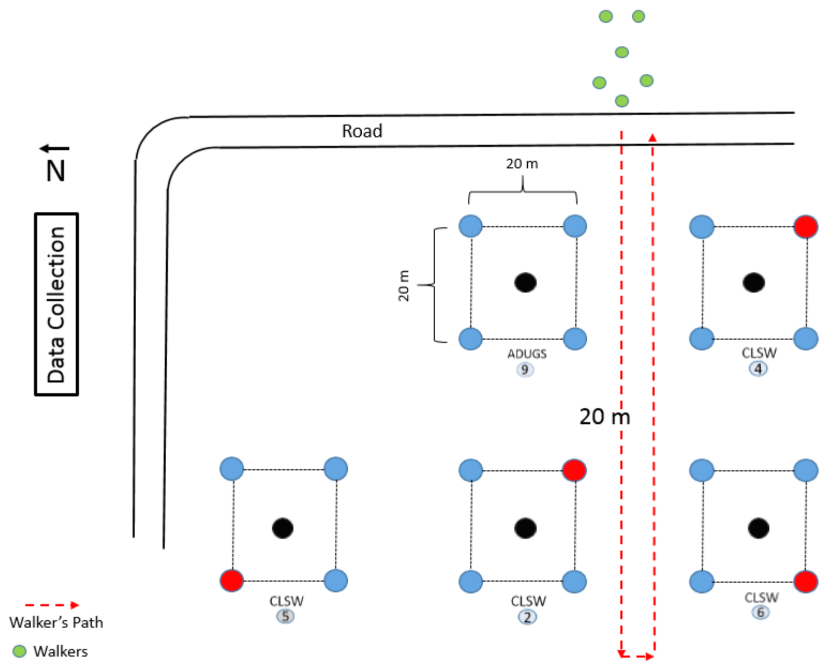

Fig. 10 **Day 3 walker's diamond in front and 2 men behind pattern**

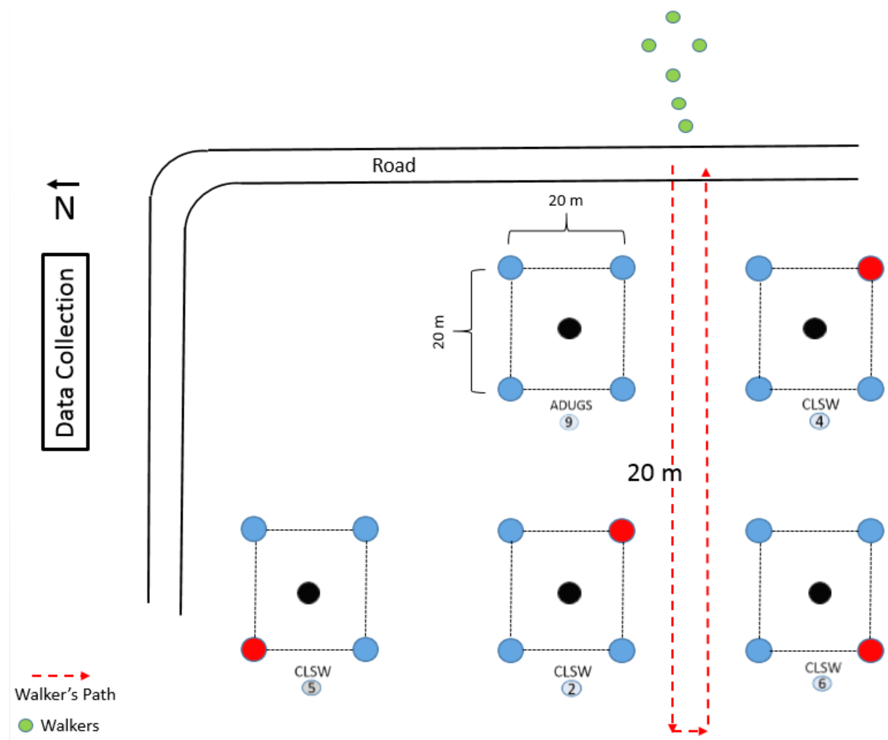

Fig. 11 Day 3 walker's point man slack man pattern

The paths each person walked through the sensor field for activities 9, 10, 11, and 12 are illustrated in Figs. 12–15, where the red dotted line indicates the path and the green dots indicates the walker's pattern for each activity. The walkers are also spaced approximately 5 m apart. For activity 12, the participants walk half the route, kneel, and then jog the remaining route for each direction.

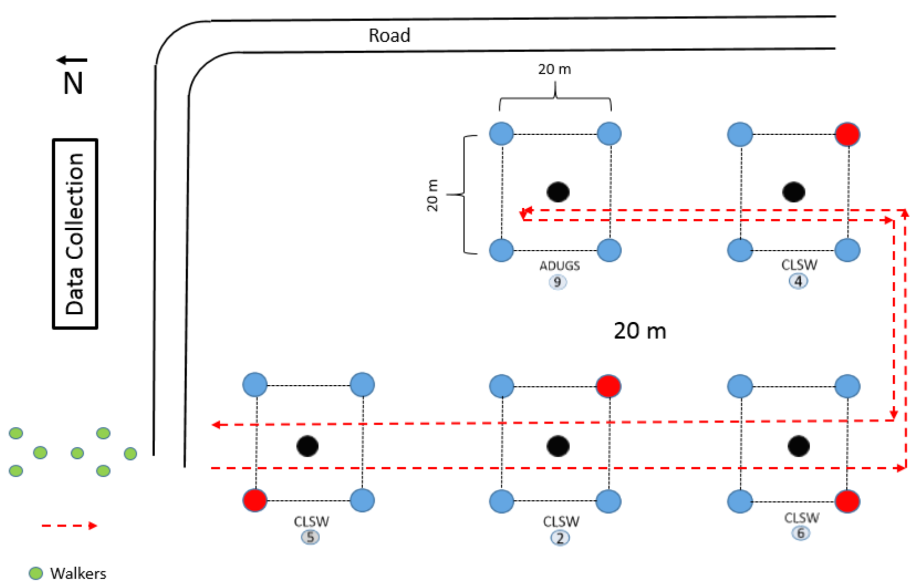

Fig. 12 Day 3 walker's diamond leading wedge pattern

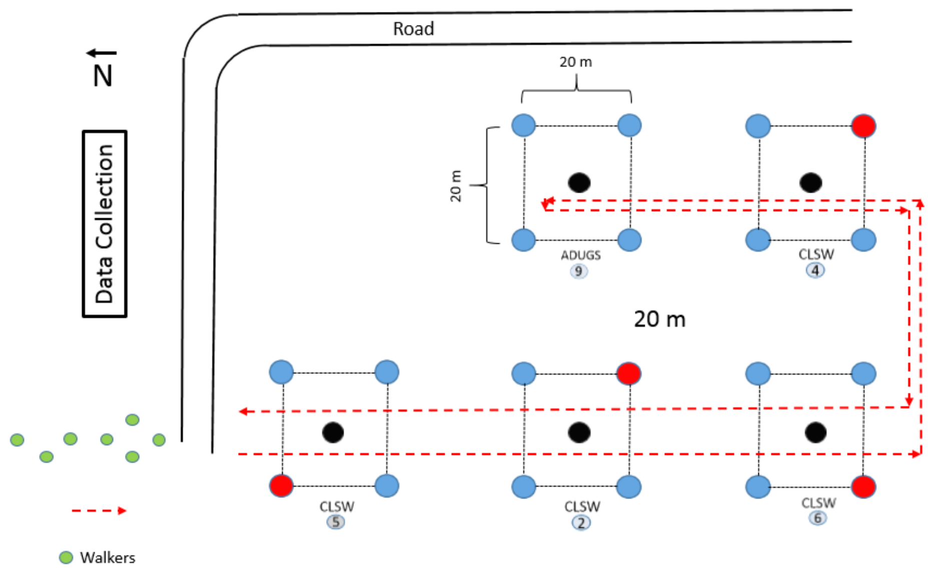

Fig. 13 Day 3 walker's diamond leading staggered column pattern

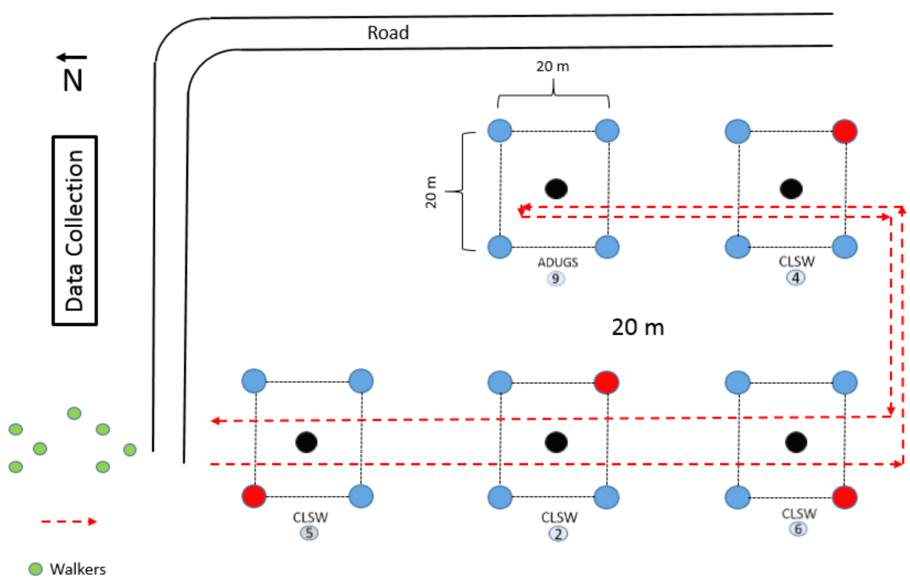

Fig. 14 Day 3 walker's heavy left wedge with trailing wedge pattern

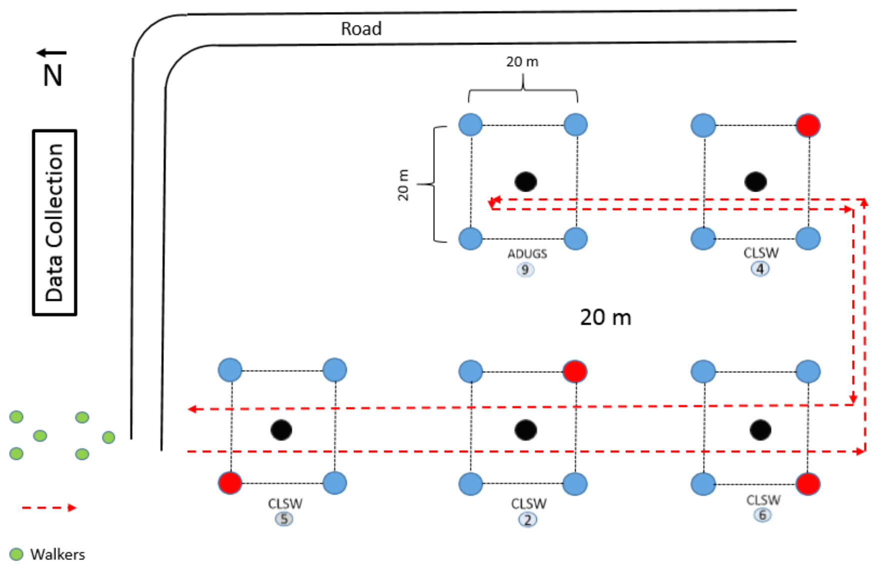

Fig. 15 Day 3 walker's 2 wedges in trail pattern with jogging

The paths each person walked through the sensor field for activities 13 and 14 are illustrated in Fig. 16, where the red dotted line indicates the path and the green dots indicate the walkers' pattern for each activity. The walkers are spaced approximately 5 m apart. In both activities, the participants walk across the sensor field, kneel, and then retreat 1 group at a time while the other group covers them.

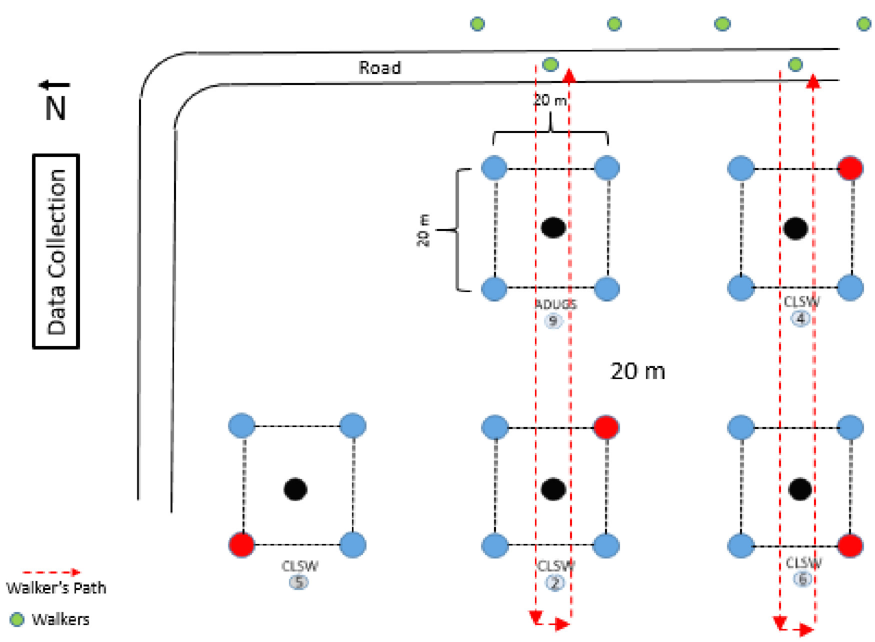

Fig. 16 Day 3 walker's 2 wedges in trail pattern with covering

The third day of data collection consisted of driving 1 to 7 vehicles around the sensor field. The data collection consisted of driving around the sensor field starting with 1 vehicle and incrementing by one up to 6 total vehicles. The vehicles were spaced 10 ms apart traveling 10 mph. The activity, participants, and time for these events are shown in Table 5 and the driving pattern is illustrated in Fig. 17.

Table 5 Day 3 vehicle participants, driving around a field

Activity	Time	Participants
1 vehicle around field twice	10:11–10:15 am	11
1 vehicle around field twice	10:15–10:19 am	9
1 vehicle around field twice	10:19–10:23 am	1
1 vehicle around field twice	10:23–10:27 am	6
1 vehicle around field twice	10:27–10:31 am	3
1 vehicle around field twice	10:31–10:34 am	10
2 vehicles around field twice	10:48–10:51 am	9,11
3 vehicles around field twice	10:52–10:56 am	1, 9, 11
4 vehicles around field twice	10:57–11:01 am	1, 6, 9, 11
5 vehicles around field twice	11:02–11:06 am	1, 3, 6, 9, 11
6 vehicles around field twice	11:06–11:10 am	1, 3, 6, 9, 10, 11

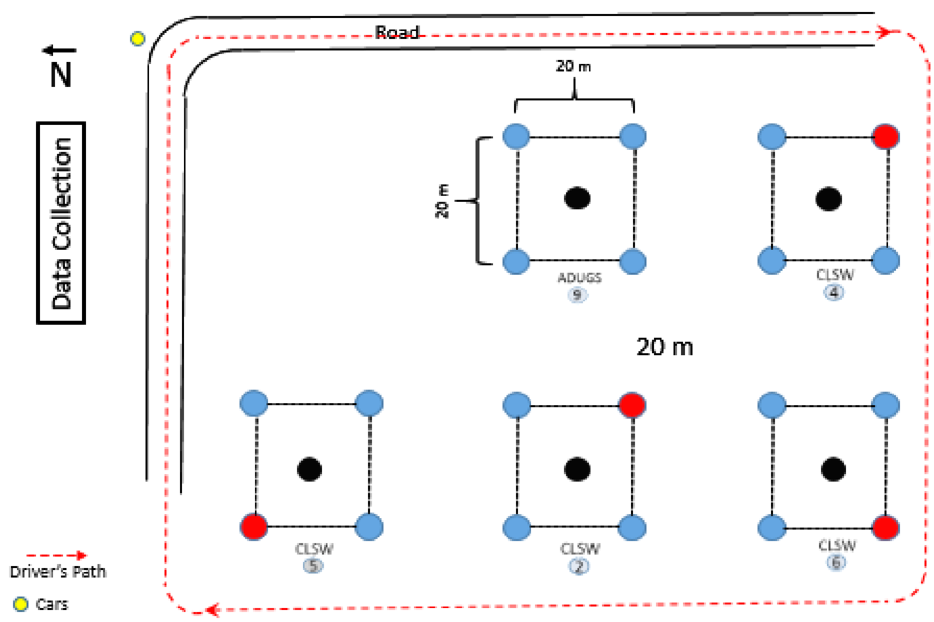

Fig. 17 Day 4 vehicles driving around the sensor field

The second data collection consisted of vehicles driving up and back on the dirt road next to the sensor field. The test started with 1 vehicle and incremented by 1 up to 7 total vehicles. The vehicles were spaced 10 m apart traveling 20 mph going up the road to a turnaround point (about a ¼ mile past the sensor field) and 30 mph coming back. The activity, participants, and time for these events are shown in Table 6 and the driving pattern is illustrated in Fig. 18.

Table 6 Day 3 vehicle participants, driving on a road

Activity	Time	Participants
1 vehicle down and back on a road	11:30–11:33 am	11
2 vehicles down and back on a road	11:34–11:38 am	9,11
3 vehicles down and back on a road	11:39–11:42 am	1, 9, 11
4 vehicles down and back on a road	11:43–11:46 am	1, 6, 9, 11
5 vehicles down and back on a road	11:47–11:51 am	1, 6, 9, 10, 11
6 vehicles down and back on a road	11:51–11:55 am	1, 3, 6, 9, 10, 11
7 vehicles down and back on a road	11:57 am–12:01 pm	1,2, 3, 6, 9, 10, 11

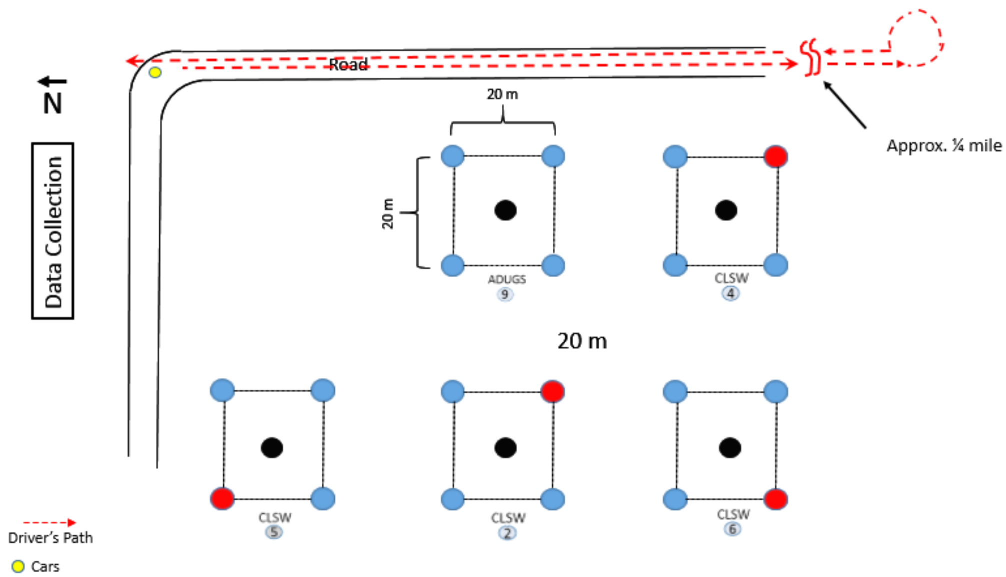

Fig. 18 Day 4 vehicles driving up and back on the road next to the sensor field

The third data collection consisted of vehicles driving pattern through the sensor field. The test started with 1 vehicle and incremented by 1 up to 3 total vehicles. The vehicles were spaced 10 ms apart traveling 10 mph. The activity, participants, and time for these events are shown in Table 7 and the driving pattern is illustrated in Fig. 19.

Table 7 Day 3 vehicle participants, driving a pattern

Activity	Time	Participants
1 vehicle driving a pattern through field	12:30–12:37 pm	11
2 vehicles driving a pattern through field	12:38–12:44 pm	9,11
3 vehicles driving a pattern through field	12:44–12:51 pm	1, 9, 11

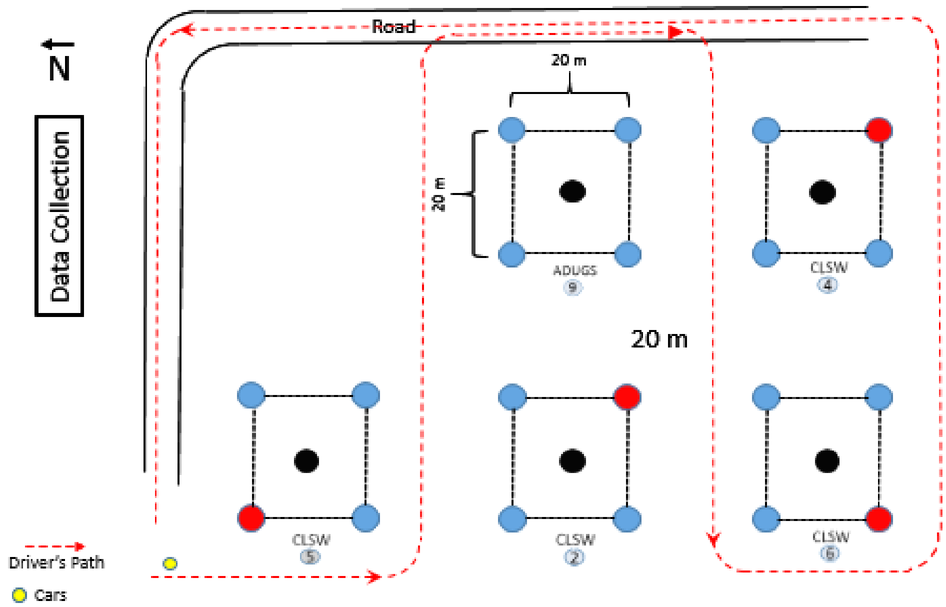

Fig. 19 Day 4 vehicles' driving pattern through the sensor field

Typical data collected using acoustic and seismic sensor are shown in Figs. 20 and 21, respectively.

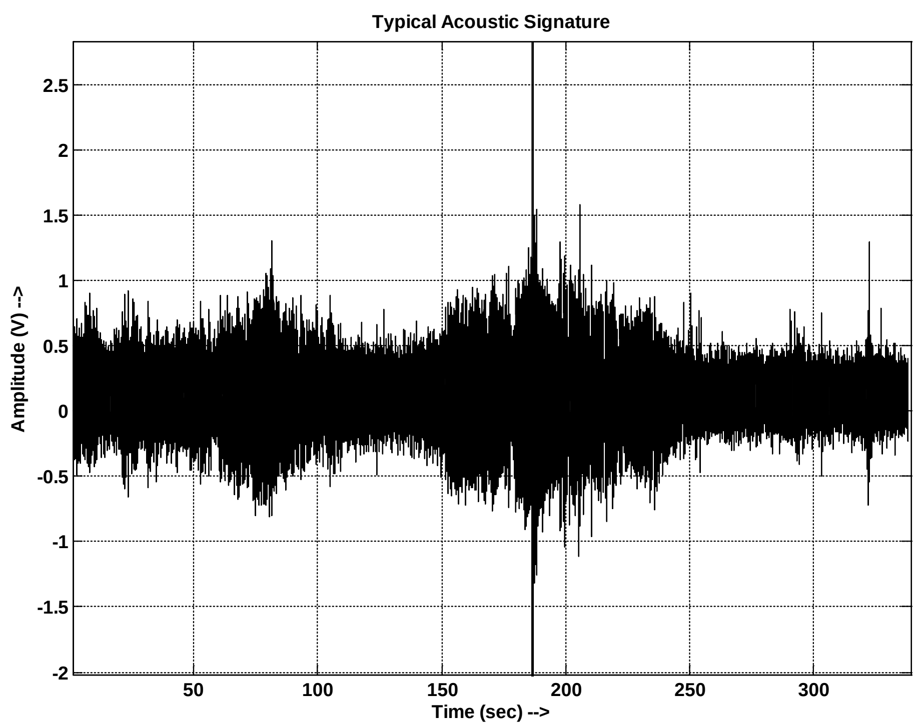

Fig. 20 Typical acoustic signature

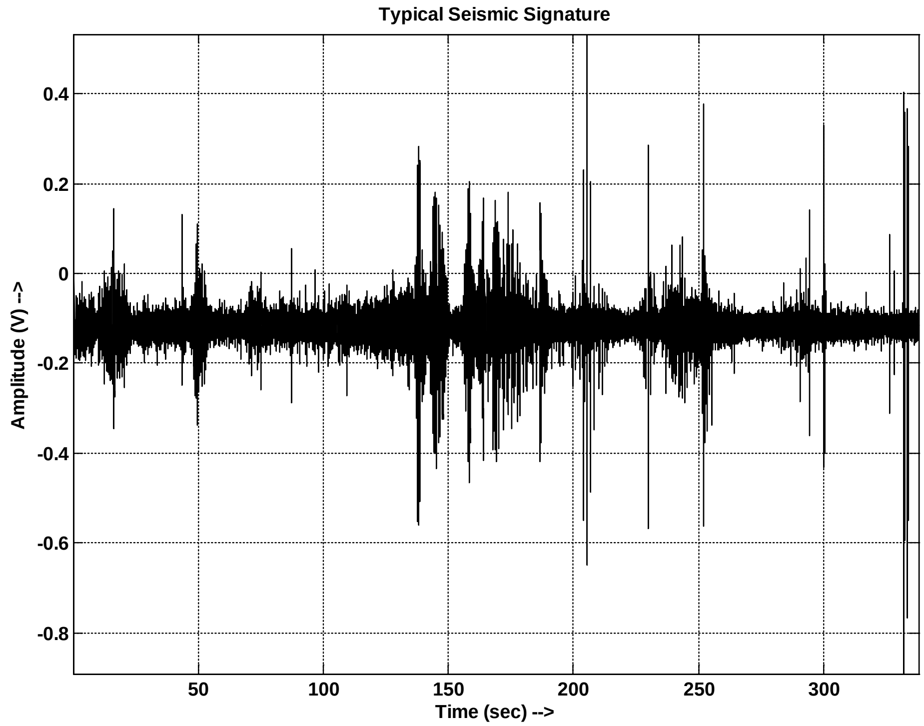

Fig. 21 Typical seismic signature

4. Conclusion

The data collection of sensor signatures taken on Spesutie Island at Aberdeen Proving Grounds, Maryland, from July 27–30, 2015, will allow researchers to develop cutting-edge detection algorithms that can detect and classify 1 or more vehicles or persons. This report provides specific information on the data collection setup to include equipment used. There is additional documentation available that provides video, GPS track location, and other information regarding experiment, available upon request from the authors.

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