

## 7<sup>th</sup> Quarterly Report – Public Page

Date of Report: *November 9, 2012*

Contract Number: *DTPH56-10-T-000021*

Prepared for: *Department of Transportation/Pipeline and Hazardous Materials Safety Administration*

Project Title: *Advanced Learning Algorithms for PIGPEN*

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For quarterly period ending: *September 30, 2012*

### ***Public Page Section –***

#### **Work Completed During this Quarterly Period**

##### *Algorithm Development and Implementation*

*During this period, PSI improved and further evaluated the self-learning algorithm. Previously, we reported analysis of data acquired during a parallel project at an Army test site. We have now used the algorithm to post-process data collected at a pipeline right-of-way test site. The data were collected during a previous project at the PSEG natural gas pipeline in Woodbridge, NJ.*

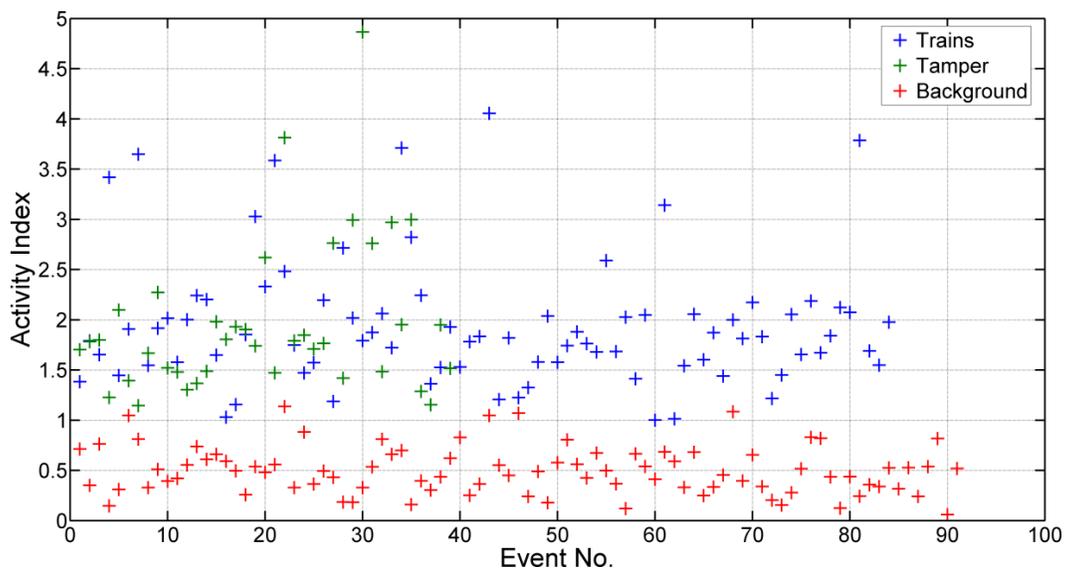
##### *Hardware Assembly and Field Test Preparations*

*As described in the previous quarter, cost-share partner Heath Consultants is building new sensor systems to be utilized in this project. The first sensor package is now scheduled for assembly in September and testing in October. Five additional sensor units are scheduled for assembly in November. Heath plans to test the six-sensor system at their Houston facility in December.*

## General Information required on all Public Quarterly Reports

### Results and Conclusions:

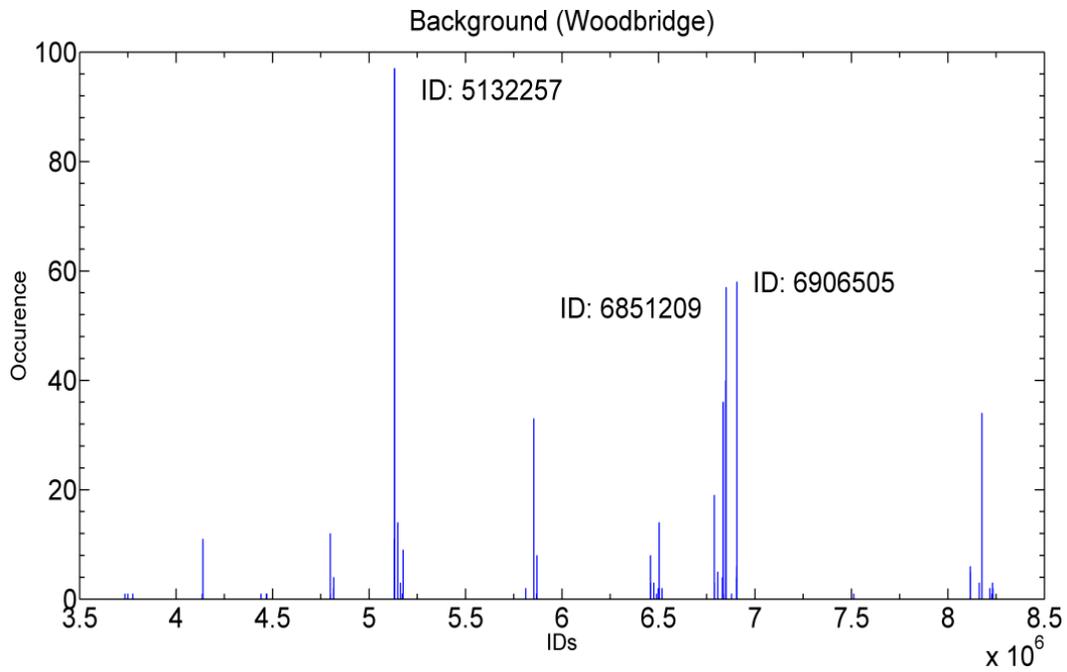
In the self-learning algorithm, the activity index is a metric that quantifies the level of seismic activity compared to a quiet background. This activity index is calculated by computing the Mahalanobis distance between the  $k$ -means clusters of an event and background. In simplistic term, abnormal events are flagged when unusually high or low activity indices are detected. Figure 2 shows an activity index plot of post-processed seismic data at Woodbridge. The seismic data consists of seismic signals from the background, trains and tamper. These signals were distinguished a priori by a trained classifier. The  $x$ -axis represents events at various points in time.



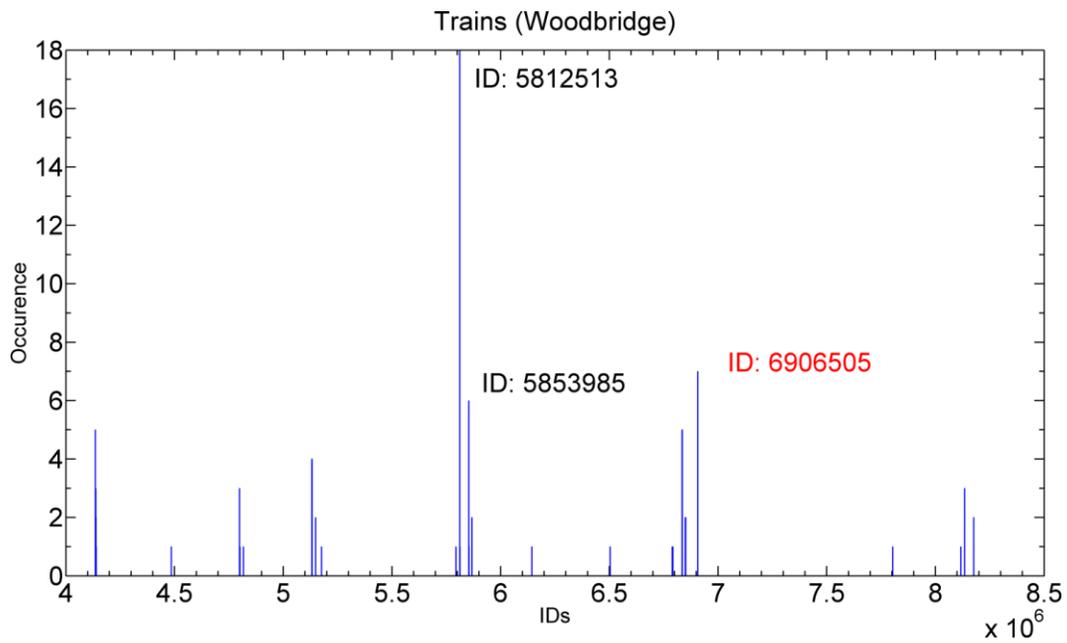
**Figure 1.** Plot of Activity index versus events in time from post-processed data at Woodbridge. The seismic data is a mixture of seismic signals coming from the background, trains and tamper.

As seen from Figure 1, an activity index  $> 1.2$  discerns events that are not background but it alone does not discriminate between the trains and tamper signals. To provide discrimination, we implemented a signal identification (ID) system, in which signals are assigned IDs based on their dominant features.

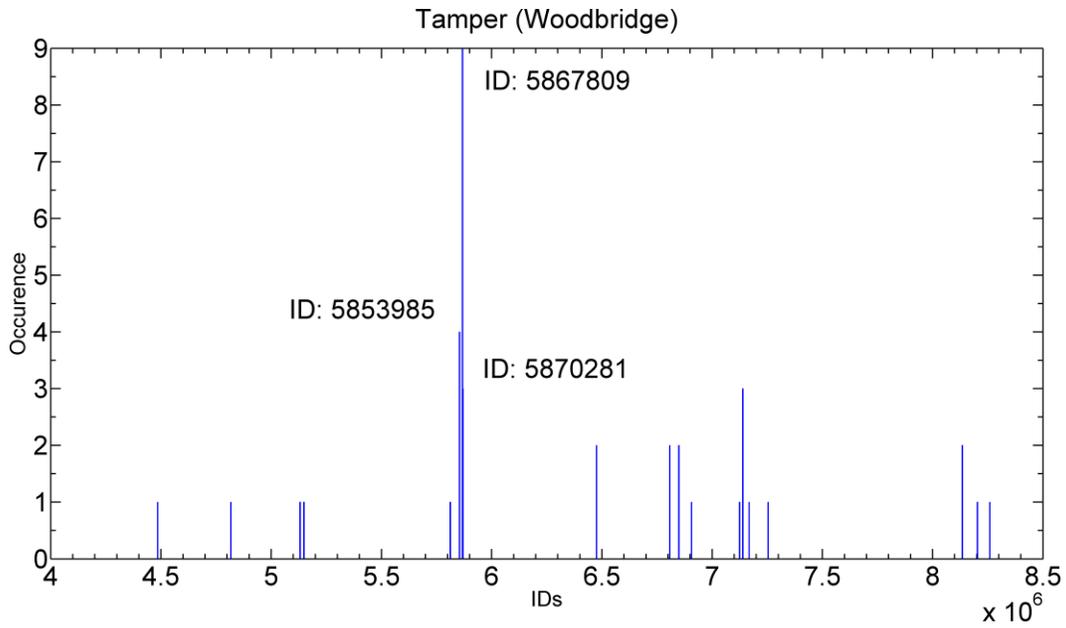
Figures 2-4 are histograms plotting the frequency of occurrence of assigned IDs on the background, trains, and tamper data respectively. The trains and tamper signals have very different dominant IDs, illustrating that the algorithm can distinguish between them. This discrimination capability enables close monitoring of specific disturbances occurring (even without knowing what the disturbance is) over time and detecting any change in behavior (e.g. signal becoming louder or weaker).



**Figure 2.** Histogram showing the frequency of occurrence of the assigned IDs on background data collected at Woodbridge.



**Figure 3.** Histogram showing the frequency of occurrence of the assigned IDs on the Trains data collected at Woodbridge.



**Figure 4.** Histogram showing the frequency of occurrence of the assigned IDs on the Tamper data collected at Woodbridge.

**Plans for Future Activity:**

*PSI, with cost share and product development partner Heath Consultants, are progressing with sensor assembly and field test planning. The initial field test using the new algorithms installed on new sensors is planned for December 2012.*