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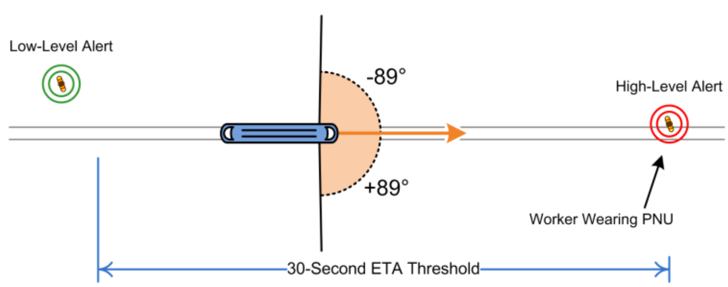
Summary

After the EMTRAC Personal Notification Unit (PNU) test conducted by Valley Transportation Authority (VTA) on Jan. 19, 2012, the development team for the Emtrac System compiled the test data and discussed the test results in detail. This document is a result of those discussions and includes information about the conditions that determine how the PNU performs, recommendations for PNU configuration at each location, as well as its capabilities and limitations.

PNU Performance

There are certain conditions that must be met in order for the PNU to trigger an alert that an EMTRAC-equipped vehicle is approaching. These conditions are programmed into the PNU by using the EMTRAC Systems Manager software. As an example, we will identify the conditions that may be set for PNUs used by rail-maintenance personnel who will be working along active rail lines. In this scenario, the PNUs are programmed with the following settings:

Systems Mgr. Setting	Resulting PNU Performance
ETA: 30	Workers adjacent to the rail line will receive a high-level alert at approximately 30 seconds before the train arrives.
Distance: N/A	Because we want the PNUs to alert at an ETA *distance* rather than a fixed distance, this setting is not applicable and will be left blank.
Velocity: 2	Workers are alerted only if the train is traveling faster 2 MPH or more.
Bearing: 89°	This setting ensures that a vehicle is approaching before the PNU triggers any alerts. Assuming the track along which the vehicle is traveling is zero degrees (regardless of actual direction of travel), the *Bearing* value is the amount of variance from that line, as shown in the following illustration. 
Caution Distance: 150 ft.	The PNU triggers a low-level alert if the vehicle is moving away from a PNU but is within 150 feet.

VTA Test Issues

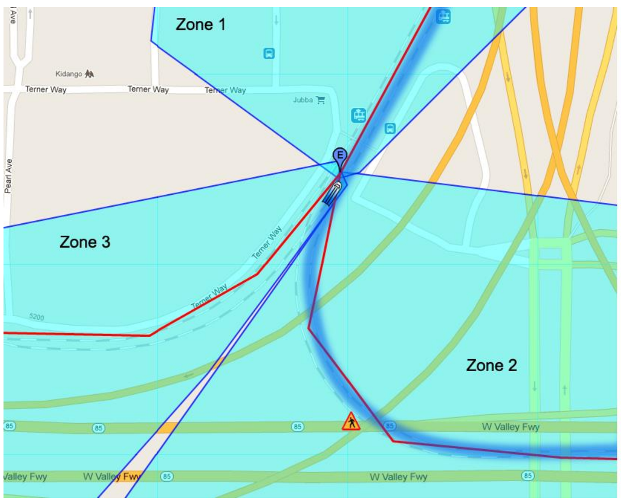
The Emtrac Systems development team has examined specific issues that arose during the PNU test along the VTA rail line. None of the issues require significant alterations to the system, and most may be corrected by editing PNU configuration settings. Included below are descriptions of each issue along with the solutions proposed by the development team for the Emtrac System:

Location	Issue	Cause/Solution
Ellis/101 Curve NB	Both PNUs (104 & 105) triggered an alert, dropped the alert, and then began alerting again before the train reached them.	While approaching the Bayshore NASA station, the train decreased speed from 35 MPH to a complete stop upon reaching the station. Because the PNUs were programmed to stop alerting when approaching-vehicles traveled at or below 2 MPH, the PNUs stopped alerting. When the train left the station and accelerated above 2 MPH, the PNUs began alerting once again. This *Minimum-Speed* value is configurable in the EMTRAC Systems Manager software.
Lick Mill Station	While approaching the Lick Mill station (NB), the onboard Control Head triggered an alert to indicate PNU #111 was ahead. After passing the PNU, the map monitor continued to display PNU #111 at this station, even when passing the station on the SB route.	This issue was seen only on the Central Monitor display (on the monitors near the cabs), and it is purely a reflection of the Central Monitor software-display settings. This instance of Central Monitor was set to display an identified PNU at the same location until another RF update is received from the same PNU. As such, Central Monitor continued displaying the Lick Mill location until the next position of PNU #111 was recognized again at Hostetter station.
All Test Locations	Control Head alert volume	Future Control Head versions will include a volume control—between fixed low and high volume levels.
Chynoweth Curve	PNU #107 alerted, stopped alerting after the train passed, and then began alerting again while the PNU was beneath the bridge.	This issue was caused by vehicle-detection zones that were configured to identify the train headings around areas where the tracks fork, as described in the following section. Because these zones overlapped, there was a small area where the PNU improperly triggered an alert. This is corrected by altering the zones so there is very little, if any, overlap.

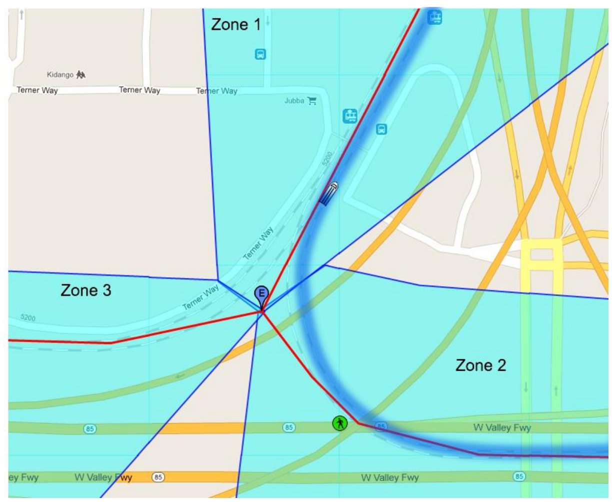
Chynoweth Curve Solution

One challenge in identifying and alerting workers of approaching trains is when there is a fork in the track, and an approaching train may alter its route path by simply switching tracks. To overcome this challenge, vehicle-detection zones are created for each forked segment of track (as shown in blue). These zones are programmed into the PNU, and they enable the PNU to recognize when a vehicle may be approaching. If the approaching vehicle switches tracks (thus no longer approaching the PNU), it crosses into a different zone. The PNU recognizes this zone change and no longer triggers an alert.

During the PNU test, these detection zones had a slight overlap (as shown between Zones 2 and 3 in the first illustration). Due to this slight overlap, the PNU recognized that the train was in Zone 3—indicating a possible approach—and triggered an alert as a result. To correct this response, we have edited these zones so there is very little, if any, overlap. The PNUs may be programmed with these edited zones to reflect the corrected layout.



Zone Configuration During Test



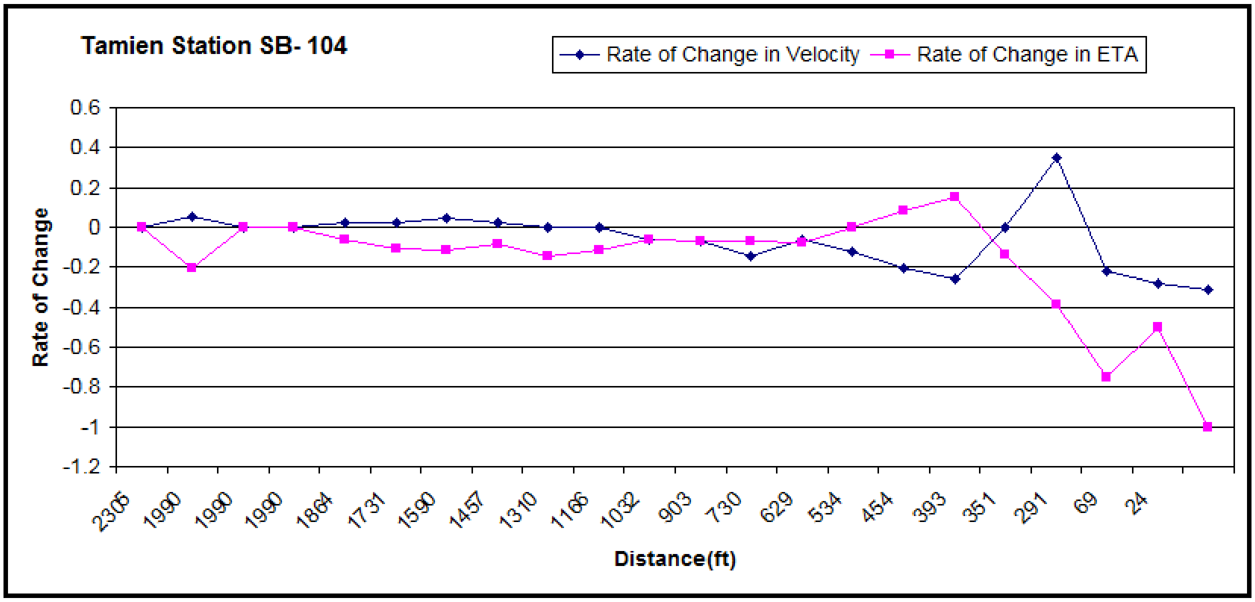
Redesigned Routes and Zones

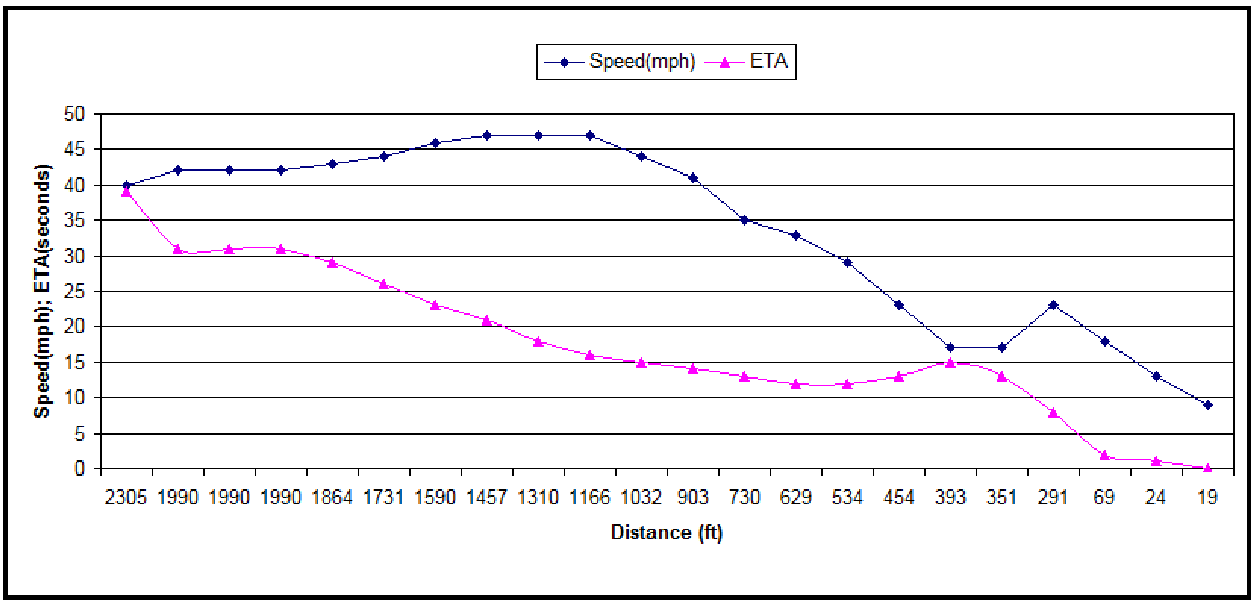
PNU Methods of Alert

The PNU is capable of alerting workers of approaching vehicles based on Estimated Time of Arrival (ETA), fixed-geographical distance, or a combination of both. Each method of vehicle alert has its advantages as well as its limitations:

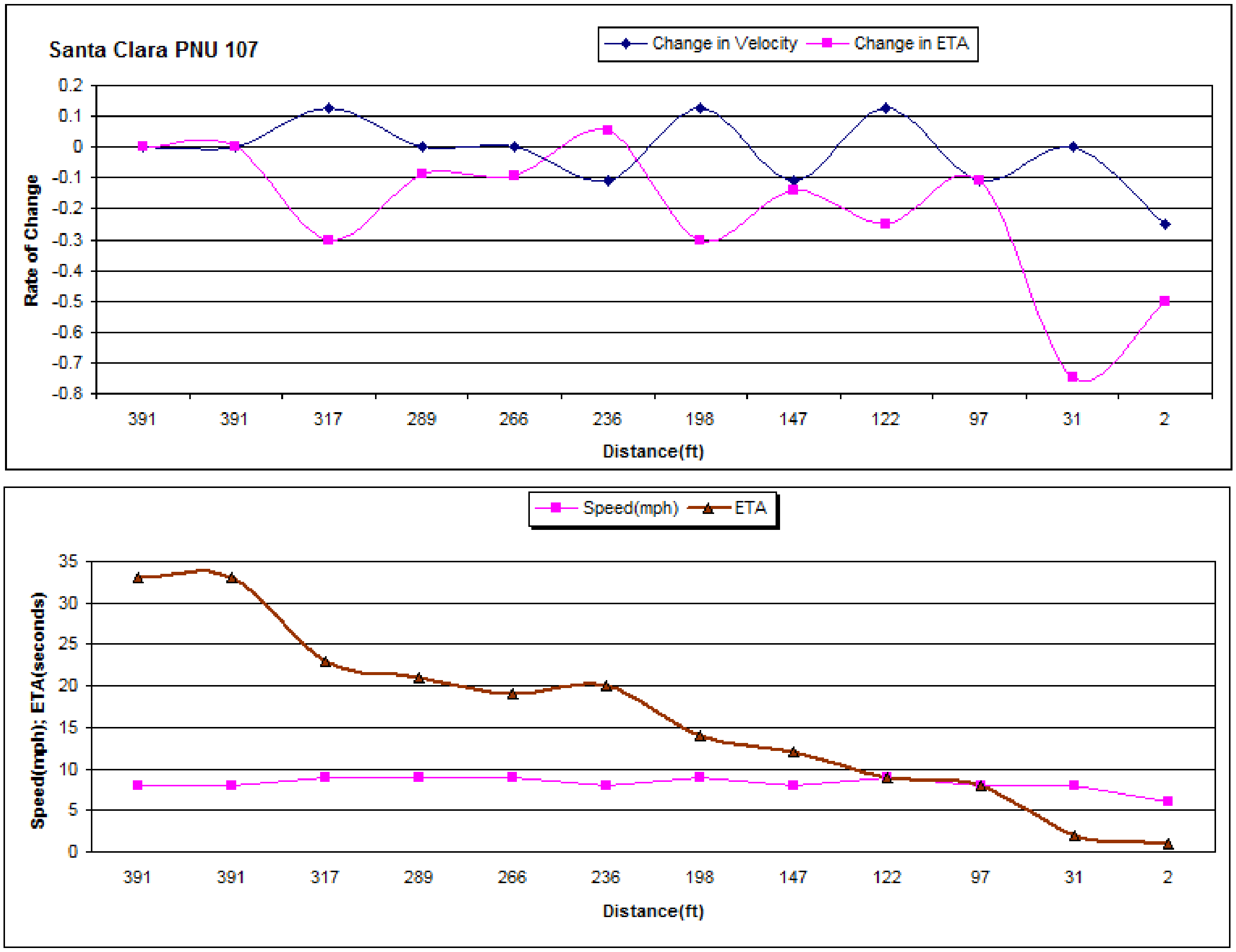
Estimated Time of Arrival (ETA)
With this method, the PNU utilizes an algorithm to calculate the time of arrival. The primary information that factors into this algorithm are vehicle speed and vehicle distance from the PNU. As the vehicle speed changes, the resulting ETA calculation can change considerably. For example, a vehicle traveling 15 MPH would reach a 30-second ETA threshold at 660 feet from the PNU, whereas a vehicle traveling 25 MPH reaches the same threshold at 1,101 feet.

Similarly, if a vehicle is traveling 15 MPH upon reaching the 30-second threshold and then accelerates after reaching the threshold, the actual time of arrival decreases and compromises PNU performance. In locations where speed changes are likely to occur during approaches, fixed-distance methods may be preferred. The relationship between changes in velocity and the resulting changes in ETA is shown in the following graphs.





Graphs showing changes in ETA as a result of speed changes during the Tamien station approach

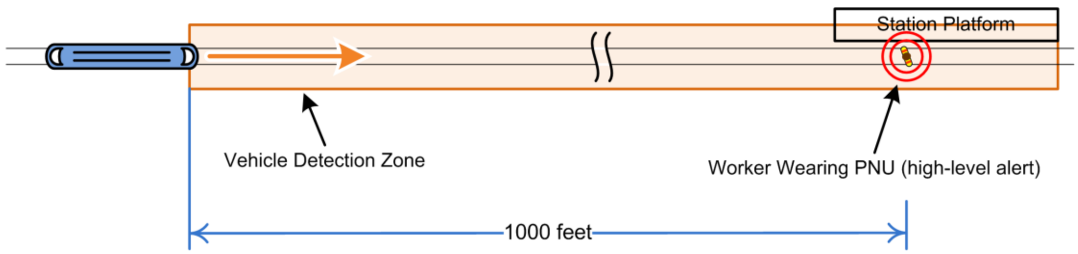


Graph showing changes in ETA as a result of speed changes at the Santa Clara station approach

One advantage to using the ETA method is for situations where vehicle operators may often travel well above track-speed, which would compromise fixed-distance methods of alert. For cases where actual vehicle speeds are more than designated track speeds, the ETA method bases alert thresholds on actual speeds rather than fixed points along the track, as described in the following section.

Fixed Distance

With a fixed-distance method, the PNU triggers an alert when an approaching vehicle reaches a specific point on the track, regardless of its speed. This is done by programming vehicle-detection zones, which are rectangular areas defined by position coordinates. If a vehicle enters one of these zones (while also meeting the other PNU-alert conditions), the PNU triggers an alert. Because this method utilizes pre-programmed vehicle-detection zones to trigger alerts, it is best used in common work areas, such as approaches to stations or wayside cabinet locations.



EMTRAC System Recommendations

The test data indicates that a *combined* approach in alert methods (both ETA and Fixed-Distance) would deliver the highest possible level of performance. This is due to the inherent limitations of the ETA method caused by fluctuations in train speed. When using a combined approach, the PNU triggers an alert when either method detects an approaching train.

STC recommendations for ideal system performance include:

- RF repeaters for high-speed areas (such as near Tamien Station) and curved areas (such as Chynoweth curve) are recommended to ensure clear radio-communication range before equipped vehicles reach alert threshold points.
- The Fixed-Distance alert method delivers higher performance in urban areas where trains are prone to slow down and quickly accelerate
- The Fixed-Distance alert method delivers higher performance for tunnels where train speeds are relatively consistent.
- The ETA alert method delivers higher performance in high-speed areas (such as the Tamien Station approach) where fluctuations in train speed are relatively minor.
- Both ETA and Fixed-Distance methods may be used simultaneously. Locations where a combined approach deliver higher performance include the Diridon Tunnel (where train speed may start high and then slow down) as well as urban scenarios (such as the Santa Clara loop), where trains speeds fluctuate depending on pedestrian activity.

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