Augmented Speed Enforcement (aSE) Smart Drums (sDrums) from a Technical Perspective Part 2- (Pilot) Deployment

Doug Galarus

Western Transportation Institute Montana State University

Larry Hayden

Western Transportation Institute Montana State University

Nic Ward

Western Transportation Institute Montana State University

NRITS 2012 Session B3: Need to talk? Solutions to Communication Problems in Remote Areas ... Monday, September 17, 2012 2:50 PM



Disclaimer

The opinions, findings and conclusions expressed in this presentation are those of the authors and not necessarily those of the the U.S. Department of Transportation, the California Department of Transportation, or Montana State University.



Abstract

In May and June 2012, WTI deployed 25+ "Smart Drums" (sDrums) along a moving workzone on SR-152 in Central California to determine if they could improve safety by warning drivers of speed violations in the work zone. Using Zigbee communication, the sDrums form a standalone, mesh network to provide warning to drivers via a synchronized light pattern triggered by radar detection of speed. Pagers are also incorporated into the system to notify workers of speeding vehicles. In this presentation, we will discuss the technical development and performance of the system. This presentation is a followup to a presentation and demonstration given at NRITS 2011.



aSE System Concept





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Subsystems

WTI Subsystem

Function: Portable work zone hazard detection system for driver and worker warning that can be integrated with existing work zone infrastructure.

PATH Subsystem

Function: Portable radar and CMS system for driver warning and CHP real time information to support CHP initiated speed enforcement.





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WTI Subsystem

Function: Portable work zone hazard detection system for driver and worker warning that can be integrated with existing work zone infrastructure.



Prototype System and Component Detail







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Speed Detection

Houston Radar Weatherproof SS300 OEM Doppler Speed Radar

- Low power: 0.10 Watts
- 300+ feet pickup range for a compact vehicle
- Data and Configuration via RS232
- Relatively small: 1.9" x 2.1" x 0.9", 0.1 lbs.
- Beam Angle: 38° x 45°
- Frequency (center): 24.125 GHz or 24.200 GHz
- Two LED Lamp outputs to drive 1.8W LED lamps with dimming. (135 mA max each up to 60VDC).
- "True Average Speed" feature can compute and log average traffic speed measurements.



Source: http://www.houston-radar.com/pdf/SS300ShortFormDataSheet-Rev4.pdf



Communication (Cone Network)

Digi XA-M14-CS2P, XBee-PRO DigiMesh 2.4, RS-232 adapter

- Similar to Zigbee (802.15.4)
- Available in 2.4 GHz and 900 MHz (We're using 2.4 GHz)
 - Data Rate: 250 Kbps
 - Indoor / Urban Range: 300 ft. / 200 ft.
 - Outdoor / Line-of-Sight Range: 1 mi. / 2500 ft.
- Available interfaces are RS-232, RS-485, USB, and digital and analog. We're using RS-232. (And USB.)
- Mesh Networking: self-forming, self-healing, Ad hoc On-demand Distance Vector routing (AODV)
- No master/coordinator required.
- Operating Temperature: -40° C to +70° C (-40° F to +158° F)
- 3.6 in. x 1.9 in. x 1.2 in., 2.3 oz.

Source: http://www.digi.com/products/wireless-modems-peripherals/wireless-range-extenders-peripherals/xbeedigimeshadapters





Communication (Administrative - Laptop to Master Cone)

Xbee-PRO PKG RF Modem on the Master Cone

- 2.4 GHz, 250 Kbps
- 4.5" x 2.75" x 1.125", 5.25 oz.
- Operating Temperature: -40° C to +85° C (-40° F to +185 °F)

XStick USB Adapter or Xbee Pro USB Adapter on the laptop.







Source: <u>http://www.digi.com/pdf/ds-xbee-pro_pkg-rf-modems.pdf</u> <u>http://www.digi.com/products/wireless-modems-peripherals/wireless-range-extenders-peripherals/xstick#overview</u> <u>http://www.digi.com/products/wireless-modems-peripherals/wireless-range-extenders-peripherals/xbeeadapters#overview</u>



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Light

Whelen L22HAP



- Certified SAE Class J845 Class II 360° (amber).
- Fully encapsulated electronics are moisture and vibration resistant.
- 100,000 hour rated life.
- Low amp draw. 0.65 amp (peak), 0.26 amp (avg.) @ 12.8 VDC.
- Permanent / Pipe mount.
- 15 flash patterns built in not used by us.
- 6-1/2" (163mm) H x 5-1/2" (140mm) Dia (Dome) x 6-3/4" (171mm) Dia (Base)

Source: <u>http://www.whelen.com/_AUTOMOTIVE/details_prod.php?head_id=1&cat_id=5&prod_id=306</u>



Controller

Moxa IA240-LX

- MOXA ART 32-bit ARM9 industrial processor
- 64 MB RAM, 16 MB flash onboard >>
- 4 RS-232/422/485 serial ports >>
- 4 digital input and 4 digital output channels (TTL signal)
- Dual 10/100 Mbps Ethernet for network redundancy
- SD socket
- Linux Kernel 2.6
- Fanless design, -40°C to 75°C wide temperature



Source: <u>http://www.moxa.com/doc/specs/IA240_IA241_Series.pdf</u>



Pager

Long Range Systems T74C232 Interface transmitter

- Operating Frequency: UHF (420-470 MHz)
- DB-9 Serial port interface, Commands sent via ASCII text
- Supports over 1000 pagers
- Operates on 110V or 220V
- Size: 4" x 8" x 1"



Source: http://www.pager.net/Long-Range-Systems/RS232-interface-transmitter.html

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Pager

Long Range Systems Service Pager

- Shock-resistant casing
- "Super Strong" Vibration
- Vibration, beep, or vibe/beep alert modes
- Nickel metal hydride batteries with life up to 72 hours on a single charge
- Charger Station





Source: <u>http://www.pager.net/Long-Range-Systems/service-pager.html</u> <u>http://www.pager.net/Long-Range-Systems/pager-charger-9.html</u>



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Power

Werker WKA12-26AH (Golf Cart Battery)

- 20.7 lbs.
- 12V, 26AH



Source: <u>http://www.batteriesplus.com/product/32624-WKA12--26NB-Werker-12V-26Ah-Battery-with-Nut-and-Bolt-</u> Terminal/574-SLI/5615-Golf-Cart-Batteries/135310-Lectronic-Kaddy/Traditional/Traditional.aspx



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Charger

Schumacher Electric INC-406A

- 6A 6/12V Automatic Four Battery Charging Station
- Fully Automatic Microprocessor Controlled
- 120VAC Input
- 10.12" x 10.60" x 4.06", 10.98 lbs



Source: http://www.batterychargers.com/ProductDetail.aspx?ProductName=94026728



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Charger

Battery Tender 10 Bank Charger

- 12V @ 2A
- Microprocessor Controlled
- 120VAC Input
- 9.5" x 6.75" x 6.75", 30 lbs



Source:

http://batterytender.com/includes/languages/english/resources/Product_Info_Shop_Charger.pdf?osCAd minsID=340cf056b7e37f3662e001e495eac704



Components Custom-Built

- Frame
- Wiring Harness
- Switch
- Software



Pilot System



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TrafFix Drum and San-Fil Base



Source: http://traffixdevices.com/cgi-local/SoftCart.exe/drum.htm?L+scstore+xjnf5884ff225022+1319248857



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Three sDrum Types:

Master / Data Logger:

- Radar
- Light
- Controller
- Power
- Communication (Zigbee)

Slave:

- Light
- Power
- Communication (Zigbee)

Pager / Pager Repeater:

- Pager Base Station / Pager Repeater
- Power
- Communication (Zigbee)



















Simplifications

- Use Broadcast to flash all lights rather than use more advanced lighting patterns that would require point-to-point communication.
- Control lights via a single master cone with a radar sensor. Then communication will only consist of light messages.
- Log data via other (backup) master cones, also equipped with radar. Do not transmit this data.
- Other than the master cone, the order of placement of cones does not matter.
- The system could consist of a master cone alone, or a master cone and variable number of slave (light) cones. Investigate the capability of the technology to implement more advanced mechanisms, but do not implement for the first run.
- No vehicle tracking the flash pattern in the relatively short length of layout for 25+ cones will pinpoint vehicles.
- Multiple master-slave subsystems could be used to provide finer granularity.
- No interaction with the other (PATH) subsystem.



Pilot Testing – Caltrans District 10 SR 152 Between Los Banos and Chowchilla May-June, 2012

HIGHWAY ...















iCone Locations for aSE in Los Banos - 5/24







This is a representation of the standard layout of the WTI drums and the iCones

Note that the third iCone is halfway between the third and fourth WTI drum

iCone Locations for aSE in Los Banos - 6/11



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iCone	ID	Latitude	Longitude
3	944	37.054133	-120.690601
4	941	37.054127	-120.686479
5	946	37.054108	-120.683527
6	945	37.054098	-120.680044







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Other (technical) items to be investigated

- General sensor performance
- XBee network performance
- Pager performance in terms of RF propagation
- Algorithms
 - Capability to integrate multiple radar sensors and perhaps other sensors.
 - Capability for more advanced light patterns.
 - Vehicle tracking?
- General setup, support and maintenance issues:
 - Charging
 - Configuring
 - Alternate Configurations
 - Deploying



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Acknowledgements

- USDOT
 - Linda Dodge
- Caltrans
 - Randy Woolley, Ha Nguyen
 - Caltrans D10
- CHP
- Students
 - James Willich, Justin Livingston, Tyler Paine
- Staff
 - Kelvin Bateman, Dan Richter



Links

Video of smart cones/drums flashing:

- <u>http://www.youtube.com/v/0eLirKmJ_CE</u>
- <u>http://youtube.googleapis.com/v/4ioP2lfX0lw</u>
- <u>http://youtube.googleapis.com/v/DScMwIRKF7U</u>
- <u>http://youtube.googleapis.com/v/q_2HOZTOcBY</u>

Animations from the driver perspective:

- <u>http://www.youtube.com/v/SnYJiZcSDhQ</u>
- <u>http://www.youtube.com/v/xJiyd1RnA68</u>
- <u>http://www.youtube.com/v/3VFoqUx-o9Y</u>

Animations from the worker perspective:

- <u>http://www.youtube.com/v/e7L1cSQ1EvY</u>
- <u>http://www.youtube.com/v/JH-BnneF9ZE</u>
- <u>http://www.youtube.com/v/4fjd_vrD3PQ</u>
- <u>http://www.youtube.com/v/IZ5JJAaBt68</u>
- <u>http://www.youtube.com/v/EfaT1A_Zlec</u>



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Questions?

