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**Federal Railroad
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Concept of Operations and System Requirements Specification for a Vehicle Tracking System at the Transportation Technology Center

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13. ABSTRACT

Transportation Technology Center, Inc. (TTCI), a subsidiary of the Association of American Railroads (AAR), performed a review of currently available Vehicle Tracking System (VTS) technologies and their applicability to operations at the Federal Railroad Administration's Transportation Technology Center (TTC), Pueblo, Colorado. This report summarizes that review and concludes with recommendations for selection of a VTS approach and vendor.

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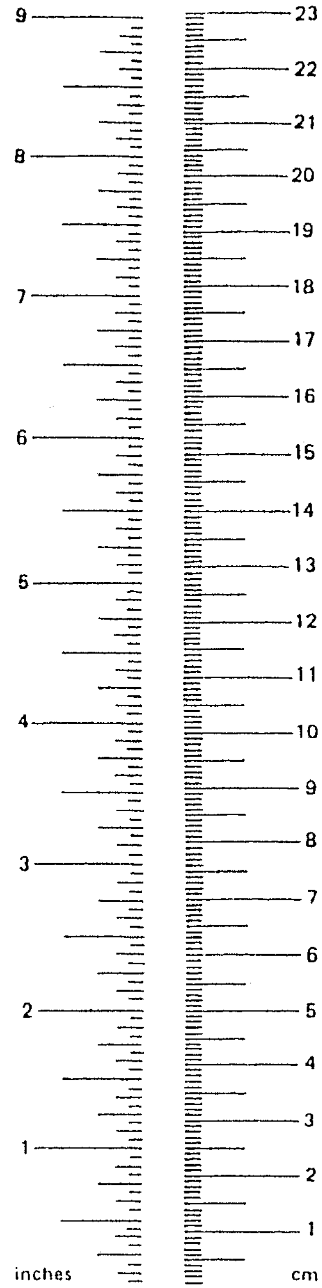
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

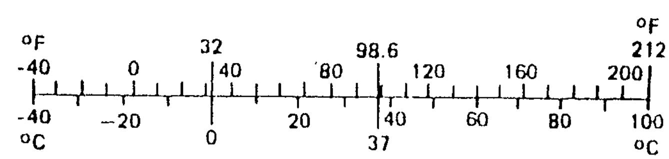
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.50	centimeters	cm
ft	feet	30.00	centimeters	cm
yd	yards	0.90	meters	m
mi	miles	1.60	kilometers	km
		AREA		
in^2	square inches	6.50	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.80	square meters	m^2
mi^2	square miles	2.60	square kilometers	km^2
	acres	0.40	hectares	ha
		MASS (weight)		
oz	ounces	28.00	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.90	tonnes	t
		VOLUME		
tsp	teaspoons	5.00	milliliters	ml
Tbsp	tablespoons	15.00	milliliters	ml
fl oz	fluid ounces	30.00	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.80	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0 76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

* 1 in = 2.54 cm (exactly)



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.40	inches	in
m	meters	3.30	feet	ft
m	meters	1.10	yards	yd
km	kilometers	0.60	miles	mi
		AREA		
cm^2	square centim.	0.16	square inches	in^2
m^2	square meters	1.20	square yards	yd^2
km^2	square kilom.	0.40	square miles	mi^2
ha	hectares ($10,000 m^2$)	2.50	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2 2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.10	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36.00	cubic feet	ft^3
m^3	cubic meters	1.30	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius° temperature	9/5 (then add 32	Fahrenheit temperature	°F



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1.0 INTRODUCTION

Transportation Technology Center, Inc. (TTCI), a subsidiary of the Association of American Railroads (AAR), performed a review of currently available Vehicle Tracking System (VTS) technologies and their applicability to operations at the Federal Railroad Administration's Transportation Technology Center (TTC), Pueblo, Colorado. This report summarizes that review and concludes with recommendations for selection of a VTS approach and vendor.

2.0 CONCEPT OF OPERATIONS

This Concept of Operations (CONOPS) provides a summary of TTCI's vision of how a VTS would be operated and used to support research and development, test and evaluation, and facility maintenance and support operations at TTC.

3.0 VTS OVERVIEW

The implementation of a VTS would provide key TTC personnel with improved situational awareness (SA) and control to more effectively and safely manage center operations. By knowing the locations and movement of active vehicles (both on-track and off-track), key personnel such as those in the Operations Control Center (OCC), the Fire Chief, and the Manager Facilities Services can control the movement of vehicles and manage center resources with improved safety and efficiency. The VTS will allow onsite engineers and customers to monitor information about vehicles involved in ongoing tests and center operations in real time. Offsite viewing of this same information will be provided via password-protected access to test engineers, customers, AAR members, and government officials via the Internet.

The VTS will use Global Positioning System (GPS) technology and radio frequency (RF) communications links to provide real-time identification and position information for selected moving and stationary vehicles located anywhere within the entire 52-square mile TTC site. To do this, the VTS will integrate vehicle identification and differential GPS (DGPS) position information from monitored vehicles with TTC's geographic information system (GIS) digital map data, and will then display the integrated information on a digitally correct on-screen map for viewing by personnel in the OCC, display-equipped vehicles, or at offsite locations via the Internet.

Figure 1 shows an example of one of several possible system architectures for the VTS. Both on-track and off-track vehicles will be monitored. All vehicles selected for VTS implementation will be outfitted with an equipment package that contains a GPS receiver that accepts DGPS corrections and an RF modem that operates at HF or UHF frequencies. A limited number of vehicles will also contain a VTS display. A master GPS base station located at TTC will broadcast site-specific DGPS corrections from a dedicated transmission tower. These corrections, along with the normal GPS satellite signals, provide the input data from which the DGPS receiver in each vehicle determines the vehicle's position, velocity, altitude, and direction of travel.

GPS and, potentially, other information gathered from on-board vehicle sensors feeds into the VTS RF modem and is transmitted over radio frequencies (UHF, VHF, or other) to a master RF polling modem situated at a centrally located communications tower. The master modem then converts and formats the consolidated information for transmission to the OCC. TTC's wireless local area network (LAN) could be used for this purpose. The main VTS computer in the OCC receives the consolidated information, integrates it with TTC GIS data, and generates VTS situational analysis and other OCC display features. Vehicles with onboard displays receive the OCC-generated information via RF links and display the same information as that available in the OCC. Offsite monitors receive the display information over Internet links.

The VTS will contain two categories of tracked vehicles: VTS-Monitored and VTS-Smart vehicles. VTS-Monitored vehicles will only transmit their identification and location information to the VTS Server in the OCC. VTS-Smart vehicles will transmit their information to the server, will have an onboard VTS display showing the situational analysis information for all VTS-monitored vehicles within the TTC test site, and will be equipped with a wireless interface (possibly via TTC's RF LAN) to the VTS server. The onboard VTS computer interface will allow VTS-Smart vehicle operators to interact with the server by sending and receiving messages through the VTS and by entering and displaying location information for an emergency response site. Both types of vehicles will carry onboard integrated equipment packages consisting of a GPS receiver, a real-time data logger, an RF modem, and associated input power interfaces. Additionally, the VTS-Smart vehicles will have an onboard laptop computer, or other integrated display, that serves as a possible wireless LAN access point and displays VTS situational analysis information (e.g., maps showing vehicle movements).

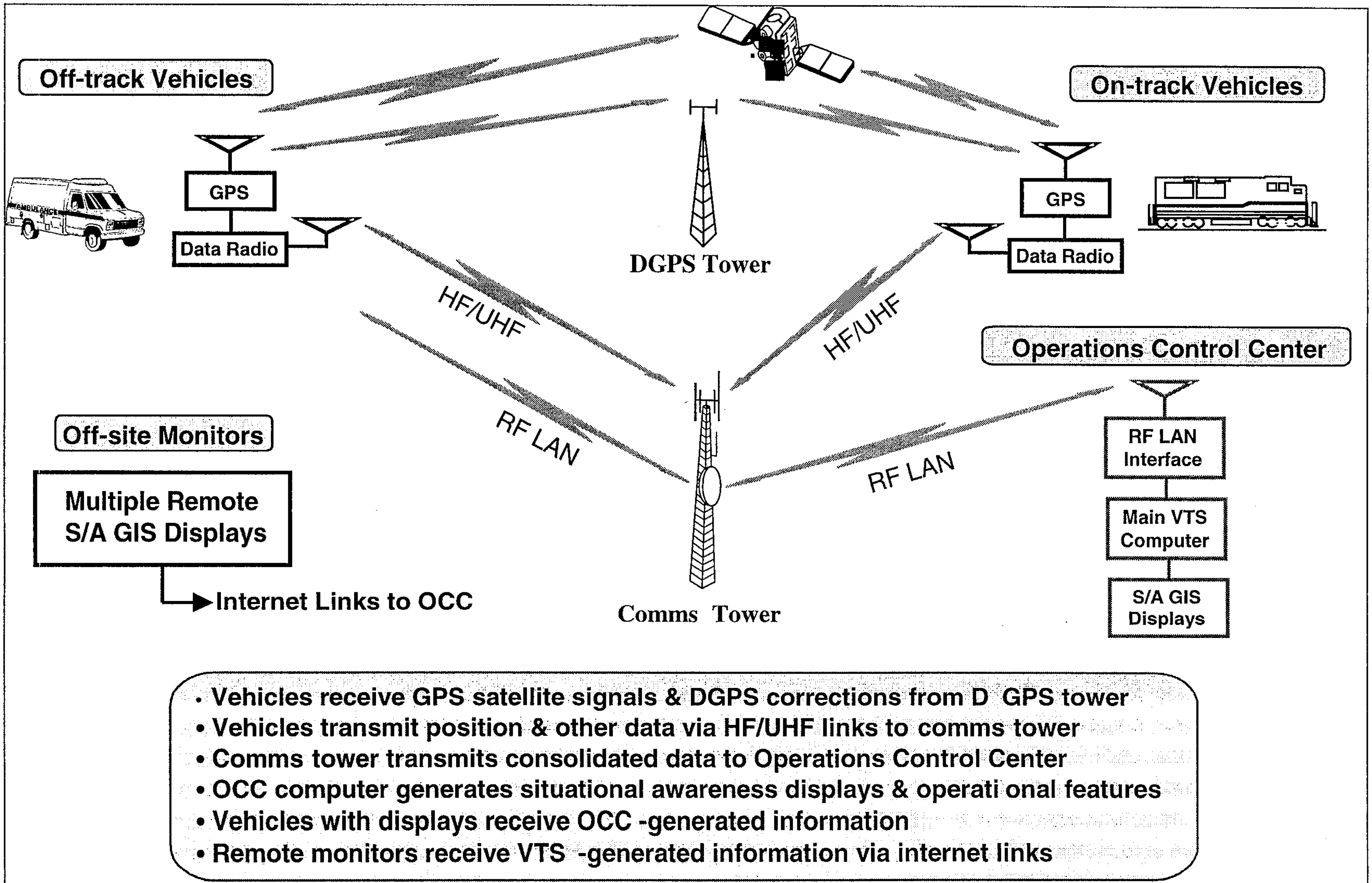

Figure 1. VTS Architecture – Example Only, Not a Requirement

from entering into potentially hazardous or proprietary test areas. Operational features of the VTS used to support these OCC include:

- Situational analysis displays that show the exact location of all tracked vehicles.
- The capability to assign specific identification parameters (e.g., icons, alphanumeric text, colors) to each vehicle and to selectively edit the parameters in real time.
- The capability to selectively activate a track history for each displayed vehicle.
- The capability to record and play back vehicle-tracking data.
- The capability to "mark" locations for identification and displayed on the SA map. For example, this feature could be used to designate the location of an emergency site or a no entry zone. This marking feature would be implemented by multiple methods, including point-and-click, click-and-drag, and directly entering identification information and GPS coordinates. The feature would also be selectable; i.e., capable of being turned on and off.
- The capability to link the SA display to offsite locations via the Internet for viewing.

3.3 VTS USE BY FIRE CHIEF AND ONSITE EMERGENCY SERVICES

Onsite emergency services (fire and rescue) will use the VTS to more precisely locate and more quickly respond to onsite emergencies. Operational features of the VTS system needed by the Fire Chief and Emergency Services include:

- The inclusion of key TTC emergency response vehicles in the VTS.
- The configuration of the vehicle used by the Fire Chief as a VTS-Smart vehicle; thereby enabling the Fire Chief to monitor the locations of all active emergency response vehicles and to coordinate and direct all emergency response activities.
- The option to configure individual emergency response vehicles as either VTS-Smart or VTS-Monitored, as needed to support emergency response operations.

at TTC, which are currently under specification development by the AAR Wireless Communications Task Force, will require TTC to be capable of supporting the various communications protocols interpreted by the CMU. If the implemented VTS were to bring to TTC one of those protocols, the resulting synergy with future CMU testing needs would prove beneficial to TTC and TTCI from both a testing capability and economic point of view. In addition, major railroads are currently developing and implementing wayside monitoring systems that communicate essential information and emergency notices via RF links. It is highly desirable that the implemented VTS provide the communications backbone to cost-effective support of the development and testing of such applications at TTC.

SYSTEM REQUIREMENTS SPECIFICATION

The following is a listing of the basic system requirements for a vehicle tracking system at TTC.

1. Developed by an established vendor with a history of on-time, on-budget performance for implementation of VTS technology in the transportation industry.
2. Uses GPS to generate location-tracking data.
3. Supports monitored-only (no display) vehicles.
4. Provides for time synchronization among distributed test platforms, some of which are mobile (e.g., for measuring latency).
5. Supports display-equipped vehicles.
6. Supports optional interaction (sending and receiving message) with the VTS server for display-equipped "smart" vehicles.
7. Supports display of map and vehicle movement via the Internet
8. Provides at least 5-meter location accuracy.
9. Robust protocol demonstrated in an operational railroad environment preferable.
10. Leverages existing TTC communications infrastructure.
11. VTS server uses off-the-shelf computer with real-time, multi-tasking operating system.

12. Peer-to-peer communications capability required.
13. Supports "no entry zones" with warnings to equipped vehicles entering/approaching them.
14. Supports capability to assign specific identification parameters to monitored vehicles and selectively edit them in real time.
15. Supports the ability to record and play back vehicle tracking data.
16. Supports development/use of "portable" vehicle VTS hardware for rapid, temporary installation in monitored vehicles.
17. Provides interchangeability of tracking system hardware and software with different communications platforms.
18. Remote unit is single-piece, containing a GPS receiver, radio transceiver, and computer controller desirable.
19. Remote unit, including display, operates on 12 VDC power with surge and reverse power protection.
20. Remote unit operational within 30 seconds (warm start) and 3 minutes (cold start) from vehicle turn-on.
21. Remote provides latitude, longitude, course, velocity, and altitude.
22. Remote unit functions as stand-alone device providing positioning to OCC base station as well as to other vehicles equipped with vehicle location display units.
23. Remote unit has Mean Time Between Failure (MBTF) of at least 50,000 hours.
24. Remote receives and displays alarm indications set by OCC.
25. Remote unit supports RTCM SC-104 DGPS format.
26. Remote unit supports connection to optional display.
27. Remote unit contains GPS receiver, accepts DGPS corrections, communicates via local RF link.
28. In-vehicle display has variable screen intensity control.
29. In-vehicle display has zoom and moving map capability.
30. Proven, system-wide railroad implementation preferable.
31. Can be cost-effectively implemented at TTC on or before December 31, 2002 (Based on reviewers judgment).