SPACE-BASED POSITIONING
NAVIGATION & TIMING
NATIONAL COORDINATION OFFICE

U.S. Space-Based PNT:
Strategic Importance of GNSS Services and Innovations for Transportation

The Asia Pacific Economic Cooperation (APEC)
Global Navigation Satellite System (GNSS) Technological Innovation Summit and Twelfth Meeting of the GNSS Implementation Team (GIT/12)
Bangkok, Thailand, 26-30 May 2008

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U.S. National Coordination Office

Introduction

- Like the Internet, GPS is a critical component of the global information infrastructure
  - Scalable applications enabling broad new capabilities
  - Facilitating innovations in efficiency, safety, environmental, public security and science

- In the past decade, GPS has grown into a global utility providing space-based positioning, navigation and timing (PNT)
  - Consistent, predictable, dependable policy and performance
  - Augmentations improve performance

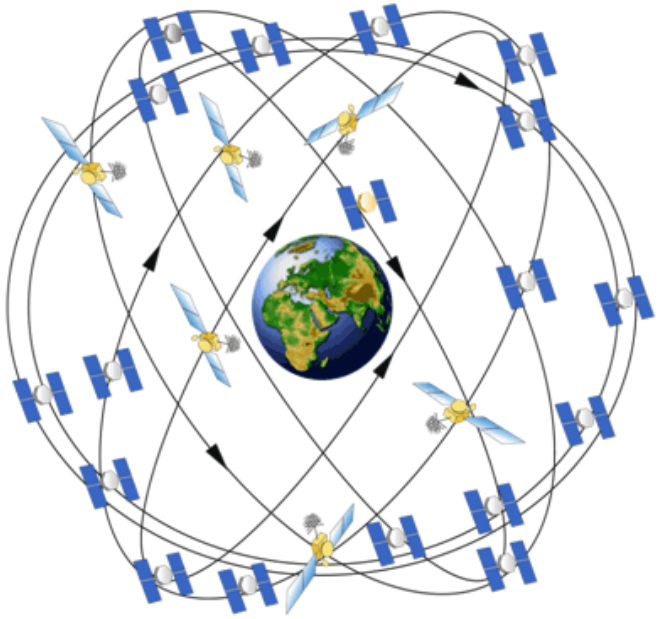
Overview

- **Systems**

- **Applications**

The Global Positioning System

- Baseline 24 satellite constellation in medium earth orbit
- Global coverage, 24 hours a day, all weather conditions
- Satellites broadcast precise time and orbit information on L-band radio frequencies
- Two types of signals:
  - Standard (free of direct user fees)
  - Precise (U.S. and Allied military)
- Three segments:
  - Space
  - Ground control
  - User equipment

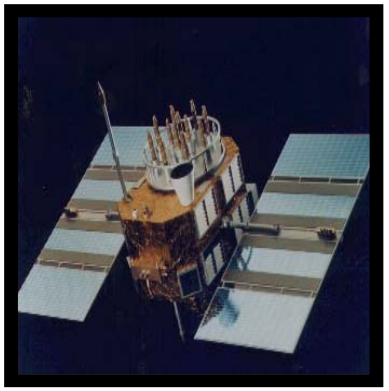


Current Constellation

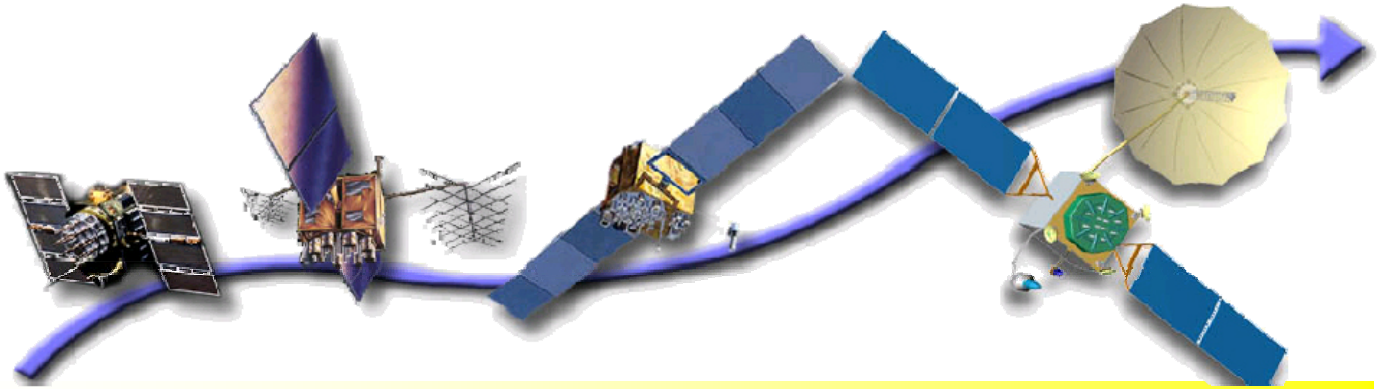
31 Operational Satellites

As of 1 May 2008 (Baseline Constellation: 24)

- 13 Block IIA satellites operational
- 12 Block IIR satellites operational
- 6 Block IIR-M satellite operational
  - Transmitting new second civil signal (L2C)
- Continuously assessing constellation health to determine launch need
  - Next launch: June 2008
- Global GPS civil service performance commitment has been met continuously since December 1993



GPS Modernization Program



Increasing System Capabilities ◆ Increasing Defense / Civil Benefit

Block IIA/IIR

Basic GPS

- Standard Service
  - Single frequency (L1)
  - Coarse acquisition (C/A) code navigation
- Precise Service
  - Y-Code (L1Y and L2Y)
  - Y-Code navigation

Block IIR-M

IIR-M: IIA/IIR capabilities plus

- 2nd civil signal (L2C)
- M-Code (L1M and L2M)
- Currently being launched

Block, IIF

IIF: IIR-M capability plus

- 3rd civil signal (L5)
- Begin launch 2009

Block III

- Backward compatibility
- 4th civil signal (L1C)
- Increased accuracy
- Assured availability
- Increased security
- System survivability
- Begin launch ~2014

Modernized GPS – Civil Signals

- Second civil signal ("L2C")
  - Designed to meet commercial needs
    - Higher accuracy through ionospheric correction
  - Began with GPS Block IIR-M in Sep 2005; 24 satellites: ~2014
- Third civil signal ("L5")
  - Designed to meet demanding requirements for transportation safety-of-life
    - Uses highly protected Aeronautical Radio Navigation Service (ARNS) band
  - Begins with GPS Block IIF
  - 1st launch: ~2008 (GPS IIR-M Demo); ~2009 (GPS IIF); 24 satellites: ~2016
- Fourth civil signal ("L1C")
  - Designed with international partners to enable GNSS interoperability
  - Begins with GPS Block III
  - First launch: ~2014; 24 satellites: ~2021

Benefits of GPS Modernization

System-wide improvements in accuracy, availability, integrity, and reliability for all users

- Higher standalone accuracy
  - Augmentations likely will still remain
- More robust against interference
- Operational capability for 2nd (L2C) and 3rd (L5) civil signals
  - In combination with GPS IIR-M and IIF satellites
- Delivers L1C for interoperability with Galileo and other GNSS
- Improved indoor, mobile, and urban use

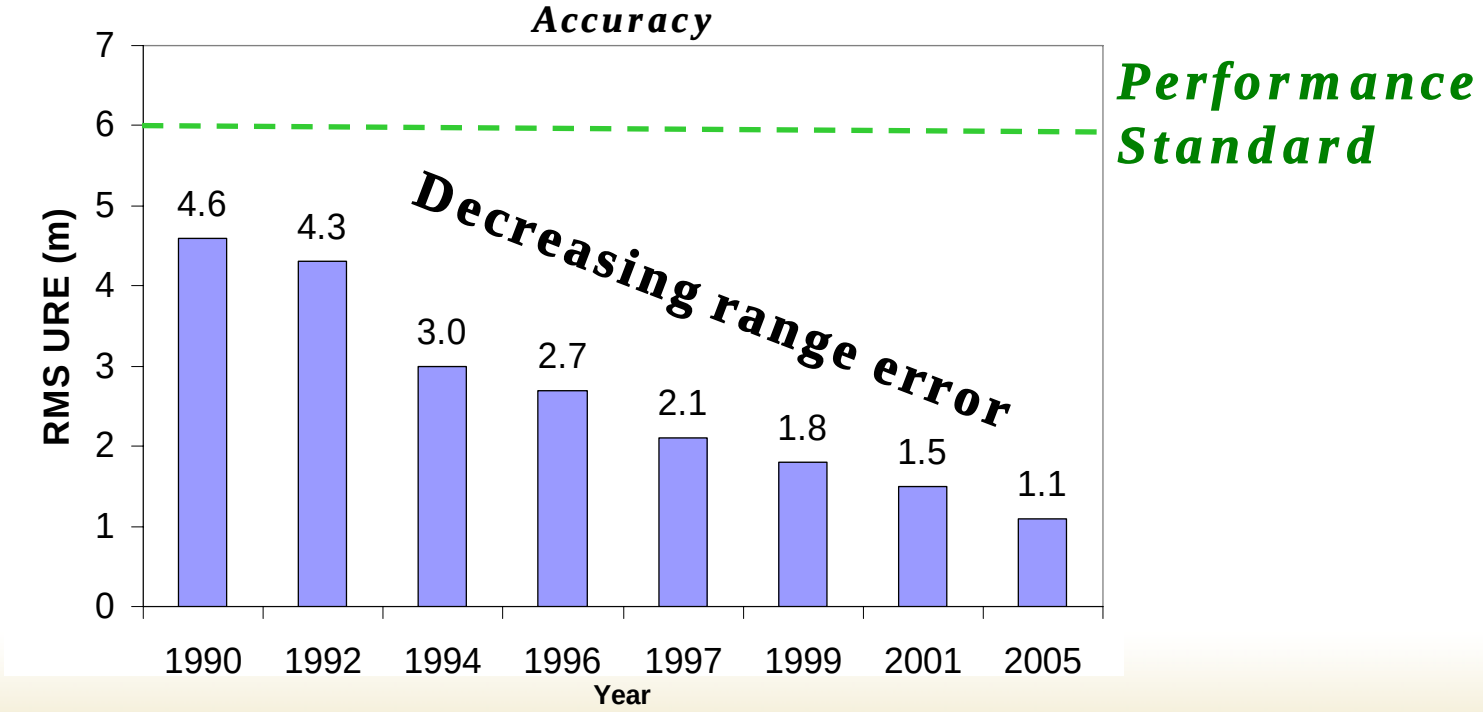
GPS Program Update

- New GPS Operational Control Segment – September 2007
- Upgrading GPS ground segment – OCX – 2012 - 2016
  - Will implement full functionality for L2C and L5
  - Contract awarded – January 2008
- Acquiring next generation of GPS satellites – GPS IIIA
- GPS SPS Performance Standard update – Summer 08

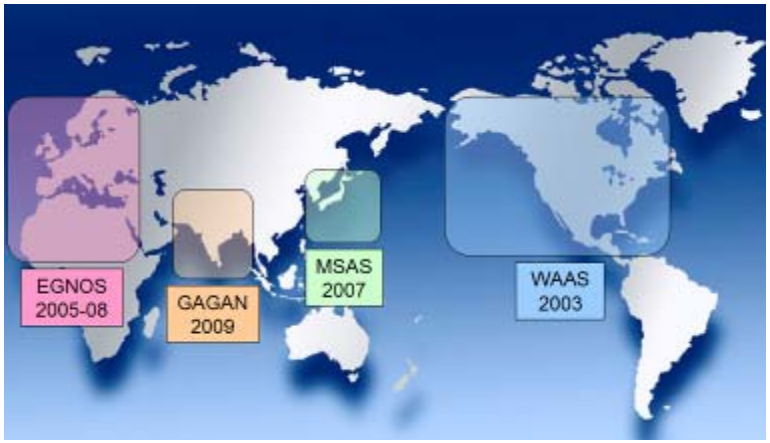
Continuous Performance Improvement

Key measures of Effectiveness to evaluate GPS services

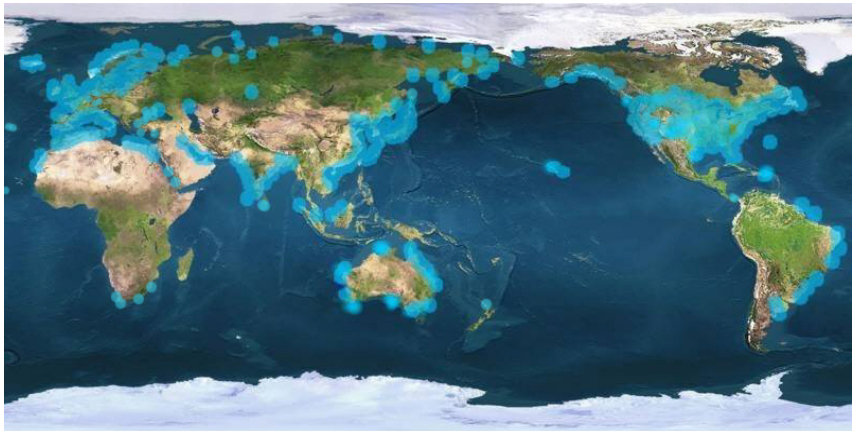
- *Accuracy*
- *Bounded inaccuracy*
- *Assured Availability*
- *Integrity*
- *Resistance to RF Interference/Jamming*



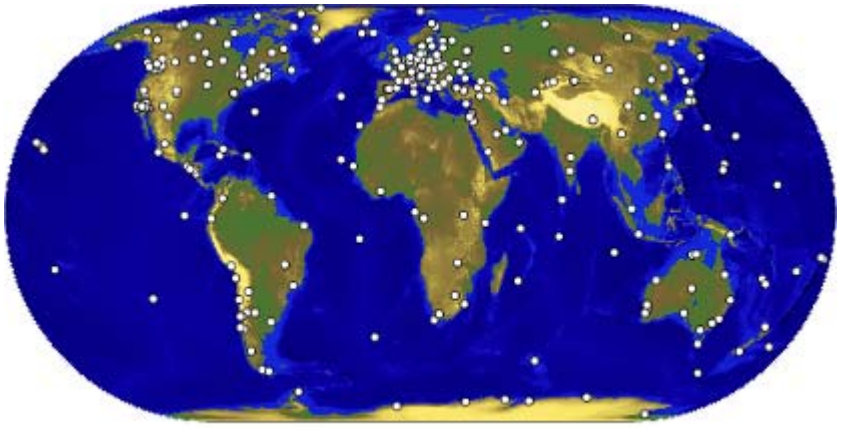
Augmentations



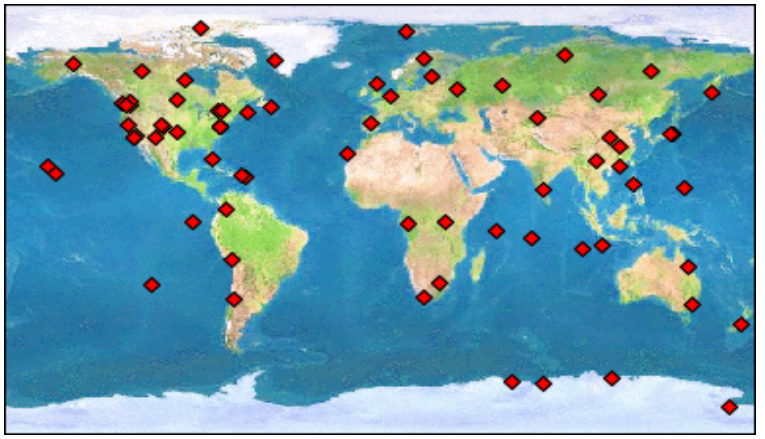
Satellite-Based Augmentations



Ground-Based Augmentations
(NDGPS, CORS, LAAS, etc.)



International GNSS Service



Global Differential GPS System

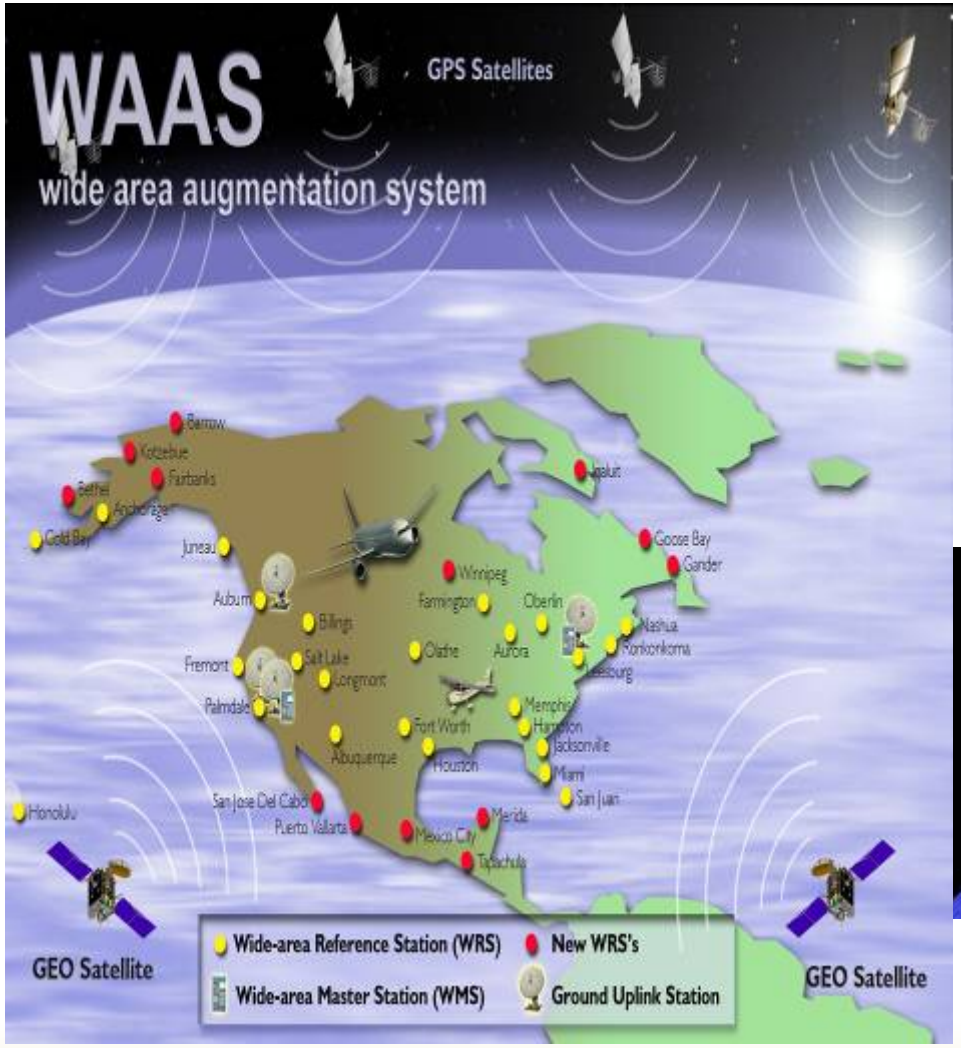
Satellite-Based Augmentations

- Geostationary satellites provide regional coverage
- GPS-like signals permit use by simple receivers
- International Partner Service Providers
  - US (WAAS), Europe (EGNOS), Japan (MTSAT), and India (GAGAN)
  - WAAS operational – Jul 03; Expanding capability with L5
  - GPS-based EGNOS leading way for Galileo
- Independent signal monitoring supports the interests of each individual State
  - International assured aviation integrity standard

U.S. GPS Augmentation Update

- Wide Area Augmentation System commissioned in 2003
  - Two GEO satellites launched in 2005 (Galaxy XV & Anik F1R)
    - Provides dual satellite coverage over the U.S.
  - Service expanded into Canada and Mexico – operational Sep 07
    - New reference stations (5 Mexico and 4 Canada)
- Nationwide DGPS System (NDGPS)
  - International standard in over 50 countries
  - DOT assessment of NDGPS inland component showed several applications
    - Transportation, agriculture, surveying and resource management

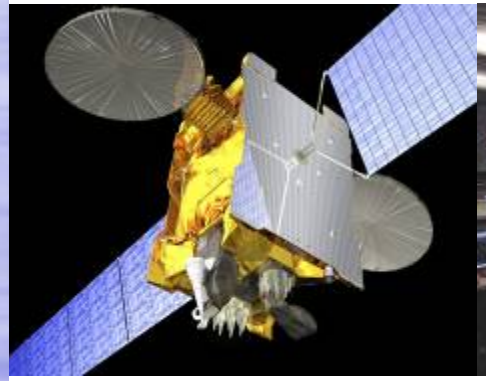
WAAS Architecture



38 Reference Stations

3 Master Stations

4 Signal Generator System/Ground Earth Stations



2 Geostationary Satellite Links

2 Operational Control Centers

Overview

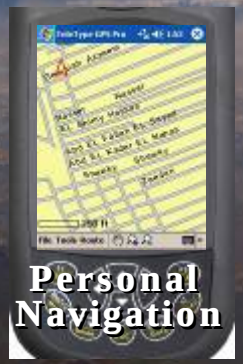
- Systems

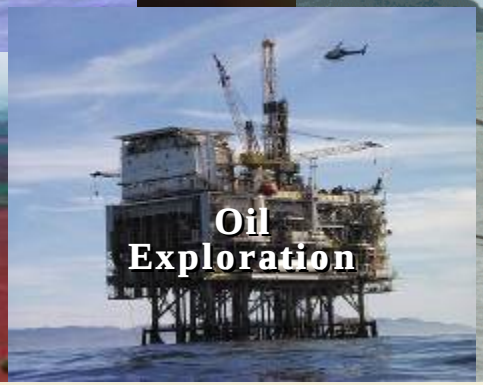
- **Applications**

Civil GNSS Applications

- Enabling technology
  - New applications emerging every day
  - $68 Billion industry worldwide by year 2010
- Wide use in transportation safety
  - Aviation, maritime, railroad, highway, etc.
  - Potential to reduce land-based navigation systems
  - Centerpiece of future transportation infrastructure
- Wide range of civil uses
  - Telecommunications, surveying, law enforcement, emergency response, agriculture, mining, etc.
  - Used in conjunction with remote sensing

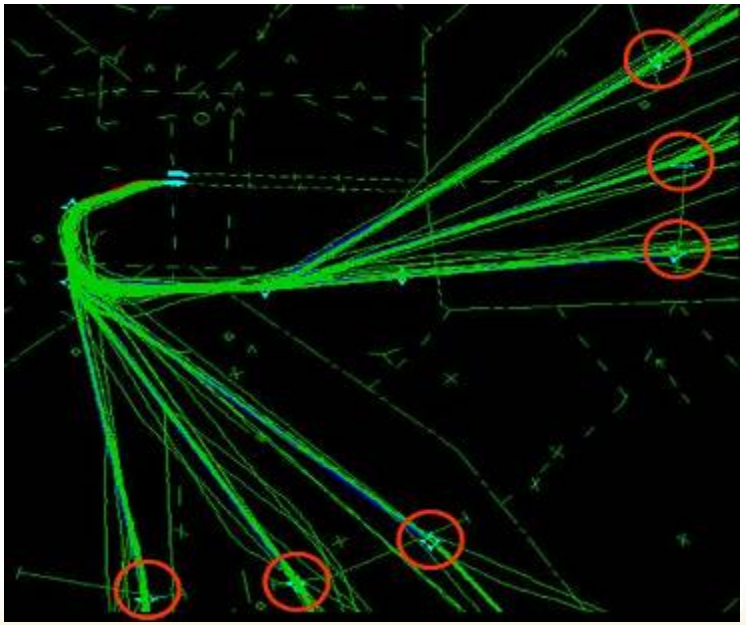
Space-Based PNT Applications Impact A Wide Range of Economic Activities





Aviation

- Reliable and accurate positioning worldwide
- Reduced delays
- More fuel-efficient routes
- Increased system capacity with enhanced safety



Maritime

- Large ships, fishing & recreation boats
- Harbor entrance and approach
  - Regardless of visibility
- Hydrographic Survey
- Buoy Positioning, etc.

Railroads

- Enhances safety
  - Reduces accidents
- Increases capacity and efficiency
  - Closer train spacing reduces investments
  - Reduces fuel consumption
- Rapid rail structure and condition mapping
  - Improves maintenance capability
- Increased efficiency and capacity through positive train control
  - Tracking location of vehicles/containers
  - Rapid rail structure and conditioning mapping

GNSS Applications – Improving Highway Operations

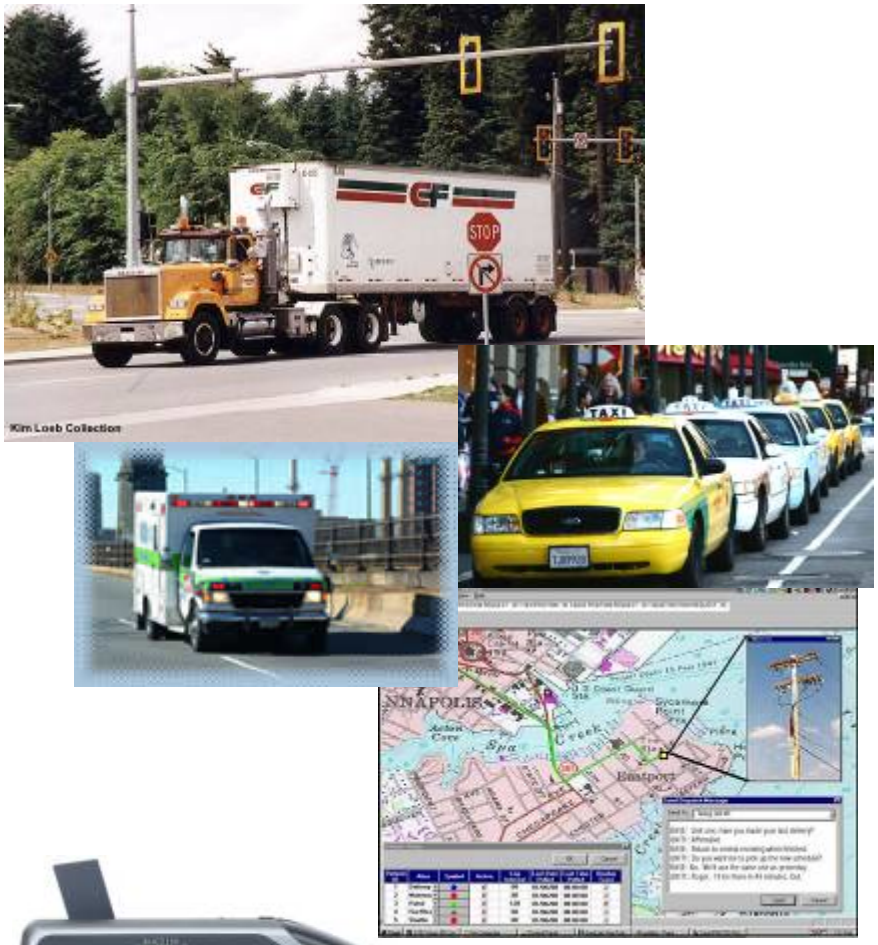
Vehicle Infrastructure Integration

(VII)

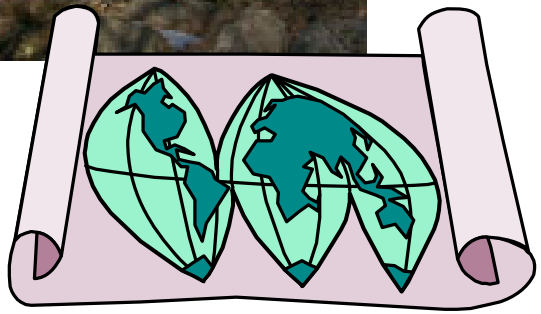
- Improving safety and reducing congestion will require more efficient management of the roadway system
- Vehicle-highway information exchange is key to improved management and operation of the transportation network
  - Provide information on traffic conditions, crashes, adverse weather and road conditions, etc.

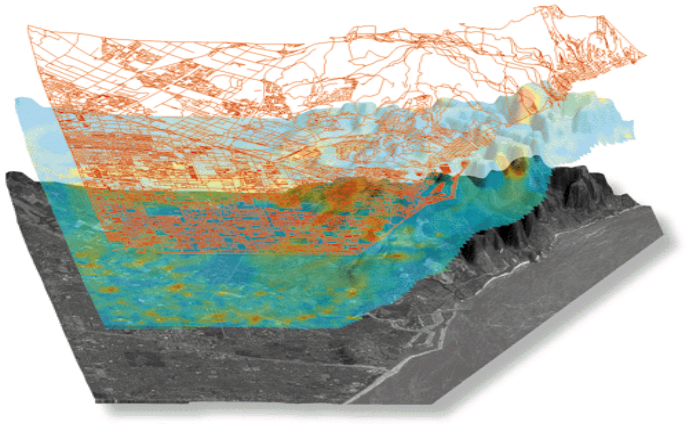
GNSS Applications – Automatic Vehicle Location

- Cargo Fleet Tracking
  - Improves safety and security
- Fleet Control/Dispatch
  - Increases fuel savings
  - Improves asset management
- Emergency Operations
  - Reduces response times
  - Reduces injury and property loss
- Road Maintenance
- In Vehicle Navigation
  - Determines accurate position
  - Reduces air pollution



Surveying/Mapping/GIS





- Sub-centimeter accuracy
- 100%-300% improvement in time, cost & labor efficiency
- Most major development projects require surveying
  - Rural electrification
  - Telecom tower placement
  - Pipeline installation
  - Dam construction
- Port dredging operations
- Oil, gas, and mineral exploration
- Flood plain mapping

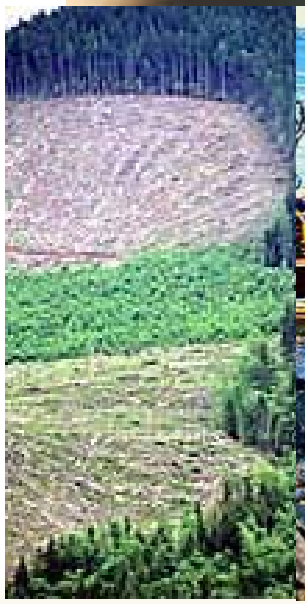
Precision Agriculture

- Maximize use of resources
  - Optimize plowing of crop rows
  - Tailor applications of seeds, fertilizer, water, pesticides
  - Improve management of land, machinery, personnel, time
  - Greater crop yields
  - Net benefit: $5-14 per acre

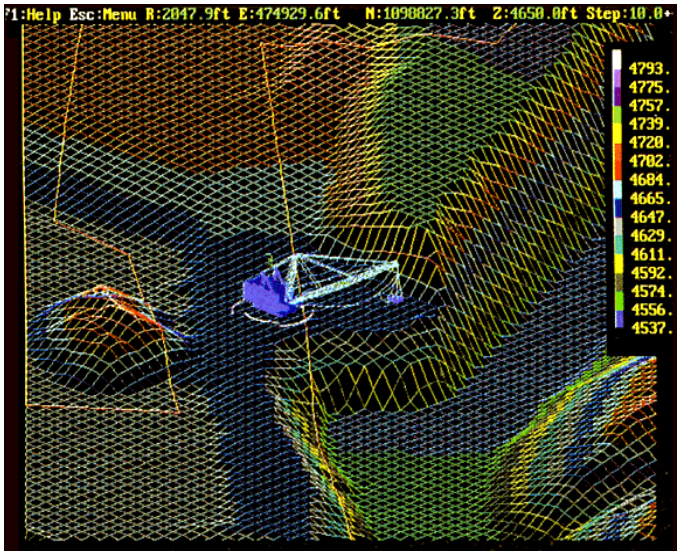
- Minimize environmental impacts
  - Localize identification and treatment of distressed crops that reduces chemical use
  - Precisely level fields to prevent fluid runoff

Environmental Protection

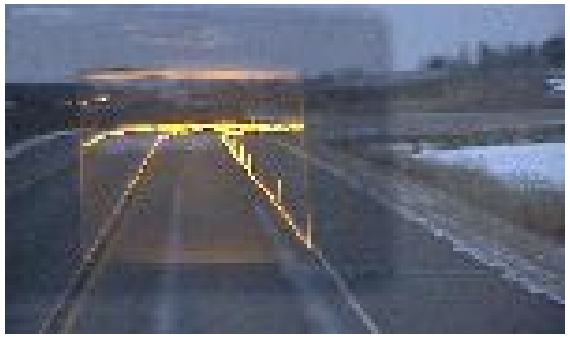
- Forest protection
  - Logging enforcement (e.g., Mato Grosso)
  - Firefighting
  - IBAMA: 230 GPS units
- Fishing boundary enforcement
- Endangered species and habitat preservation
- Natural resource management
- Hazardous cleanup
  - Oil spills, toxic waste
- Atmospheric modeling



New Applications Emerging Every Day



- Wireless/mobile applications
- Child/pet tracking
- Spacecraft control
- Power grid management
- Open pit mining
- Automatic snowplow guidance



Snow Plow Video

Web-based Information

- **PNT.gov** established to distribute information on the U.S. National Executive Committee to include:
  - U.S. Policy, Executive Committee membership, Advisory Board and frequently asked questions
  - Recent announcement on Selective Availability and offer letter to International Civil Aviation Organization
  - All recent public presentation
- **GPS.gov** established for public information about GPS applications
  - Available in English, French, Spanish, Arabic and Chinese
  - Brochure also available in hardcopy upon request
  - Contains additional links to various other web sites

Summary

- Continuing to improve USG space-based PNT system performance
- New GNSS applications only limited by imagination
- Civil users will want interoperable and compatible GNSS systems to enable the new applications
- GNSS advances more efficient and sustainable economies

Contact Information

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Presentation and other GPS information available:
www.PNT.gov