GPS Technology in Korea - the state of the art

Next

Sang Jeong Lee*, Chansik Park**

*Chungnam National University
eesjl@cslab.chungnam.ac.kr

**Chungbuk National University
chansp@cbucc.chungbuk.ac.kr

Contents

- Introduction
- Receiver Technology in Korea
- Application Technology in Korea
- GPS Augmentation as a National Infrastructure
- Conclusions

Introduction

Back

- GPS Overview
- GPS Past, Present and Future
- Applications and Markets

GPS Overview

Back

- What is GPS ?
- How GPS works ?
- Configuration of GPS

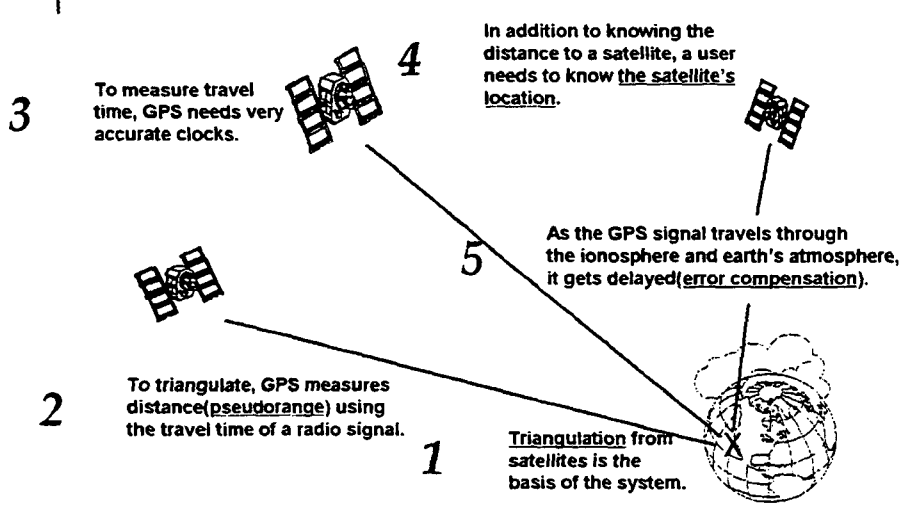
What is GPS ?

Back

- NAVSTAR GPS
  - NAVigation Satellite Time and Ranging
  - Global Positioning System
- A space-based radio positioning system
- PVT(position, velocity, time) in 3D
- Globally, all weather condition, passive,unlimited users
- Worldwide common grid reference
- High jamming resistance/Spread spectrum technology
- Anti spoofing / No Selective Availability

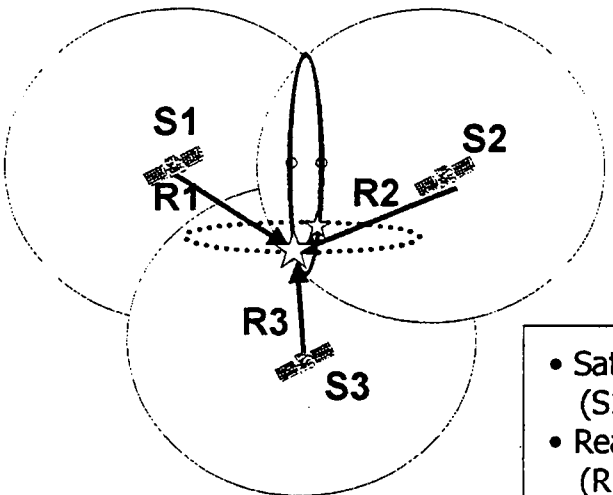
How GPS works ?

Back



Triangulation

Back

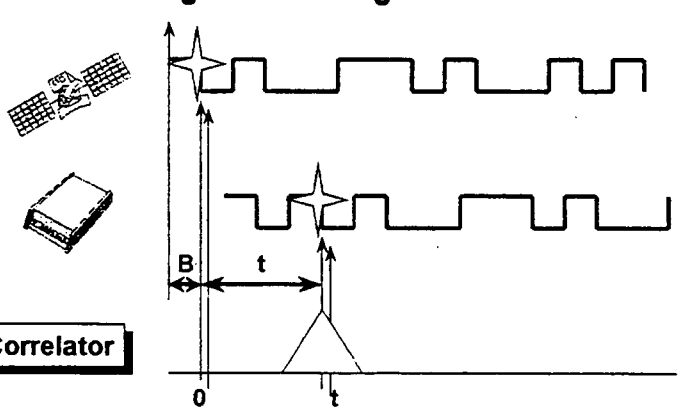


- Satellite Position (S1, S2, S3)
- Real range (R1, R2, R3)

Pseudorange

Back

- **Pseudorange = Real range + Receiver Clock Error**



Correlator

PseudoRange

C x (t + B) = Range + Clock Bias

Navigation Message

Back

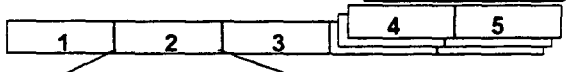
Ephemeris, SV clock correction, Error Correction, Status of SV

Almanac, Message

1 MASTER FRAME (12.5Min.)

25 Pages

1 FRAME (30Sec)



1 SUBFRAME (6Sec)

1 WORD = 30 BITS (0.6Sec)

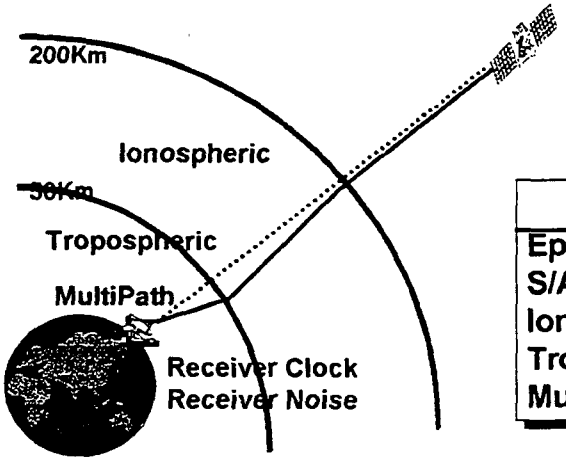
Data

Parity

1 BIT = 20 C/A Code (0.02Sec)

Error sources

Next



Ephemeris
Satellite Clock
S/A(Selective Availability)

Error	1σ
Ephemeris	3m
S/A(Old)	30m
Ionospheric	30m
Tropospheric	30m
Multi Path	5m

Error compensation

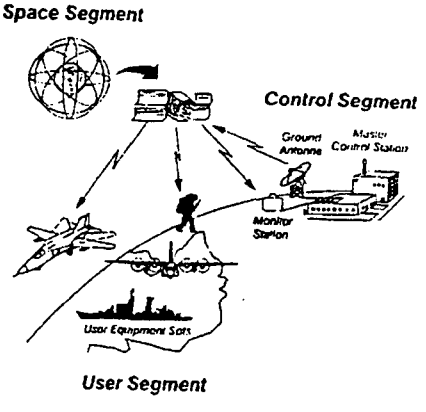
Back

- SA(Selective Availability)
  - Fade away at May 1, 2000
- SV clock
  - Using the coefficient included in Navigation Message
- Ionospheric Delay
  - Using Klobuchar model coefficient included in Navigation Message
  - About 50% compensation
- Tropospheric Delay
  - Modified Hopfield model

Configuration of GPS

Back

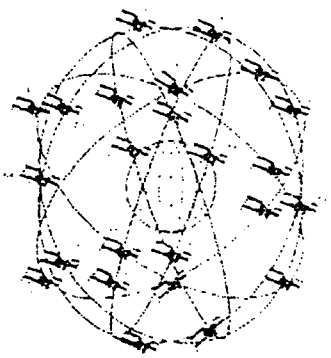
- Space Segment
- Control Segment
- User Segment



Space Segment

Back

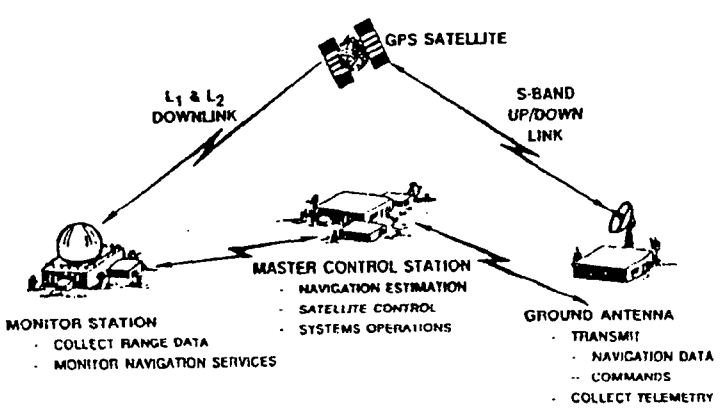
- GPS Constellation
  - 21 Satellites + 3 on-orbit spares
  - Circular 12hour Orbits
  - 6 Orbital Planes
  - Each plane inclined 55o
- Visibility
  - Direct LOS to at least 4 satellites
  - Typically see 6 - 8 satellites
- Transmission
  - Dual frequency(L-band)
  - Spread spectrum
  - Pseudo random codes
  - Navigation message data



Control Segment

Back

- Monitor and control of Satellites



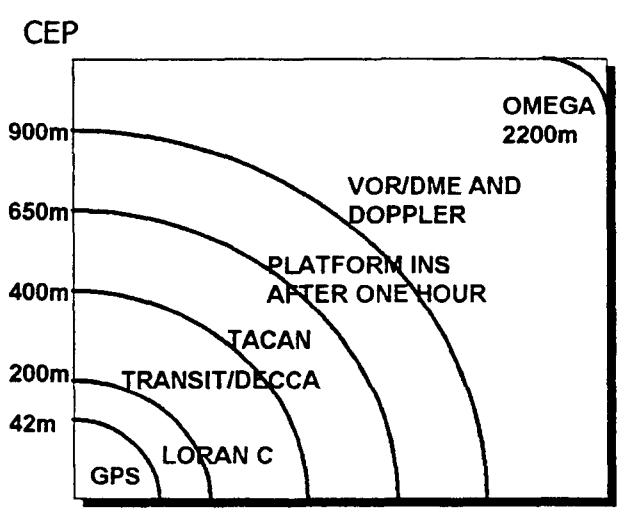
GPS Past, Present and Future

Back

- Accuracy of Navigation System
- Improving Accuracy
  - DGPS
  - CDGPS
- Present GPS Accuracy
- The Future
  - GPS Modernization
  - Future GPS Accuracy

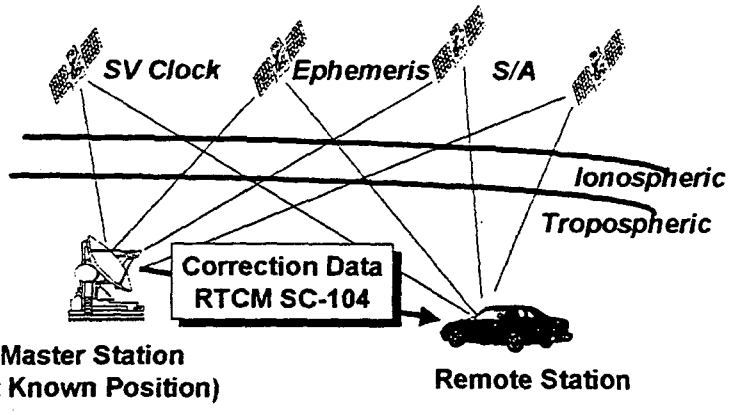
Accuracy of Navigation Systems

Back



Differential GPS

Back

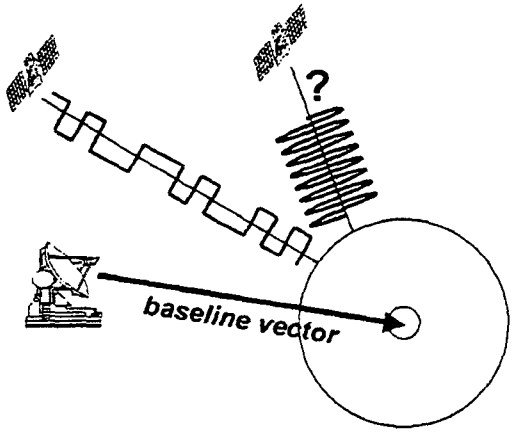


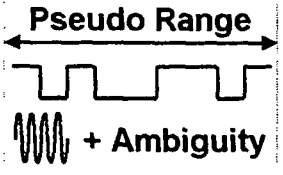
Correction Data = S/A + SV Clock + Ephemeris + Iono. + Tropho.

Carrier phase DGPS

Next

- Code Vs. Carrier phase measurement

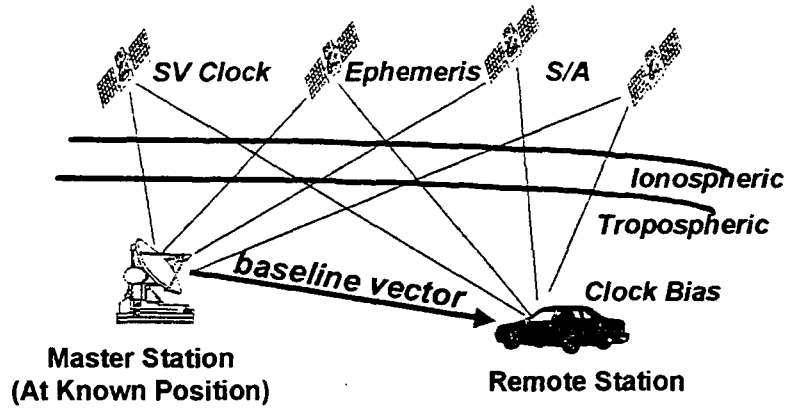




	Code	Carrier
λ	300m	19cm
1%	3m	1.9mm

Relative Positioning

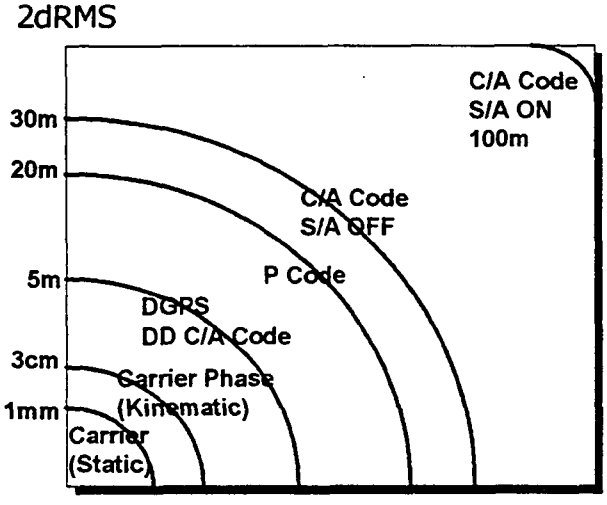
Back



Double Difference: $\Psi_{AB}^{ij} = (\Psi_A^i - \Psi_A^j) - (\Psi_B^i - \Psi_B^j) = r_{AB}^{ij} + v_{AB}^{ij}$
Elimination of S/A, SV Clock, Ephe., Iono., Tropo., *Clock Bias*

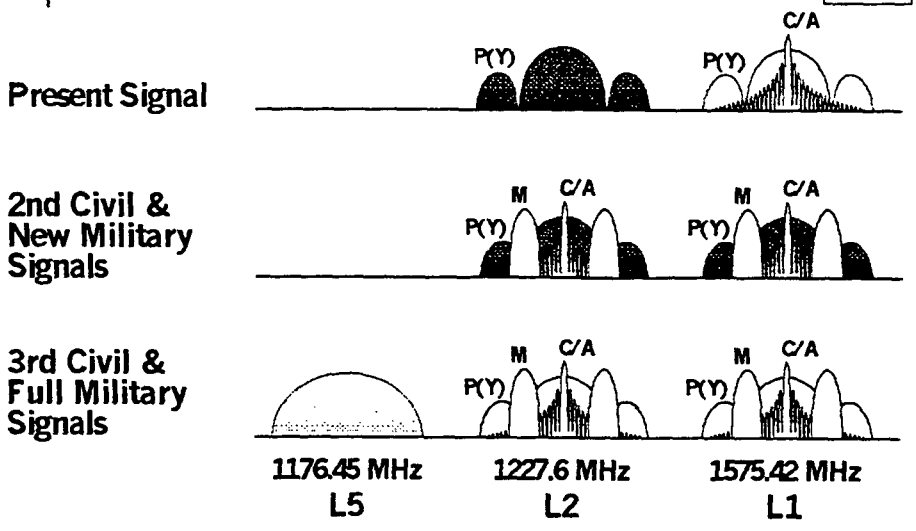
Present GPS Accuracy

Back



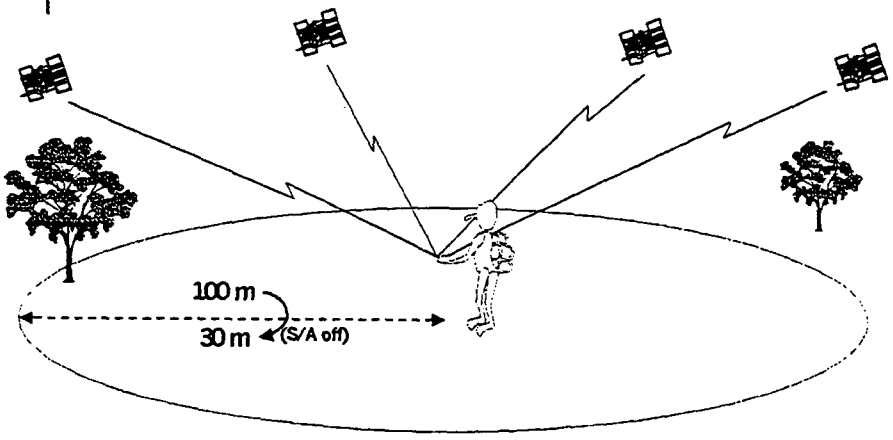
GPS Modernization: New signals

Back



Basic Civil Positioning: Today

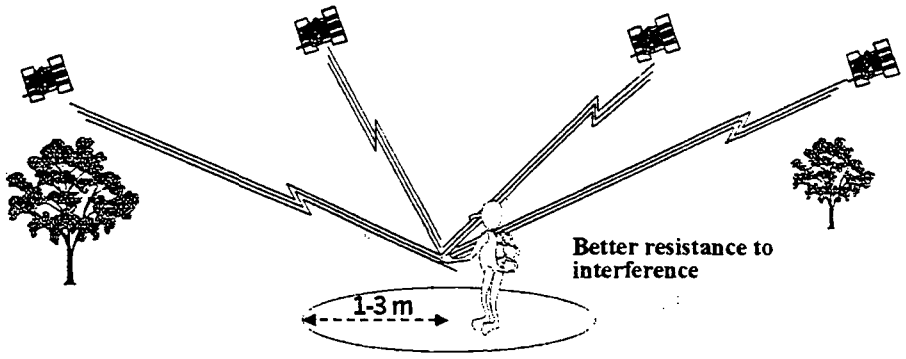
Next



- C/A Code on L1
- Selective Availability → S/A off

Basic Civil Positioning: Tomorrow

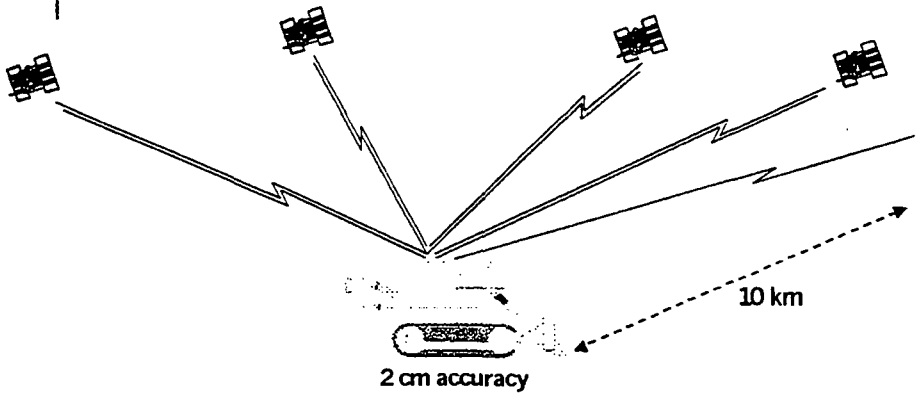
Next



- C/A Code on L1
- C/A Code on L2
- New Code on L5
- No Selective Availability

Advanced Positioning: Today

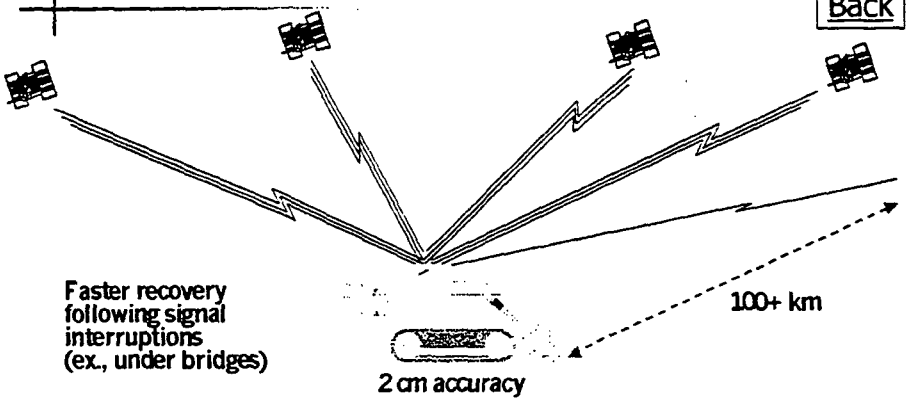
Next



- L1 Code and Carrier
- L2 Carrier
- Data Link

Advanced Positioning: Tomorrow

Back



- L1 Code and Carrier
- L2 Code and Carrier
- L5 Code and Carrier
- Data Link

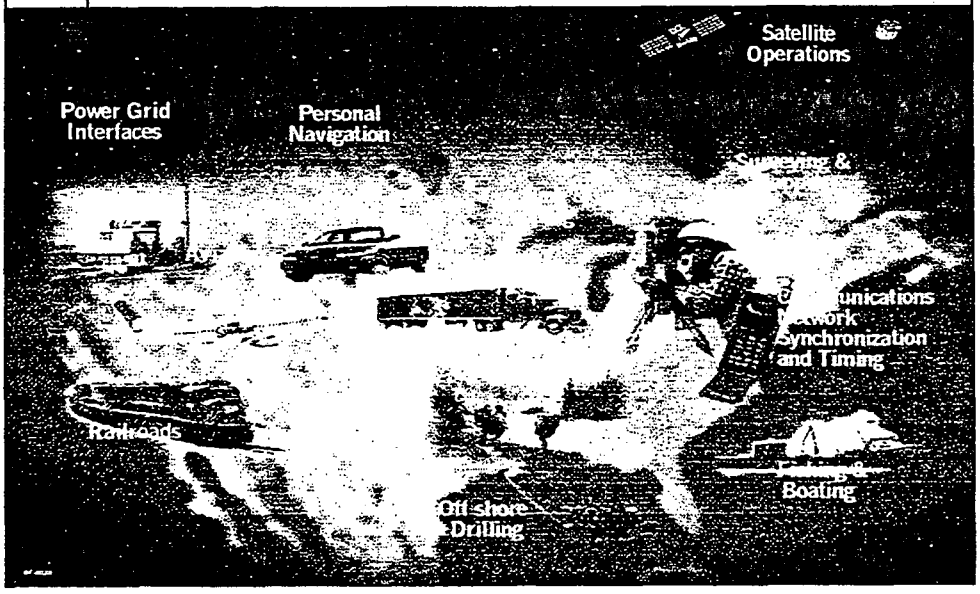
Applications and Markets

Back

- Major GPS Markets
- Worldwide Sales of GPS Related Goods & Services
- Global Sales by Market Segment

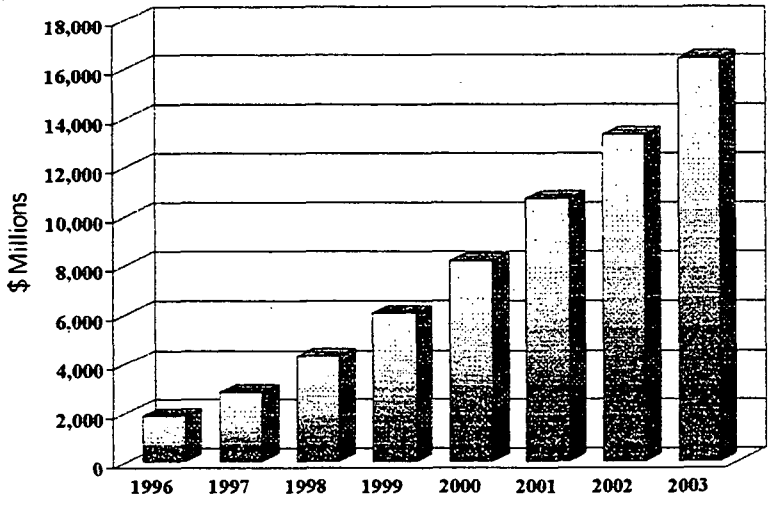
Major GPS Markets

Back



Worldwide Sales of GPS Related Goods & Services (Projected to Exceed $16B by 2003)

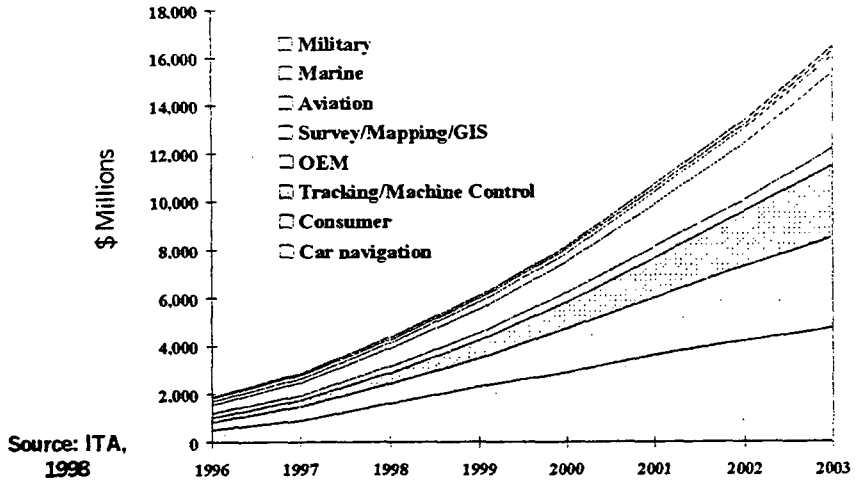
Back



Source: ITA, 1998

Global Sales by Market Segment

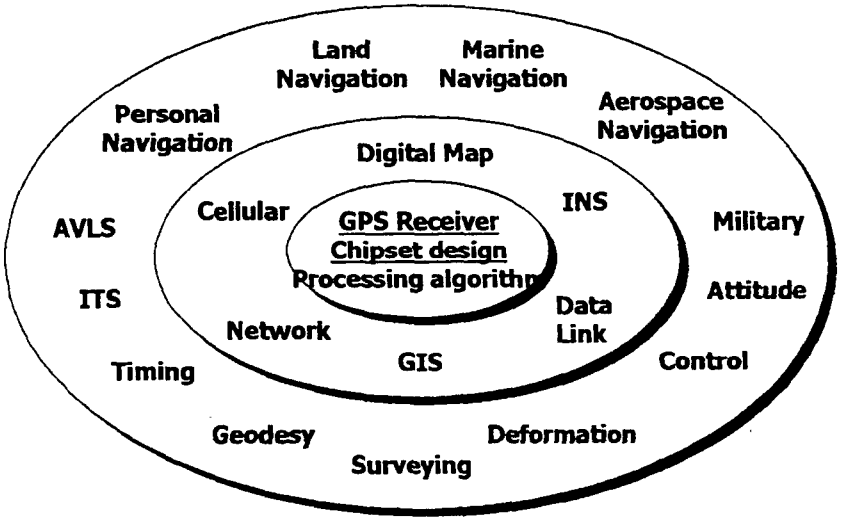
Back



Source: ITA, 1998

Receiver Technology in Korea

Back



Classifying GPS receivers

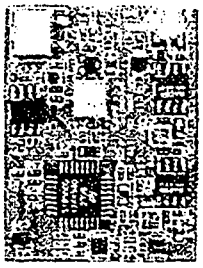
Back

- Navigation
  - Positioning
    - Stand alone
    - DGPS
  - Attitude
  - GPS
  - GPS/GLONASS
  - Integrated with INS or DR or MM
  - Special Purpose (translator etc.)
- Surveying
- Timing
  - PTS(Precise Timing Synchronizer)
  - NTP(Network Timing Protocol) Server

12 Channel GPS Receiver

Back

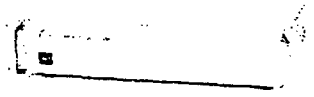
- Compact Size : 29.2(W) X 39.2(D) X 8.8(H)mm
- 3.3Vdc Operation
- Power Sleep Mode
- 12 Channel Tracking : All-in View
- L1 & C/A Code
- Cost Effective



GPS Receiver for DGPS Reference Station

Back

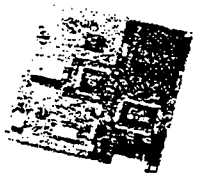
- Optional Dual DGPS Receiver Configuration
- Receiver Autonomous Integrity Monitoring(RAIM)
- 19-inch Rack Mount Type
- Status LED Display
- 12-channel Simultaneous Satellites
- L1-band C/A-code & Carrier Tracking
- RTCM SC-104 Version 2.1/2.2 Message
- Configurable Update Rate : 1Hz Typical
- Selectable Output Message Type(Type 1, 3, 9)



Two-antenna GPS Receiver

Back

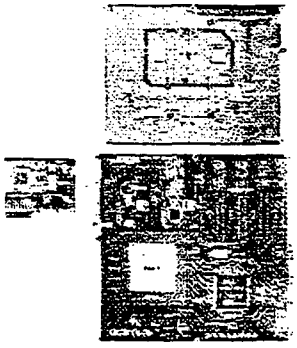
- Real time Azimuth Determination with 0.4[deg] Accuracy
- L1 C/A Code & Carrier Tracking
- 2 Independent antennas
- 6+6 Tracking L1 channels
- 1Hz Position Output rate
- NMEA-0183 Protocol



GPS/GLONASS

Back

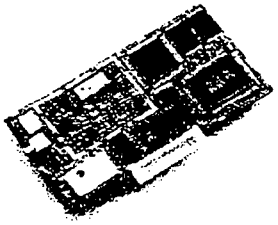
- 16 channels GPS/GLONASS Receiver
  - GPS L1 (1575.42MHz, C/A)
  - GLONASS L1 (1602.5625 ~ 1608.75 MHz, C/A)
- Environment
  - Acceleration : less than 7g
  - Velocity : less than 1000m/s
  - Altitude : below 18km



GPS Receiver with Dead-reckoning

Back

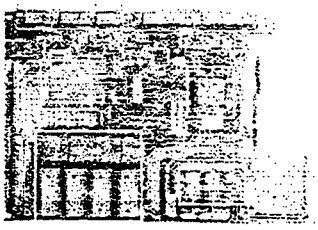
- Combining GPS & Dead_Reckoning
- L1 & C/A Code
- 12-channel Tracking
- High Speed & Course Accuracy
- Cost-effective
- Compact size
- DGPS Ready



Integrated GPS with INS

Back

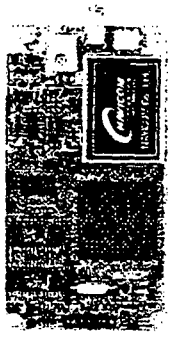
- Accuracy
  - Attitude : < 0.8 [deg] (Roll&Pitch)
    < 0.4 [deg] (Yaw)
  - Velocity : < 0.5m/s (1σ)
  - Position : < 46m(SA off, SEP)
- Real-time OS porting
- SDLC & RS-232 Interface
- ARINC 429 FMC interface
- Output Rate
  - Position, Velocity: 10Hz
  - Acceleration, Attitude, Attitude Rate: 100Hz



GPS Receiver for High Dynamic Application

Next

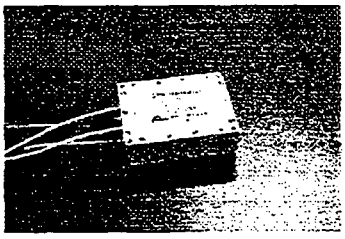
- High Raw Data Update Rate : 20Hz(Max)
- High Position Update Rate : 10Hz(Max)
- High Acceleration
- 12-channel Tracking
- Tracking L1 & C/A Code, Carrier
- Tracking Simultaneous 12 Satellites
- Inverted Differential GPS Capability



Translator

Back

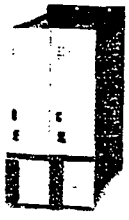
- S-band Range Telemetry
- High Raw Data Update Rate : 50Hz(Max)
- High Position Update Rate : 50Hz(Max)
- High Acceleration
- 12-channel Tracking
- Tracking L1 & C/A Code, Carrier
- Tracking Simultaneous 12 Satellites
- Inverted Differential GPS Capability
- IF data storage



PTS(Precise Timing Synchronizer)

Back

- GPS Timing Receiver
- 8-channel
- L1 & C/A Code
- Time Stability
  - < 1.0 E-11 (Allan variance at τ=100sec)
- Time Accuracy
  - GPS locked : < 100 ns with SA on
  - Holdover : $\pm$7 us/day to UTC with SA after Learning Operation
- Dual RS-232 Interface
- Serial I/O (RS 232)



NTP(Network Timing Protocol) Server

Back

- GPS Timing Receiver
- 8-channel
- L1 & C/A Code
- Time Accuracy
  - Network : 1 ~ 10 ms typical
  - GPS : < 1 us to UTC
  - 1PPS : 130 ns with SA on
- Network Interface (10/100 Base-T Ethernet, UDP/IP, TCP/IP)
- Serial I/O (RS 232)
- Alphanumeric Front Panel Display (2-line, 16 character LCD)

Chipset Design

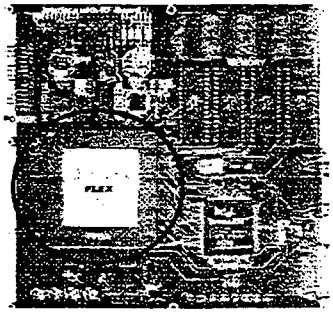
Back

- GPS Receiver Chipset
- L1 C/A Code GPS Receiver
  - RF Front End
  - Digital Correlator

Digital Correlator for GPS Receiver

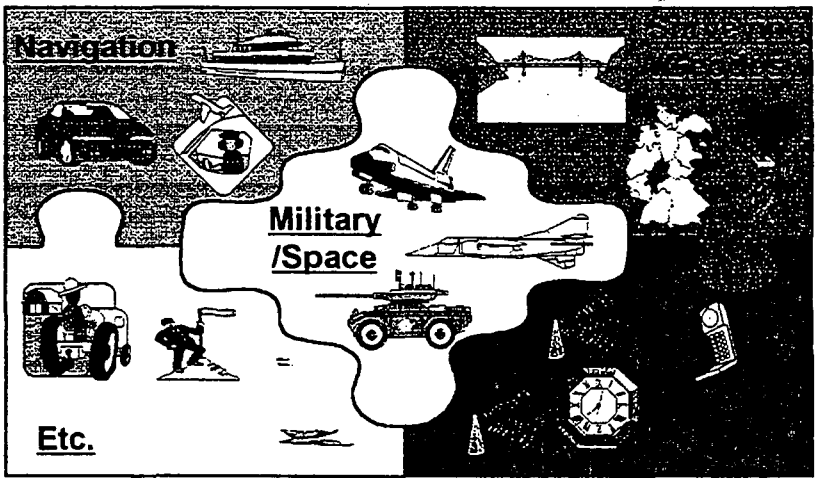
Back

- Fully Independent Correlation Channels
- 1PPS UTC Aligned Timing Output
- Compatible with 32bit Microprocessors



Application Technology in Korea

Back



Navigation

Back

- Land Navigation
- Maritime Navigation
- Aerospace Navigation
- Personal Navigation

- DGPS

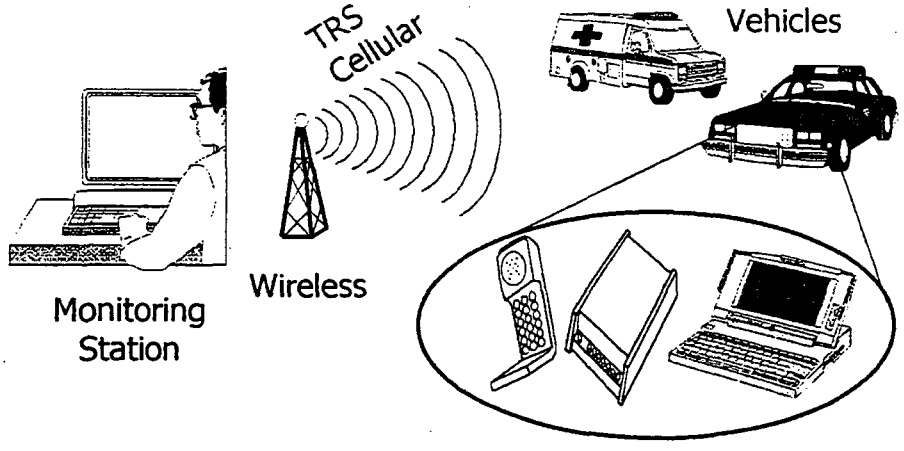
Land Navigation

Back

- CNS(Car Navigation System)
  - GPS only
  - GPS + MM(Map Matching) + DR(Dead Reckoning)
- ITS(Intelligent Transportation System)
  - ATMS(Advanced Traffic Management System)
  - ATIS(Advanced Traveler Information System)
  - APTS(Advanced Public Transportation System)
  - CVO(Commercial Vehicle Operations)
  - AVHS(Advanced Vehicle & Highway System)
    - AVLS(Automatic Vehicle Location System)

AVLS(Automatic Vehicle Location System)

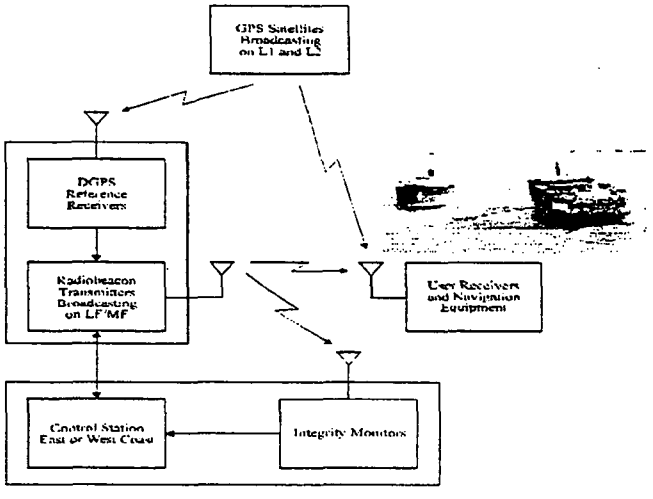
Back



Maritime Navigation

Back

- **Radio Beacon System**



Aerospace Navigation

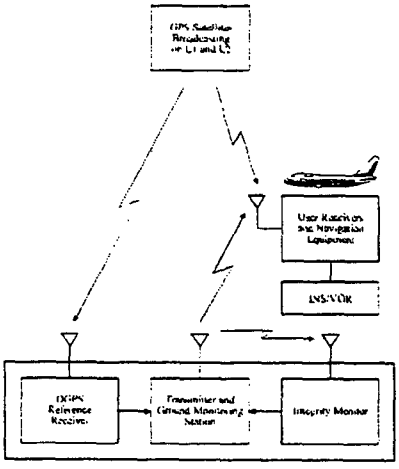
Back

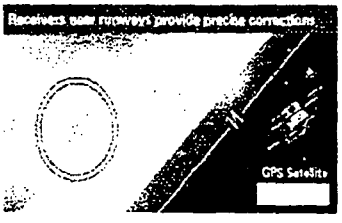
- Integration of GPS/INS
  - Loosely Coupled GPS/INS
  - Tightly Coupled GPS/INS
  - Integration of Attitude-GPS/INS
- Integrity Monitoring
- UAV(Unmanned Air Vehicle)
  - Attitude-GPS/INS + Auto Pilot
- LAAS

LASS

Back

- Ulsan Airport

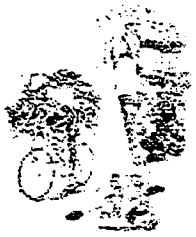




Personal Navigation

Back

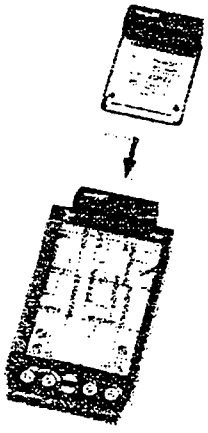
- Wireless Location (or Geolocation)
  - Indoor Capability
  - E-911
- PDA(Personal Data Assistance) + GPS
- Portable GPS Receiver
- Small Size GPS Receiver
  - SOB(System On Board) /SOC(System On Chip)
- Low Power GPS Receiver



PDA(Personal Data Assistance) + GPS

Back

- GPS Receiver for PDA



DGPS

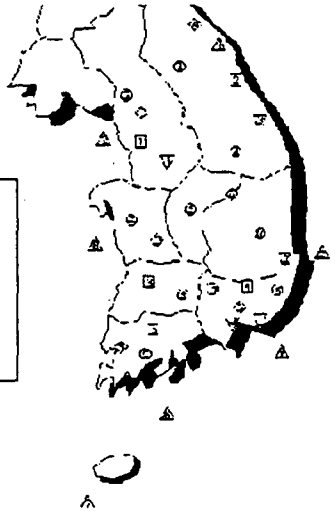
Back

- DGPS Reference Station
- FM – DARC(Data Radio Channel)
  - MBC
- LAAS Evaluation
  - KARI at Ulsan Airport
- DBR(Data Beacon Radio)

DGPS Ref. Stations

Back

- 7 Government's Bureaus implement and control independently
- Will have interoperability if NDGPS operates



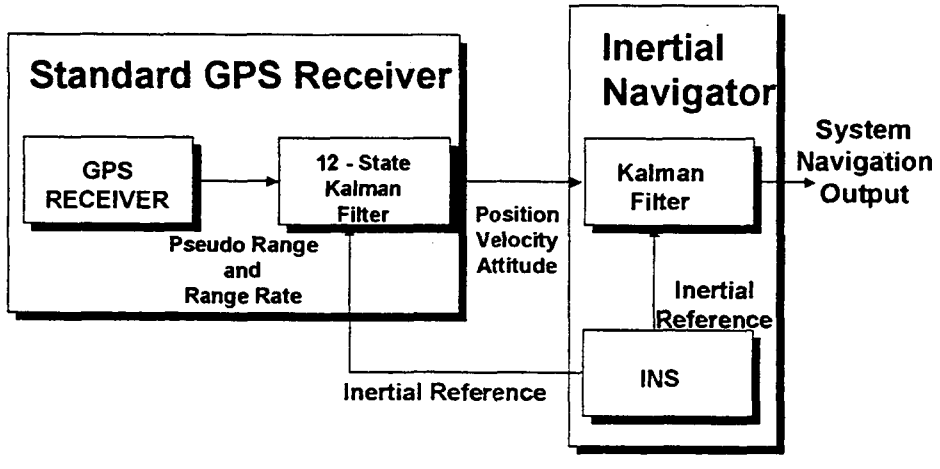
Military and Space

Back

- Integration of GPS/INS
- Integration of Attitude-GPS/INS
- GPS/GLONASS Receiver
- Telemetry System
  - Translator

GPS/INS Integration

Back



Surveying/Geodesy

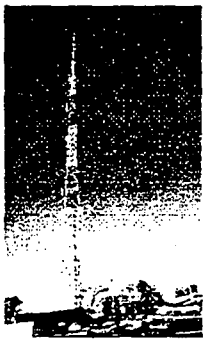
Back

- Mining and Construction
  - Seo-Kang Grand Bridge
- Monitoring of Deformation of Dam/Bridge
- Digital Map
- GIS

Timing

Back

- PTS(Precise Timing Synchronizer)
  - CDMA Network
  - Pager Network
  - Power Plant
- NTP(Network Timing Protocol) Server



Etc.

Back

- Precise Farming
- Leisure
- Emergency
  - E-911
- Weather Forecasting
  - Vapor estimation
- Ionosphere estimation
- Pseudo-Lite
  - Indoor applications
- SDR(Software Defined Radio)

GPS Augmentation on a National Infrastructure

Back

- Background
- Current Status
- Plan

BACKGROUND : Transportation Requirements

Next

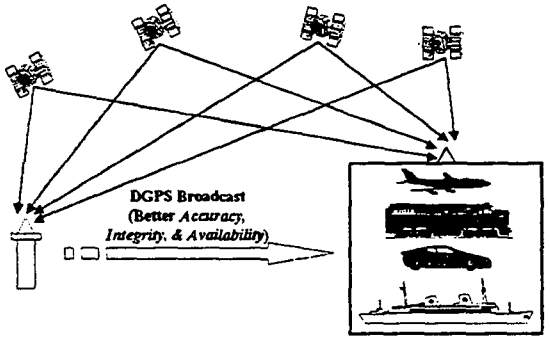
	Transportation Application	Integrity	Availability	Accuracy
Maritime	Ocean transit	Yes	Yes	Yes
	Coastal Navigation	Yes	Yes	Yes
	Inland waterway	No	No	No
	Harbor entrance & approach	No	No	No
Land	Highway navigation	Yes	Yes	Yes
	Emergency Response	Yes	Yes	Yes
	Transit vehicle management	No	No	No
	Railroad train control	No	No	No
Aviation	Oceanic en route	Yes	Yes	Yes
	Domestic en route	No	No	Yes
	Non-precision approaches	No	No	Yes
	Precision approaches	No	No	No

Requirements can be met by GPS Alone — Yes

Requirements cannot be met by GPS Alone — No

DGPS for better Accuracy, Integrity & Availability

Back



DGPS Reference Station
1. Knows its position accurately.
2. Receives GPS signals.
3. Calculates GPS errors.
4. Broadcasts the differential message.

DGPS Users
1. Receive GPS signals.
2. Receive the differential message.
3. Correct the GPS information.
4. Know their position accurately & also the condition of the GPS service.

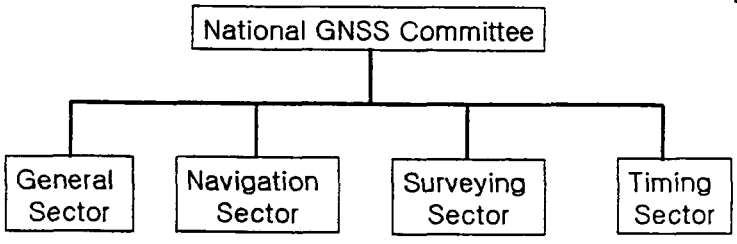
Current Status

Back

Application		Number of Reference Station	
		Constructed	Planned
Navigation	Aviation	1	15
	Maritime	8	10
	Land	5	5
Surveying	Cadastral Mapping	30	50
	Topographical Mapping	11	20
Scientific Research		22	50
Etc		0	120

Plan : Interagency Committee

Back



- **Maritime DGPS beacon network**
- **LAAS(possibly WAAS)**
- **CORS**

Conclusions

Top

- Technology
  - Basic technology in GPS receivers
  - Various application technologies
  - Advance scientific and technical capabilities
- Policy
  - Government plans many public services for DGPS
  - Promote safety and efficient in transportation or other fields
- Private sector investment in GPS technologies & services
- Transportation benefits
  - ITS, MTS, Asset Management, Surveying, Mapping, Weather forecasting, etc