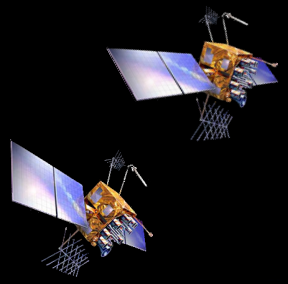

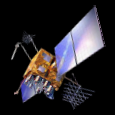

LGSP: A Lightweight GNSS Support Protocol for Military and Civil Applications

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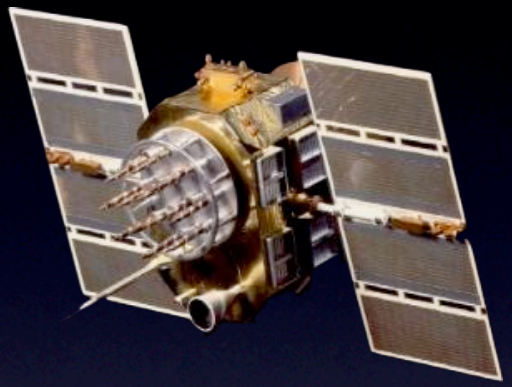
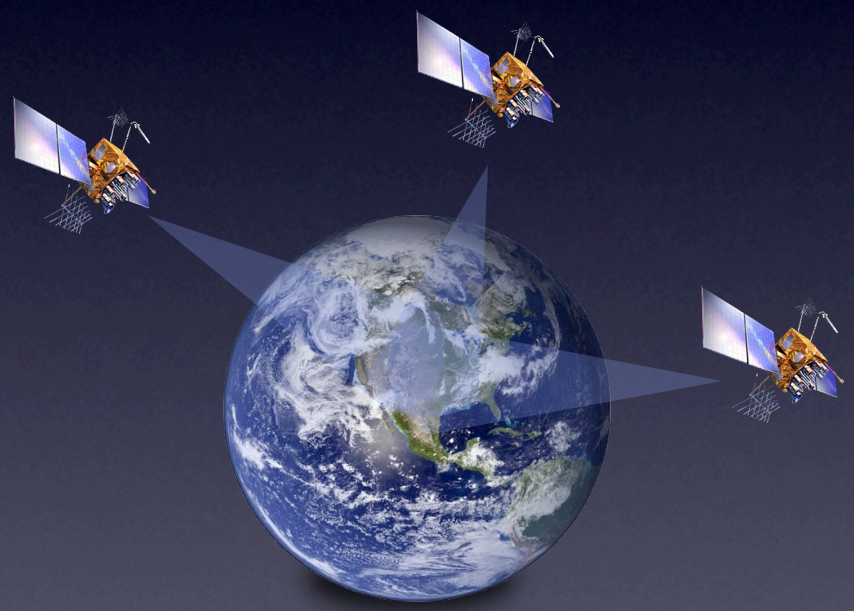
Overview

- Background
  - Global Navigation
  - Augmentation
- Rationale
  - Shortcomings in traditional communication model
  - Alternative: IP
- LGSP advantages
- Messaging
- Conclusion



Global Navigation Satellite Systems

- Orbiting satellites transmit signals to Earth
- Receivers analyse signals from several satellites to generate a position estimate.
- U.S.'s Global Positioning System (GPS) is the most mature and well-known GNSS.

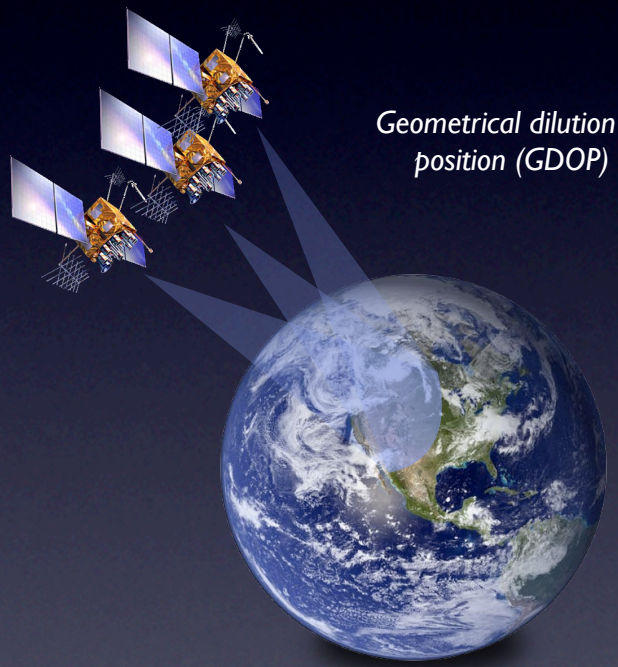


Global Navigation Satellite Systems

- Used in
  - Land, air & sea navigation
  - Surveying
  - Geology
  - Accurate positioning for military applications
  - Mobile telephony applications (Recently, E-911 mandate introduced, requiring emergency call-related positioning)

GNSS Precision

- Accuracy is affected by factors such as
  - tropospheric and ionospheric delays
  - clock drift
  - out-of-date orbital data
  - geometrical dilution of position



Local Area DGPS (eg. LAAS)

- A precisely-surveyed ground station (GS) receives GPS signals and generates a position estimate
- GS calculates discrepancy between known location and position estimate
- GS broadcasts discrepancy over radio, which is used by receivers to adjust their position estimate

Wide Area DGPS (eg. WAAS)

- Many precisely surveyed wide area ground reference stations (WRS) observe the GNSS signal
- A wide area master station (WMS) analyses the data from the WRSs and generates correction information
- The WMS uploads the correction message to a geosynchronous satellite
- Message is broadcast from satellite on the GPS L1 frequency
- Receivers use correction information to correct position

DGPS over Radio: Shortcomings

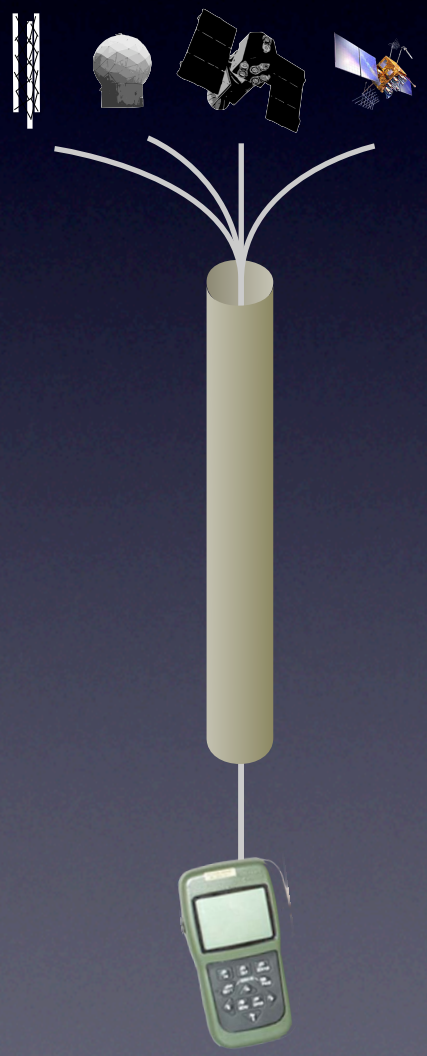
- Operating over a radio link, all DGPS systems require a dedicated, discrete channel
- Increases cost
  - Monetary hardware cost
  - Power consumption
  - Hardware reliability
  - Heat dissipation
- Sub-optimal use of radio spectrum (limited resource)
  - Interference issues
- Vulnerability to jamming, other fading effects
- Low data rate typical - slow update rates

Another option: DGPS over IP

- Many devices with GNSS functionality already have access to an IP channel (JTRS, WiMAX, GPRS, IEEE802.11, etc)
- Typically more robust, faster, more affordable than dedicated radio links
- Bidirectional
- Lower costs, while increasing robustness and flexibility

Lightweight GNSS Support Protocol (LGSP)

- The Lightweight GNSS Support Protocol (LGSP) provides for transport of a variety of GNSS support data over an Internet Protocol (IP) channel, including
  - Local Area DGPS (eg. LAAS)
  - Wide Area DGPS (eg. WAAS)
  - GPS almanac data
  - GPS navigation data

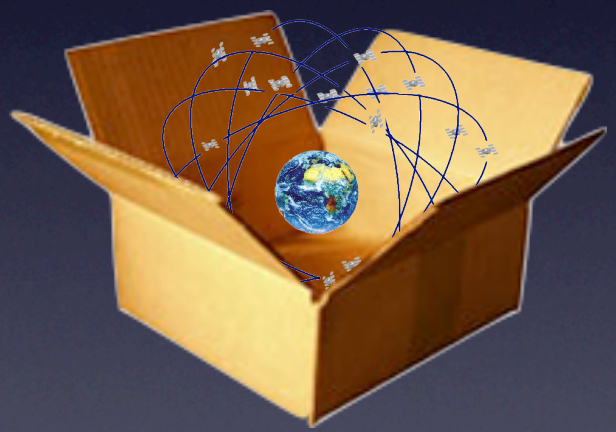


Some Advantages of LGSP

- A pre-existing, robust IP channel can be used for acquisition of GNSS data - Automatically protected by any jam-resistance provided by the IP channel
- GPS start-up time can be reduced as almanac data can be fetched over a high-bandwidth IP link, instead of downloading from the slow satellite link (complete download over satellite link takes 12.5 minutes!)
- Availability of GPS increased, as almanac can still be retrieved when satellite link is weak

LGSP Messaging

- LGSP specification defines messaging formats for:
  - GPS family messaging (eg. GPS NAV messages, almanac pages, LAAS and WAAS messages)
  - messaging for the European Galileo system (including EGNOS correction messages), and
  - messaging for the Russian GLONASS system.
- Can carry a large variety of GNSS support information



Other LGSP Features

- Sophisticated channel protection for use over rudimentary/insecure channels: Encryption and Forward Error correction
  - Provides ‘best effort’ protection even when running over ‘casualty mode’ channels
- Redundant hierarchical architecture with mirroring
  - Increases robustness and availability
  - Load balancing
- Multiply-redundant backup server provisions
- Multicast streaming mechanism for distributing short life-span data

ECCM/EPM - Jam Resistance

- Resistance to jamming is conferred by the Physical and Datalink Layer designs of the channel which is carrying LGSP traffic.
- In military applications it is envisaged that LGSP will run over established military networks and datalinks.
- Eg: JTIDS/MIDS/LET susceptible to repeater mode jamming which degrades throughput; JTRS expected to be more resilient.
- LGSP optimisations for ECM intensive environments based on the use of stateless transactions allowing rapid recovery from packet loss.
- If heavy jamming of the physical/datalink layers occurs, LGSP will not be driven into an unrecoverable state by loss of packets.

LGSP Summary

- Providing a transport for GNSS support data over an IP channel, instead of a dedicated radio link, allows for usage of channels that are mature and often already in place
  - Lowers cost
  - Increases robustness
  - Increases performance
  - Increases security

LGSP Summary

- LGSP provides an alternate means for obtaining GPS almanac data
  - Much faster start-up times from a cold start
  - Increased availability - almanac can still be retrieved when satellite link is weak
- Expansion messaging modes provided for future evolutions of GNSS

Questions?

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Some clipart by US. Mil.

http://www.csse.monash.edu.au/research/san

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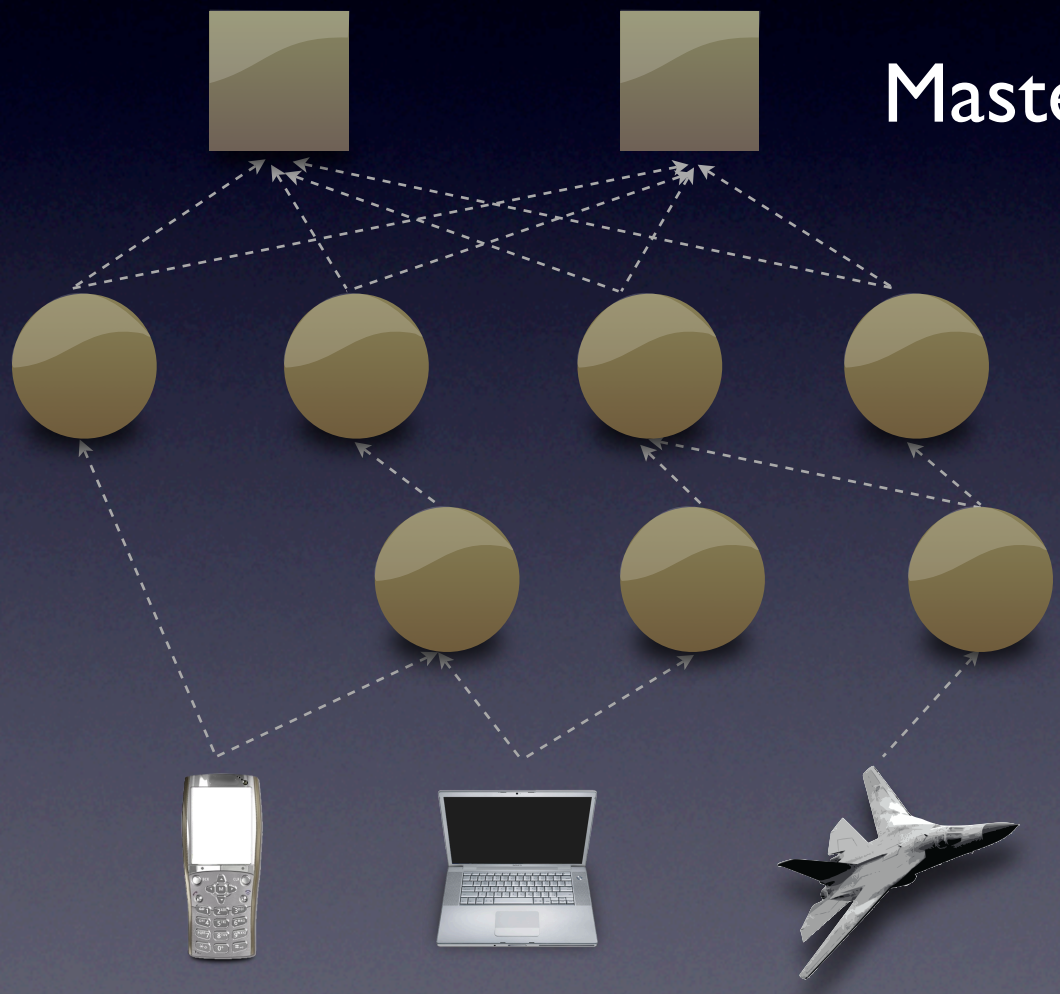
LGSP Protection

- LGSP designed for operation over many different channel types
- Needs adequate protection when operating over rudimentary channels
- Needs to differentiate between user classes in order to provide privileged services

LGSP Protection

- Message exchanges in Protected Mode encapsulated in D-TLS, inside a Forward Error Correction code.
- Authentication provided by D-TLS certificate exchanges

LGSP Architecture Example



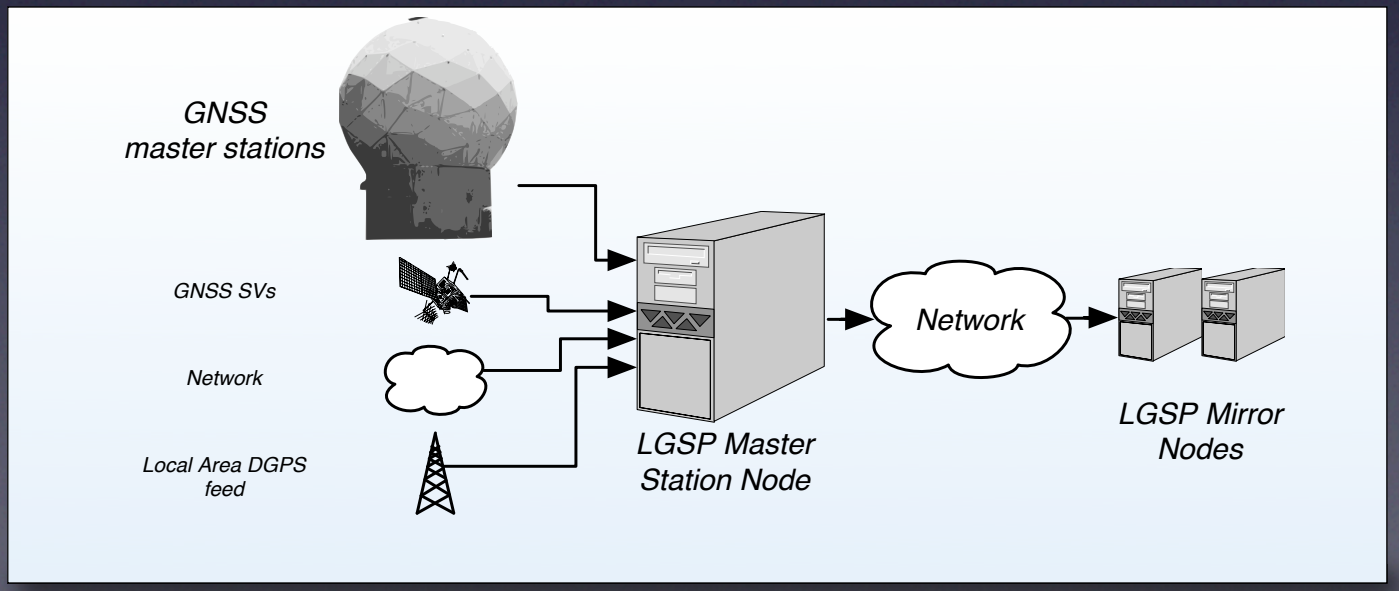
Master Station Nodes

Mirror Nodes

Clients

LGSP Architecture: Master Station Nodes

- LGSP Master Station Nodes
  - Can connect to GNSS master stations, local area DGPS feeds, forward data from GNSS SVs, or auxiliary information from a network source
  - Accept connections only from LGSP Mirror Nodes



LGSP Architecture: Mirror Nodes

- LGSP Mirror Nodes
  - Provide distribution for data from LGSP Master Station nodes (load bearing, security, redundancy)
  - Can also provide local DGPS feed data, and forward data from GNSS SVs, independently of a connection to a LGSP Master Station