Virtual Reference Stations (VRS) (RTN)

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Overview

- Why VRS/RTN ?
- The Concept of Virtual Reference Stations
- A typical network setup
- Required Hardware
- Data communication
- VRS Performance

Classical RTK Surveying

- Local reference station required
- Error growth with baseline length
- Rover/Reference distance is limited due to error growth
- Reliability and Performance decrease with distance from reference

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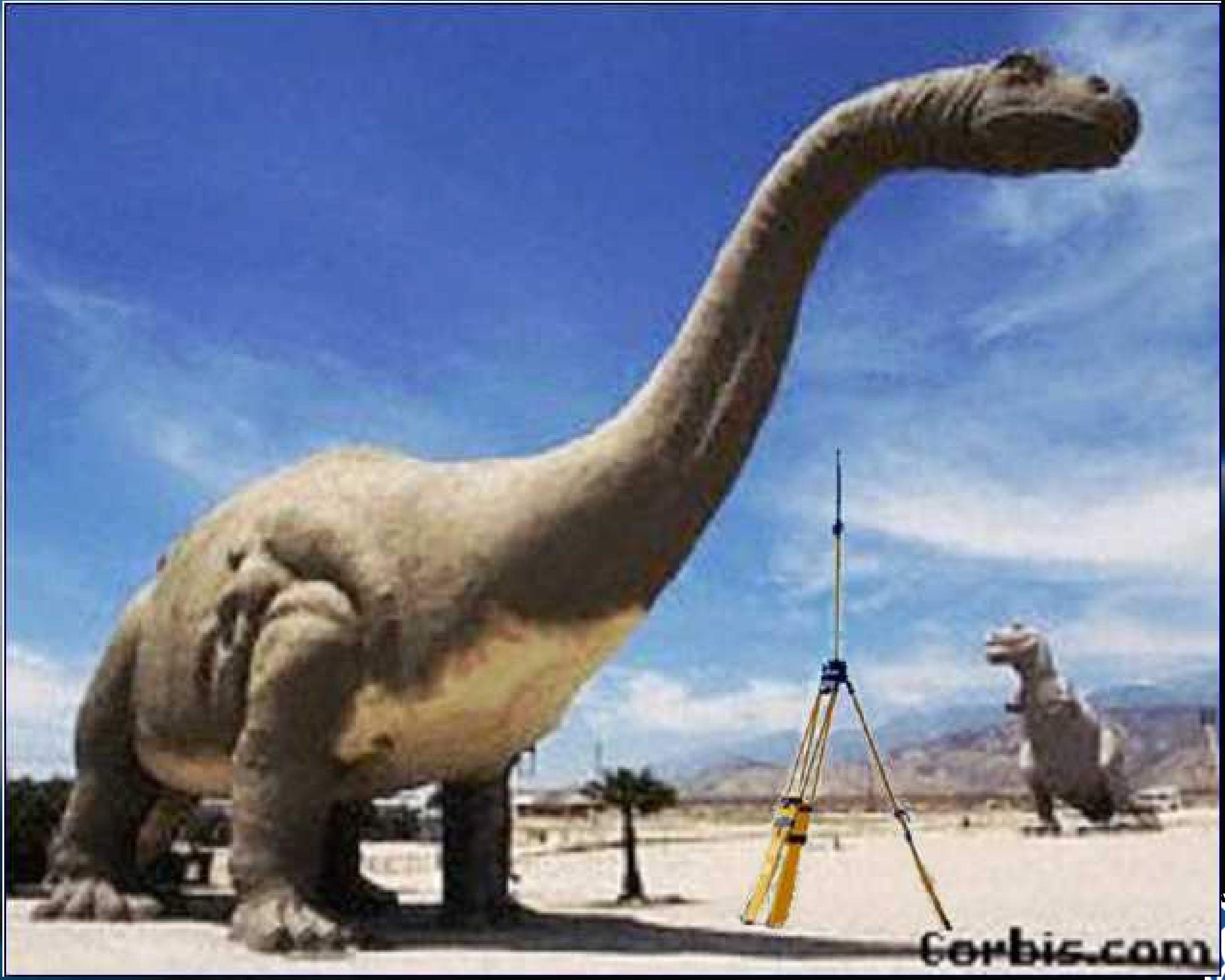
Limitations of Classical RTK Surveying

- Limited range from single reference station
- Potential gross error in establishing reference station
- No integrity monitoring
- Dependency on single reference station
- Productivity loss
- Coordinate System
- Security
- Communications FCC
- Power supply

Classic RTK Example



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VRS - How does it work?

- Uses observations from multiple reference stations
- Continuously monitors integrity of reference station data
- Models systematic errors including:
  - ionosphere
  - troposphere
  - satellite orbit errors
  - multipath
- Creates a unique virtual reference station for each user's location
- Delivers the data in RTCM or CMR+ format to the rover

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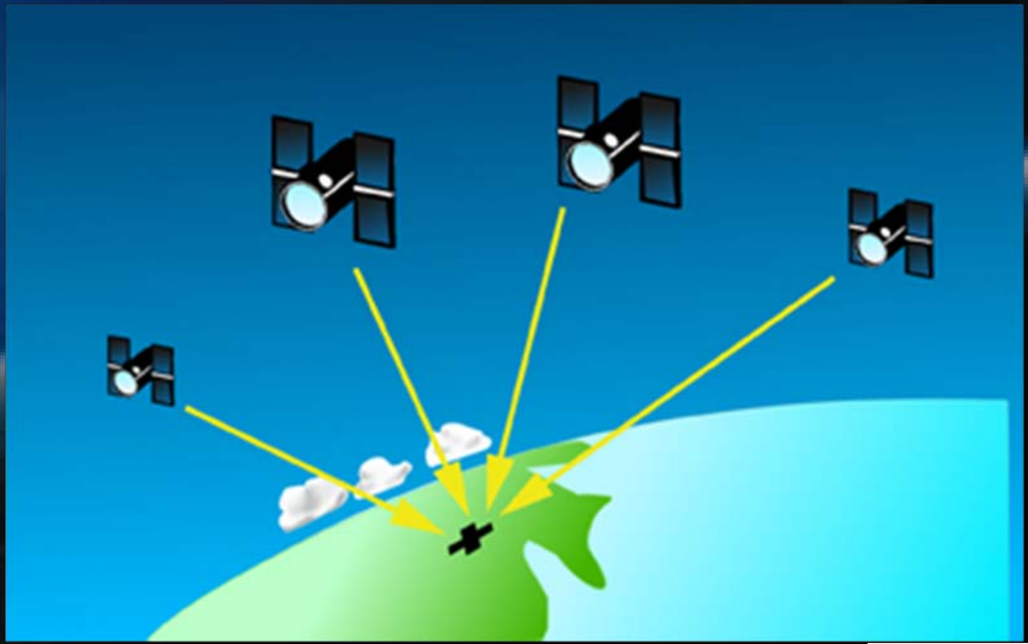
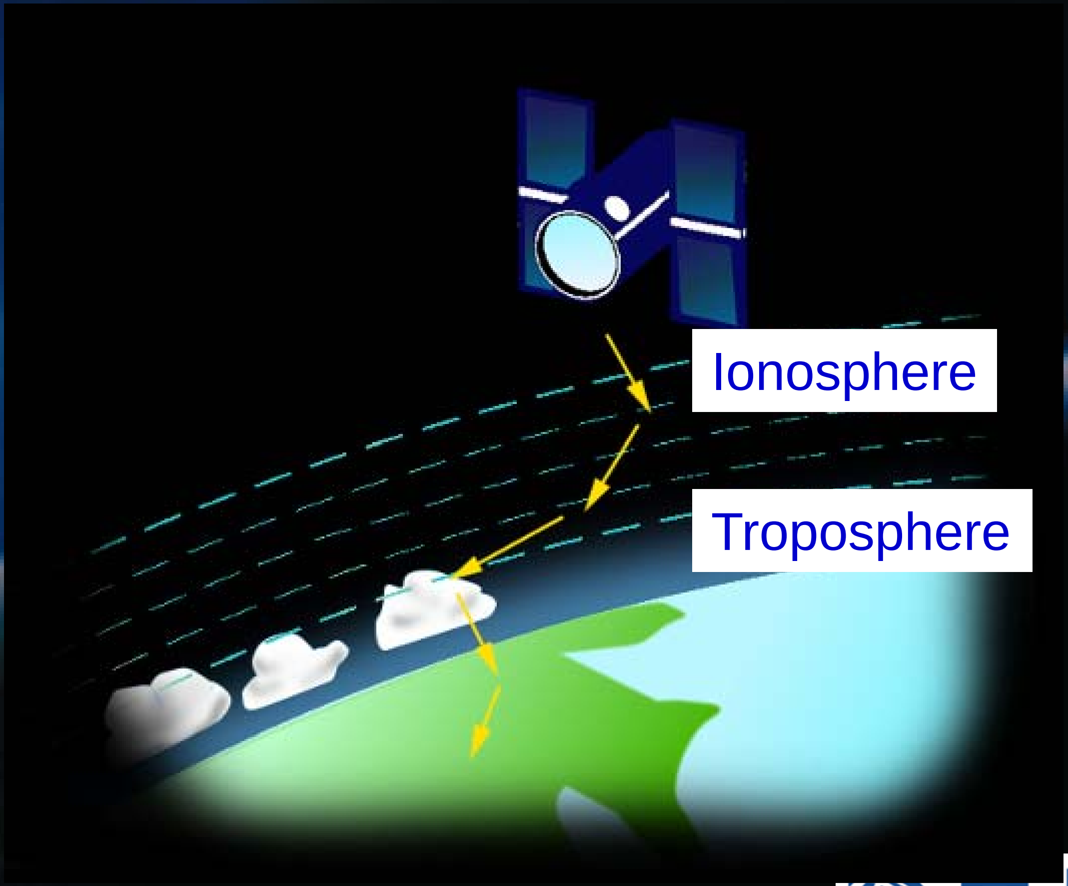
GPS Positioning

- Four distance measurements are needed to determine position and time



GPS Signals

- Troposphere and Ionosphere affect signals

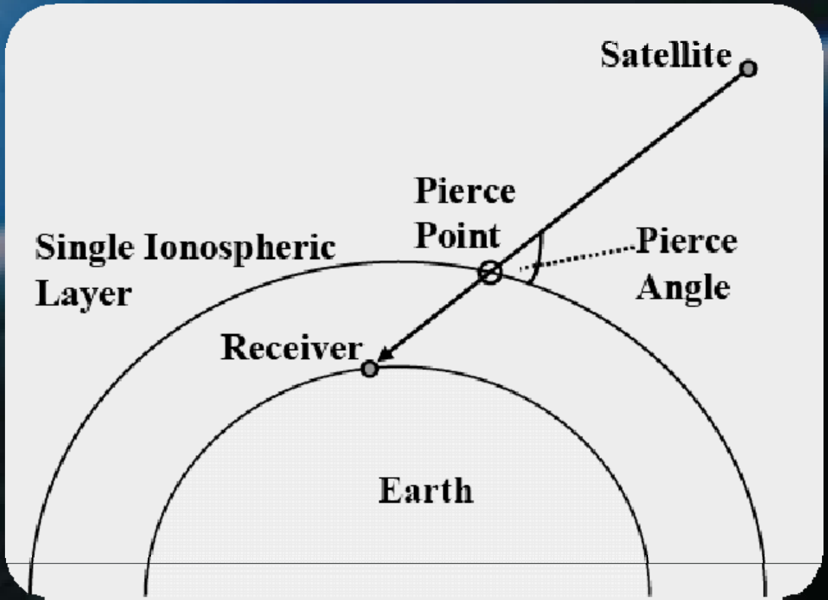


GPS Signals

- Troposphere
  - Region of atmosphere where weather occurs (up to 50-80 km altitude)
  - Wet and Dry component
  - Varies largely based on water vapor content in the atmosphere
  - Frequency independent
  - Affects GPS heights

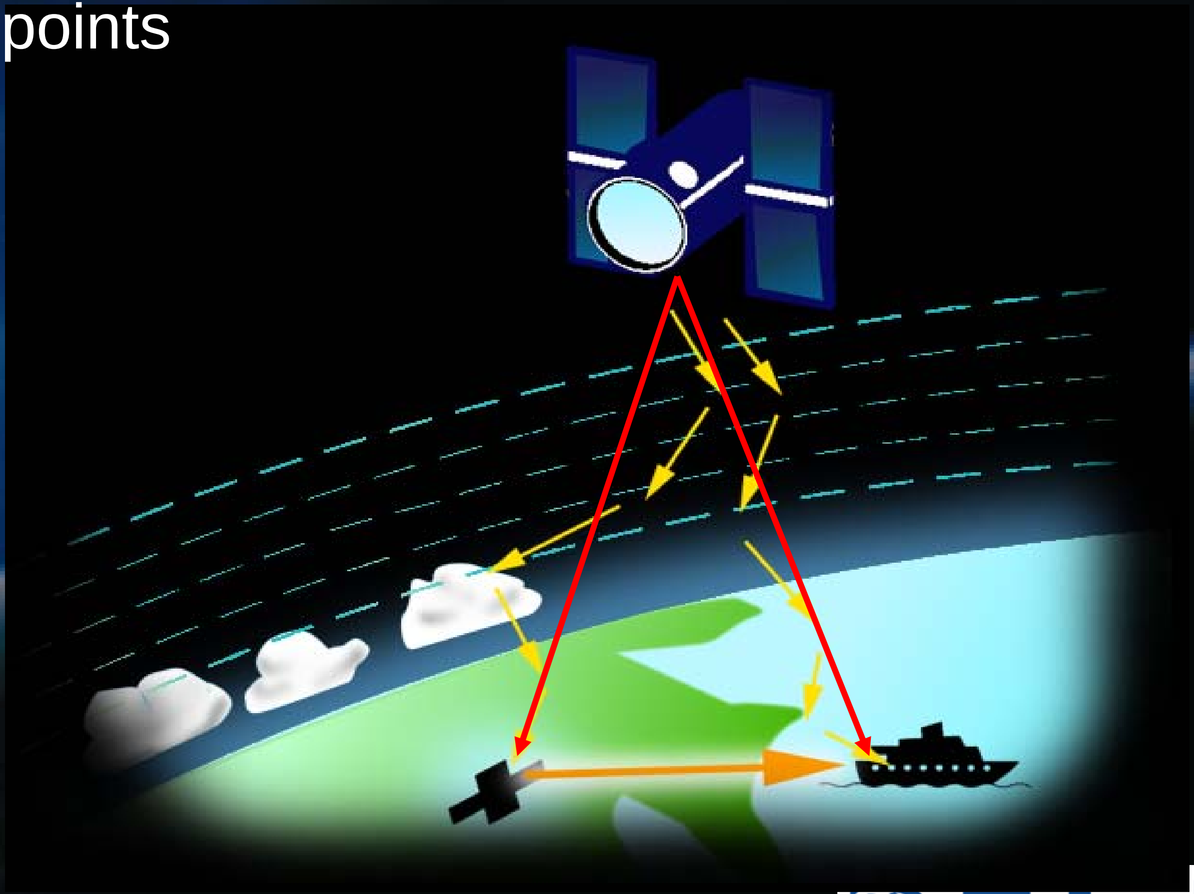
GPS Signals

- Ionosphere
  - Region of atmosphere 50-1000 km filled with charged particles
  - Creates non-linear dispersion of electromagnetic signals (frequency dependent)
  - Varies substantially based on sunspot activity, solar flares, latitude and time of day and elevation of the satellite signal

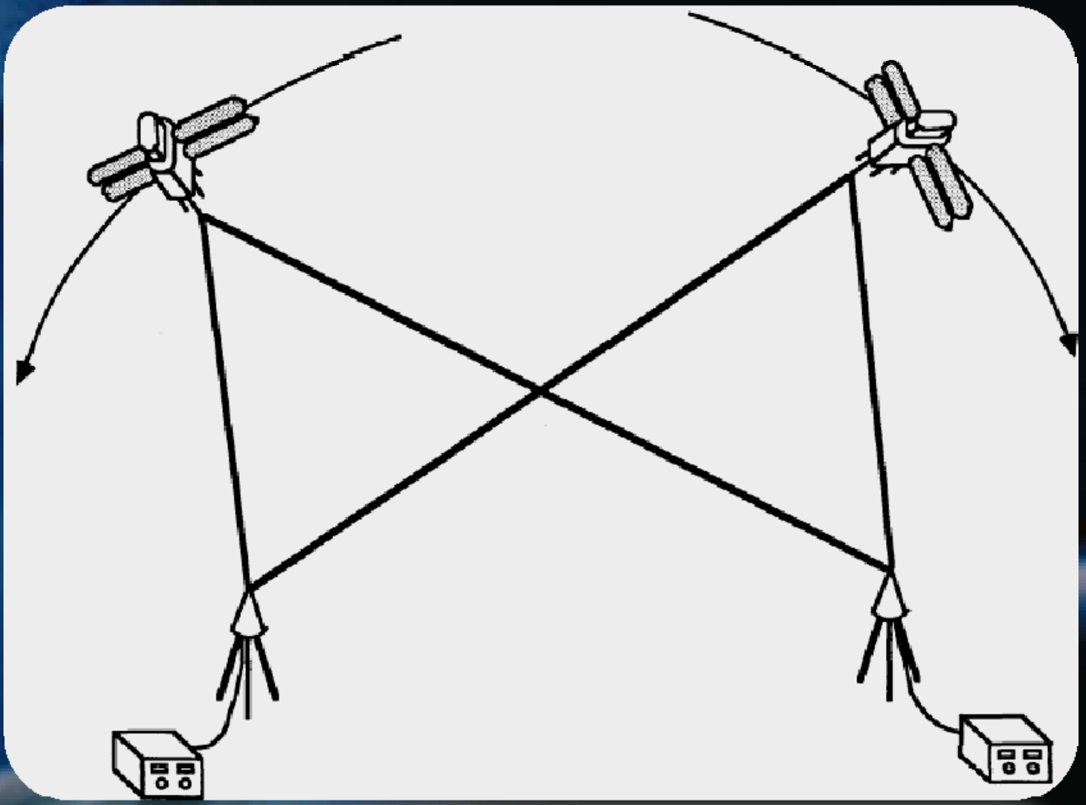


GPS Signals

- Variable signal paths and piercing points



Satellite-Receiver Double Differences



$$\nabla\Delta p = \nabla\Delta\rho + \nabla\Delta d_{ion} + \nabla\Delta d_{trop}$$

$$\nabla\Delta\Phi = \nabla\Delta\rho + \lambda\cdot\nabla\Delta N - \nabla\Delta d_{ion} + \nabla\Delta d_{trop}$$

What do we do about the differential Iono and Tropo errors?

- Keep distances between base and rover short.
  - Assume that the remaining errors are the same at both base and rover
  - Greater the distance is, the less likely this assumption is to be valid

What do we do about the differential Iono and Tropo errors?

- Model the iono and tropo
  - Using observations from known stations, create a model of the biases
  - Concept used for creating the broadcast models for the tracking segment of GPS
  - Concept used for FAA WAAS Augmentation system on a national level
  - VRS Concept

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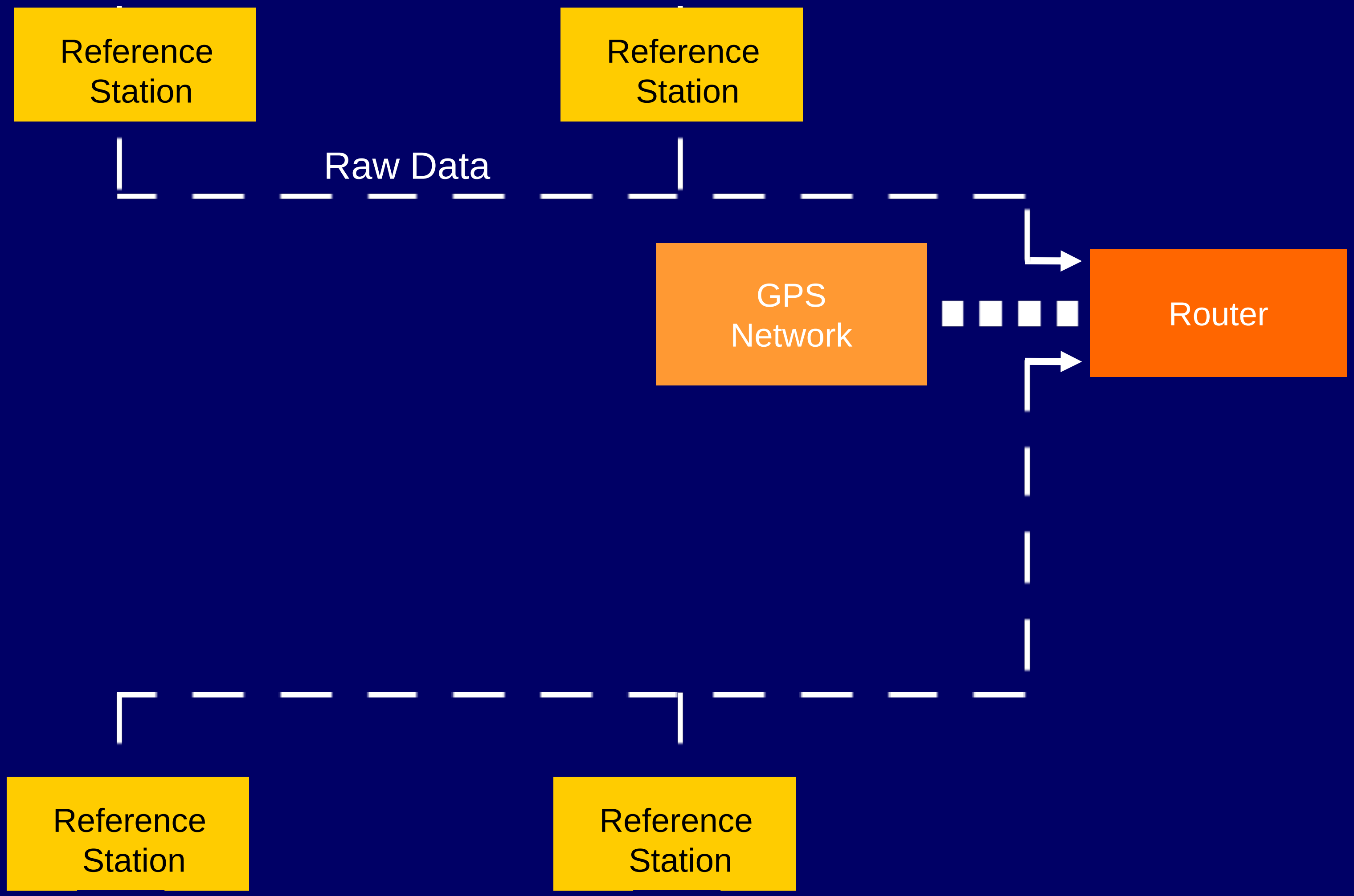
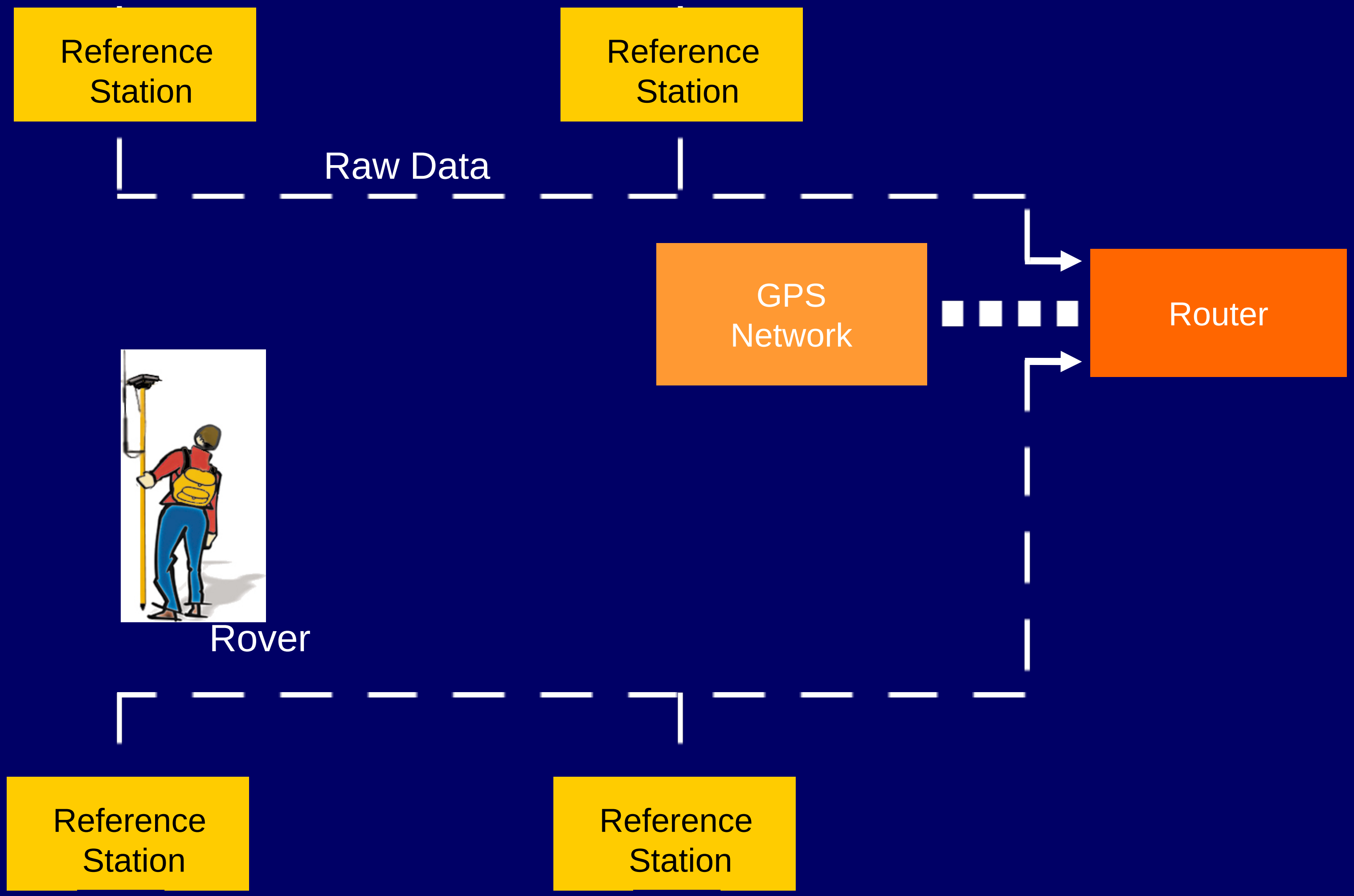
Why use VRS/RTN™ ?

- Extended operating range with improved initialisation and accuracy
- Increased productivity
- Eliminates need to establish reference station
  - Set-up, power, physical security become non-issues
- Provides integrity monitoring
- All users in common, established coordinate frame
- Eliminates dependency on single reference station
- Uses established communications

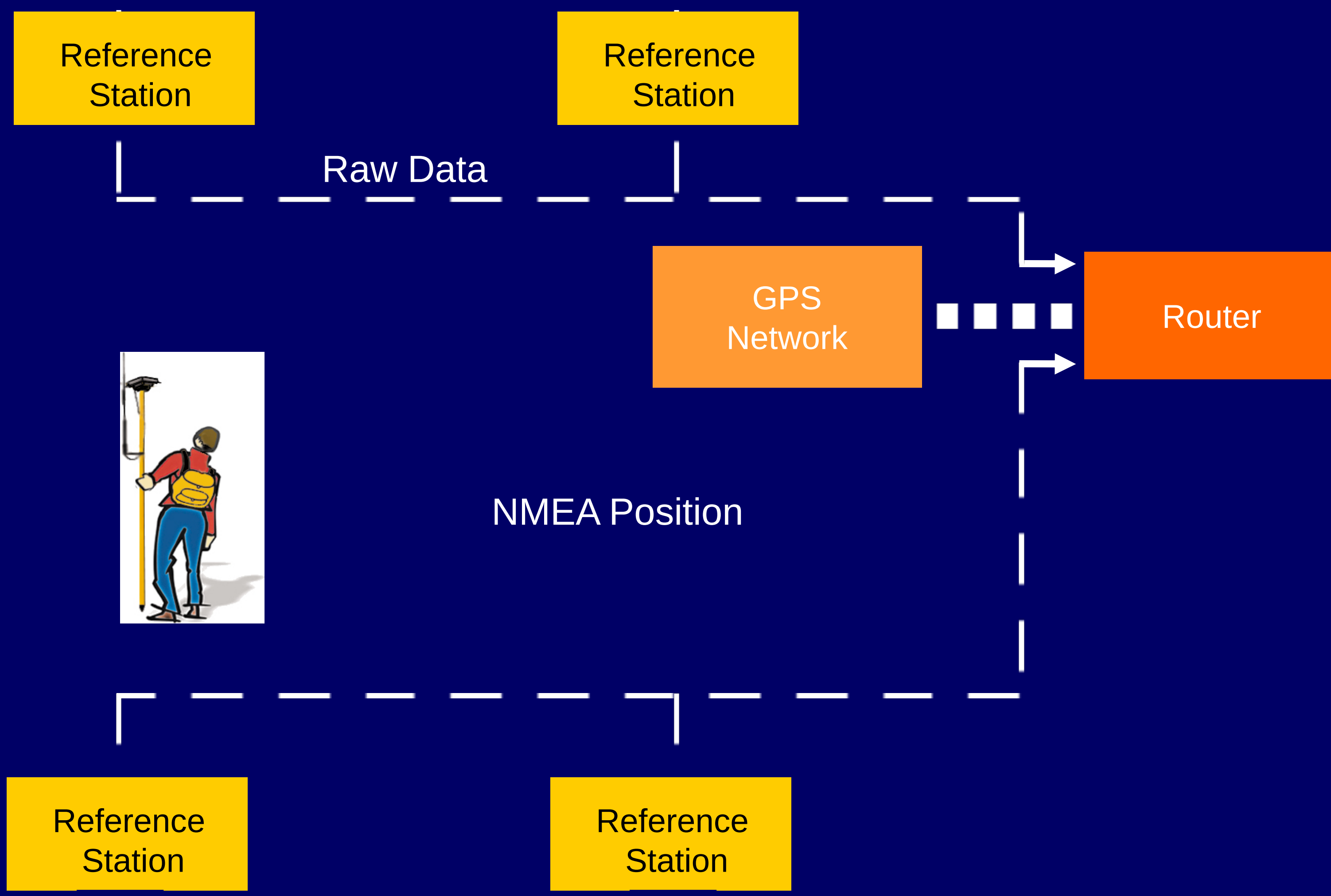
Data Flow in Network using digital cell phone



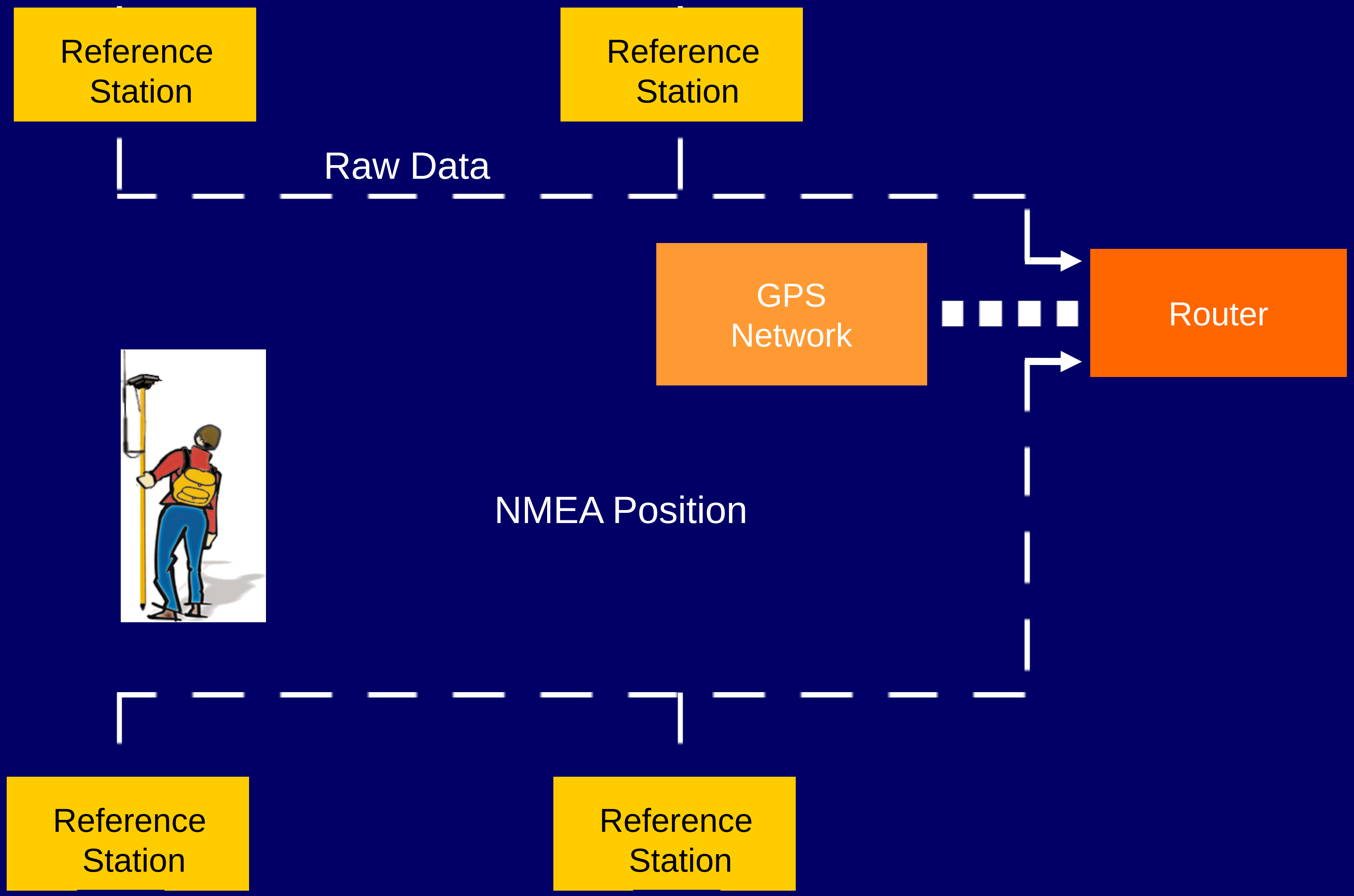
Data Flow in the Network



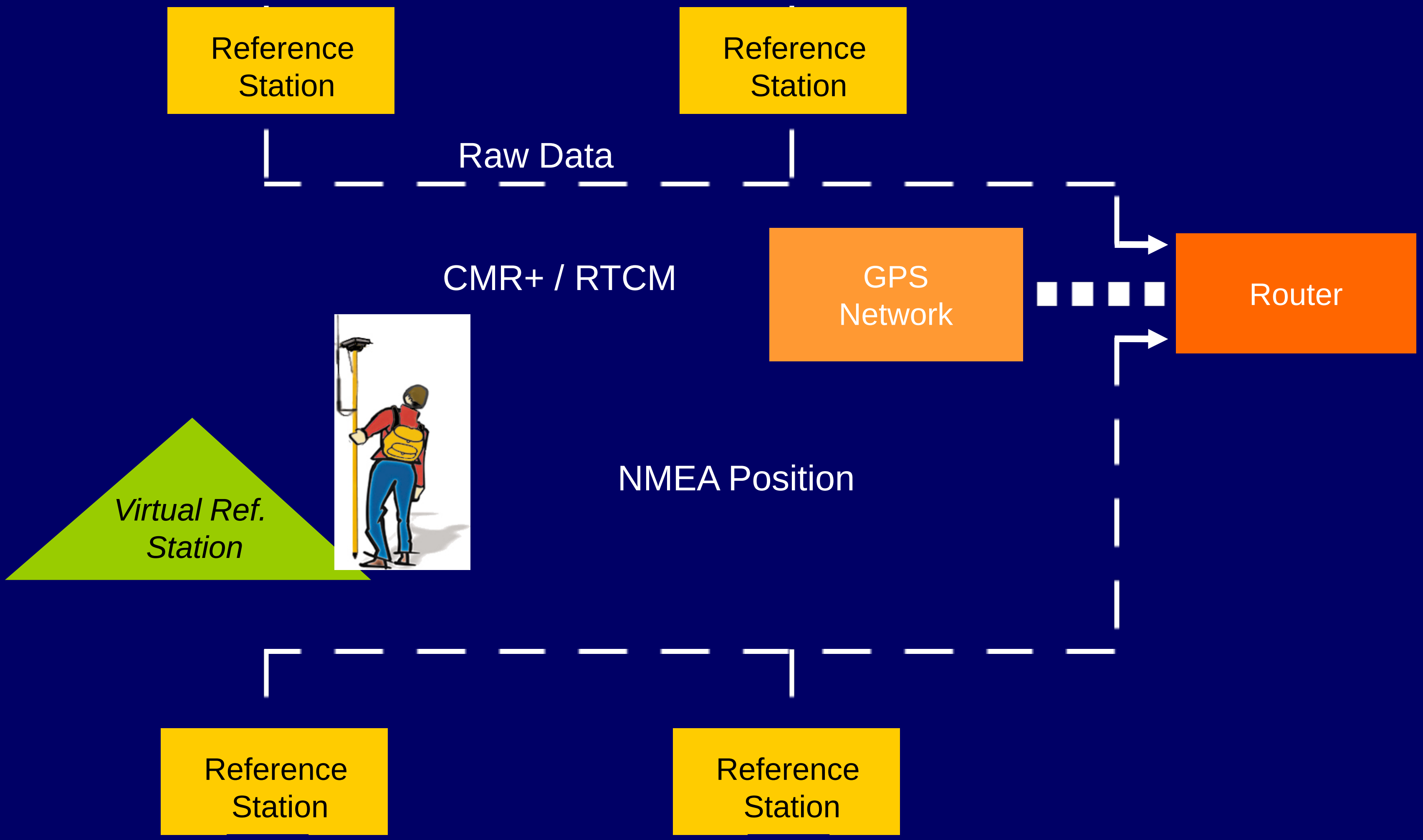
Data Flow in the Network



Data Flow in the Network

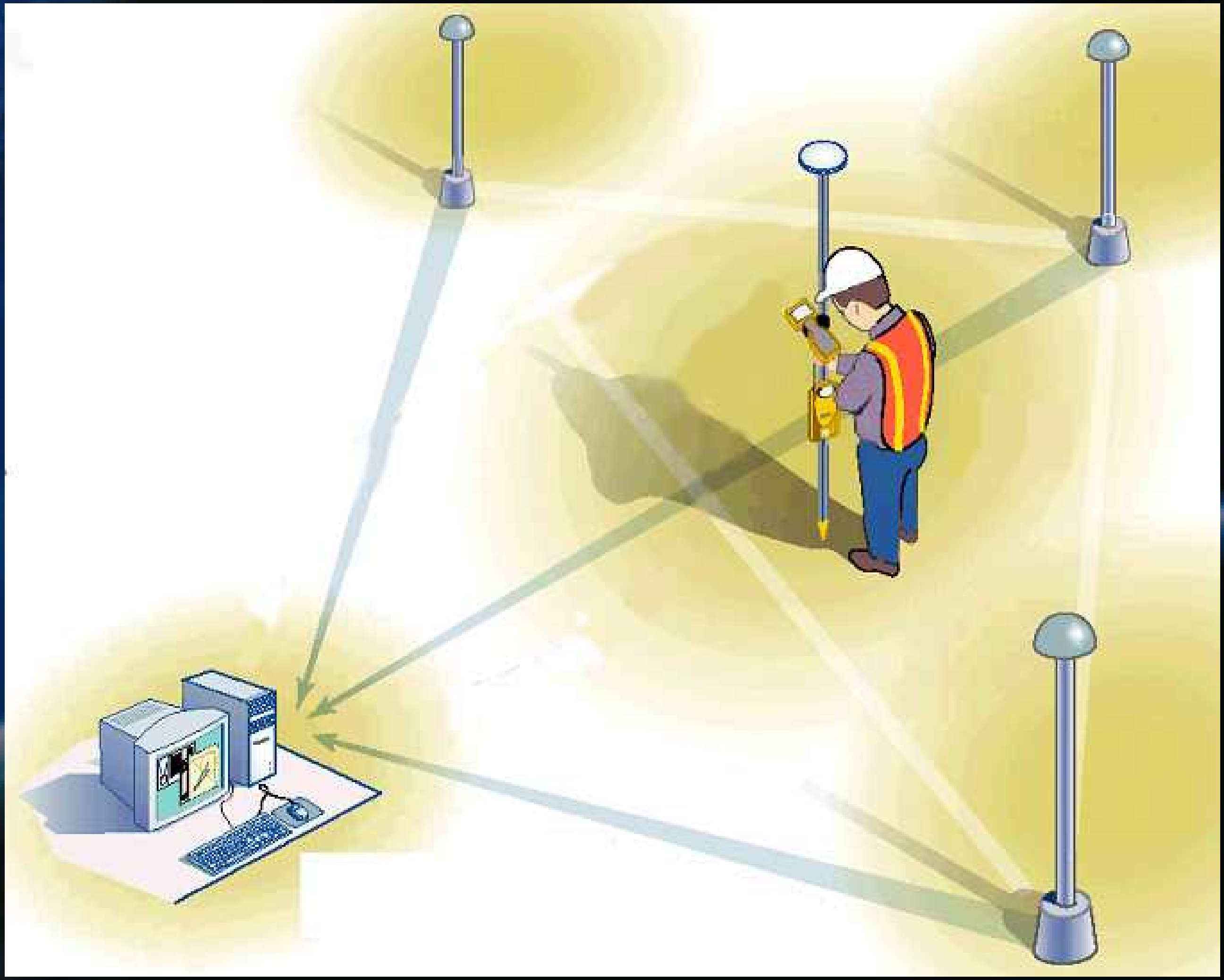


Data Flow in the Network



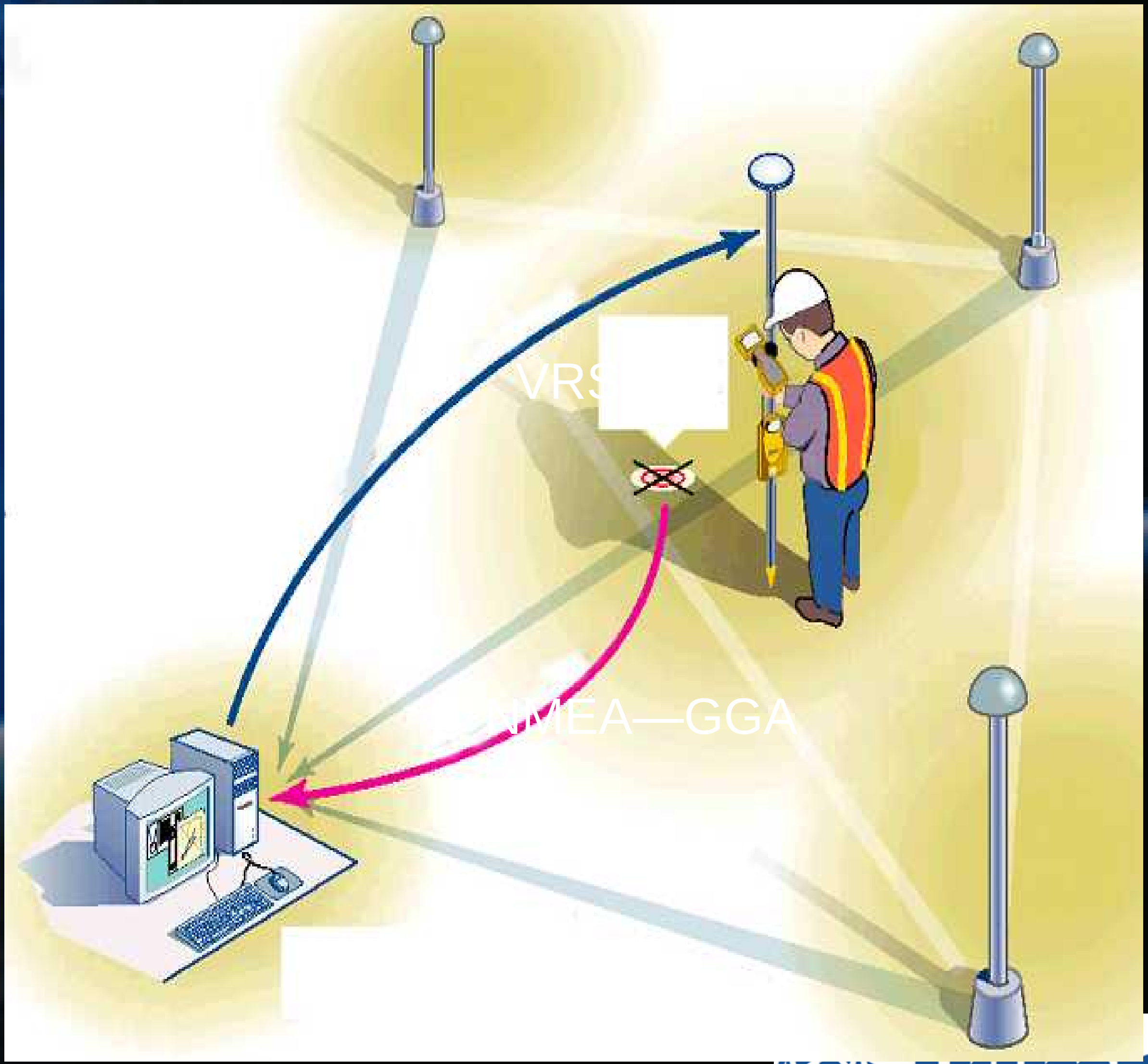
VRS Data Flow

Reference station data streams back to server through LAN, Internet, or radio links



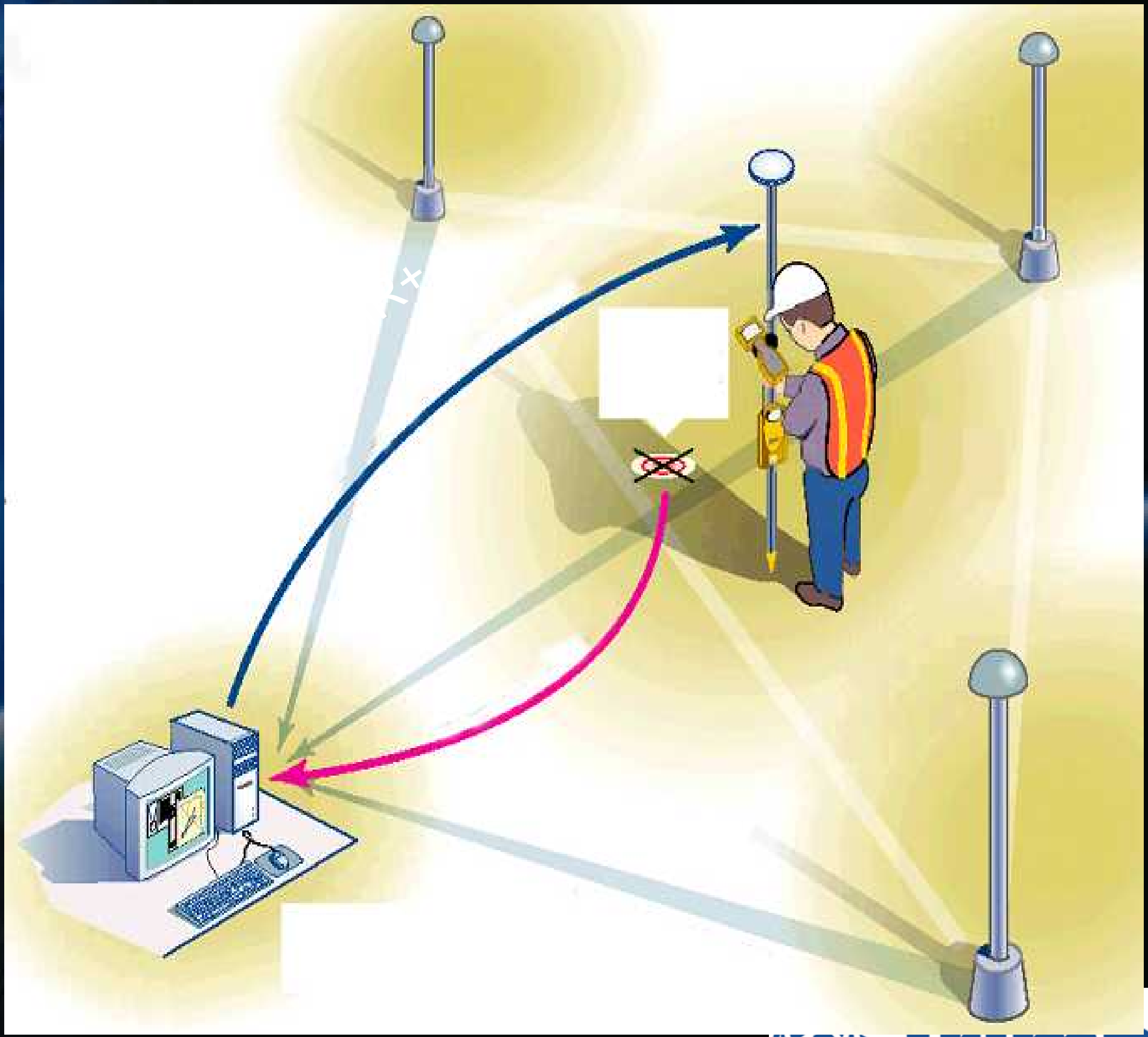
VRS Data Flow

Roving receiver sends an NMEA string back to server using cellular modem. Virtual Reference Station position is established.



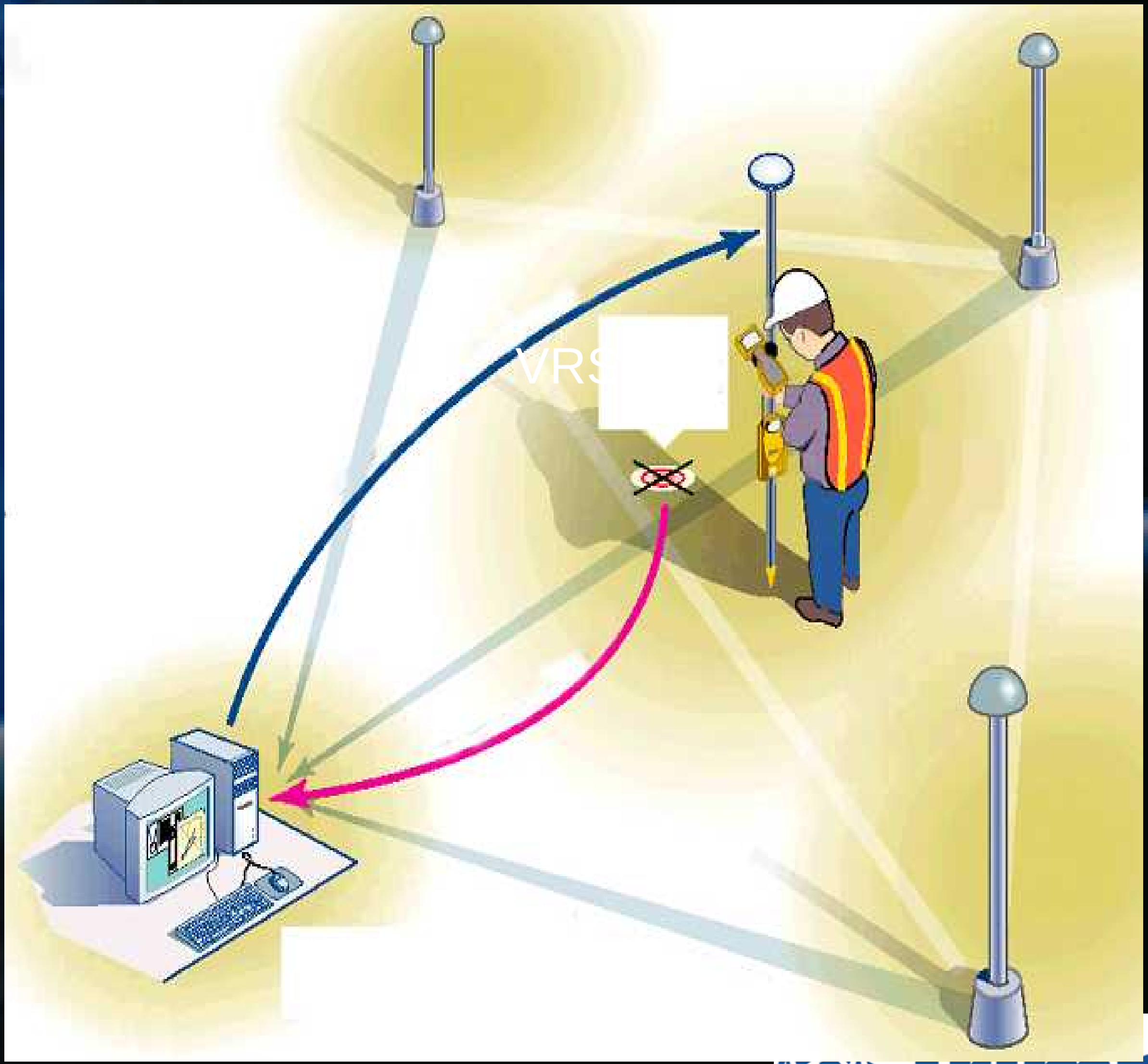
VRS Data Flow

Server uses VRS position to create corrected observables and broadcasts them to the rover

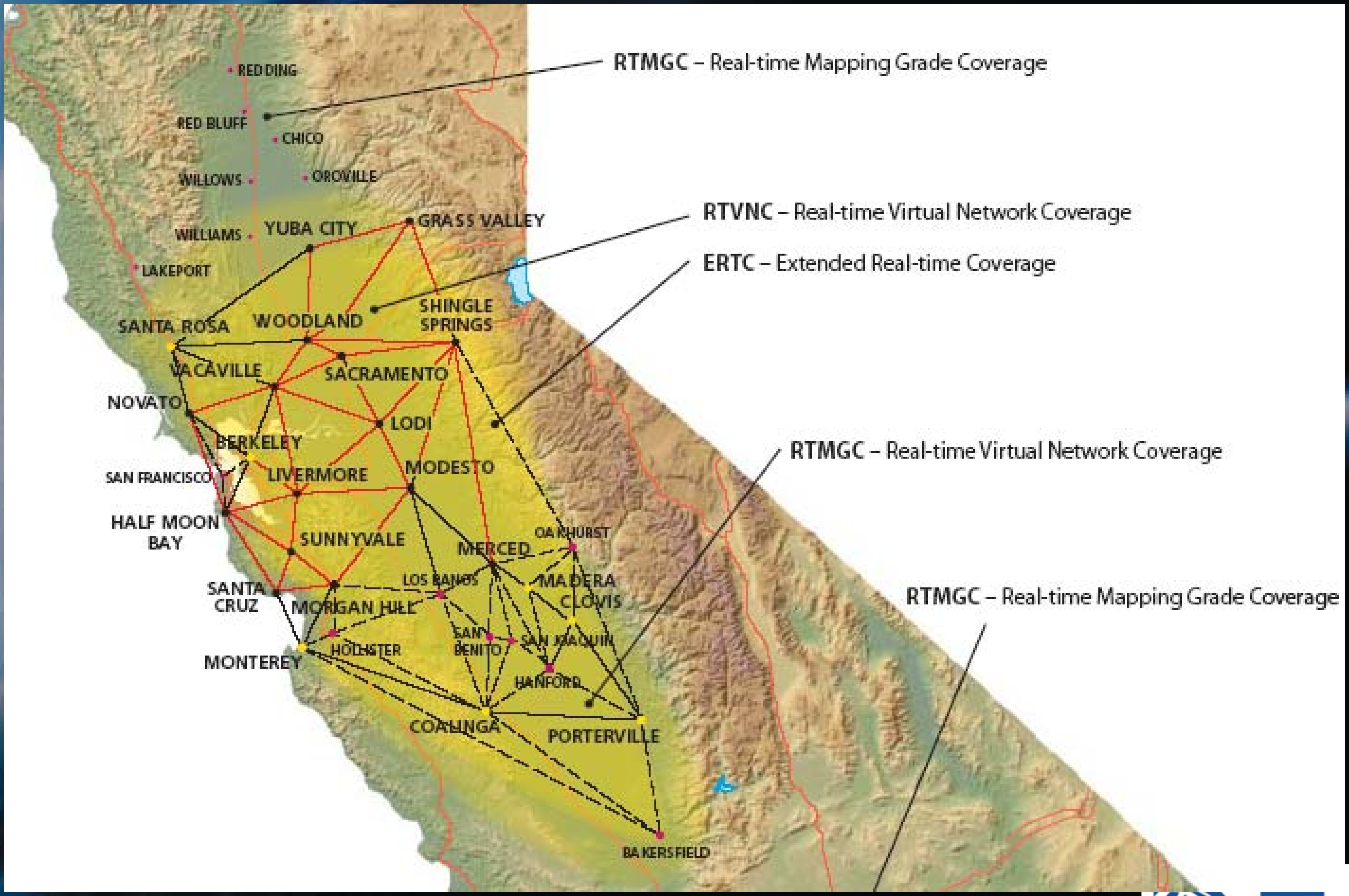


VRS Data Flow

Rover surveying in normal RTK mode but data is relative to the VRS



CSVSN Coverage Map



Full Time Monitoring - 24/7/365

CSVSN: Operation Status: Summary View

Show Operational Status (summary)	Show Alert History	Load scheduler state	Start scheduler	List Disabled Hosts/ Watches/ Svcs	Test Mon Config File
Show Operational Status (full)	Show Downtime Log	Save scheduler state	Stop scheduler	Reload auth file / List Mon PIDs	Reset Mon

This information was presented at 10:44:09 on Friday, 21-Apr-2006 (log in).
The scheduler on **localhost:2583** is currently running. This page will reload every 180 seconds.

Host Group	Service (legend)	Last Checked	Est. Next Check
Auburn	tcp	-4m15s	+43s
Berkeley	tcp	-3m40s	+1m18s
Livermore	ping	-51s	+1m8s
Lodi	tcp	-3m39s	+1m19s
Modesto	tcp	-3m30s	+1m28s
MorganHill	tcp	-4m14s	+44s
PaloAlto	tcp	-3m37s	+1m21s
Sacramento	tcp	-3m29s	+1m29s
SantaCruz	tcp	-4m18s	+40s
SantaRosa	tcp	-4m22s	+38s
ShingleSprings	tcp	-3m49s	+1m9s
Turlock	tcp	-4m19s	+40s
VSNServer	fping	-4m6s	+52s
VSNServer2	tcp	-3m26s	+1m32s
Vacaville	tcp	-4m20s	+39s
Woodland	fping	-4m0s	+58s
YubaCity	tcp	-22s	+37s

Service color legend: (top of table)	Unchecked	Good	Failed (no alerts sent)	Failed (alerts sent)	Disabled

Show Operational Status (summary)	Show Alert History	Load scheduler state	Start scheduler	List Disabled Hosts/ Watches/ Svcs	Test Mon Config File
Show Operational Status (full)	Show Downtime Log	Save scheduler state	Stop scheduler	Reload auth file / List Mon PIDs	Reset Mon

For questions about this server,
contact ed@csdsinc.com

mon.cgi v1.52

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Online Helpdesk

Welcome to the **California Survey Virtual Survey Network Helpdesk**

- Home
- Products
- Support
- Online-Support
- Contact

Logout | Ticket-Overview | New Ticket | FAQ | Preferences

04/25/2006 09:41:09

Welcome Demo User (demo@csvsn.com/csvsn01)

Ticket-Overview

Ticket **1** - **0** of 0 - Site: - (Show closed Tickets)

Ticket#	Age	Subject	State	Queue	Owner
U / D	U / D		U / D	U / D	U / D

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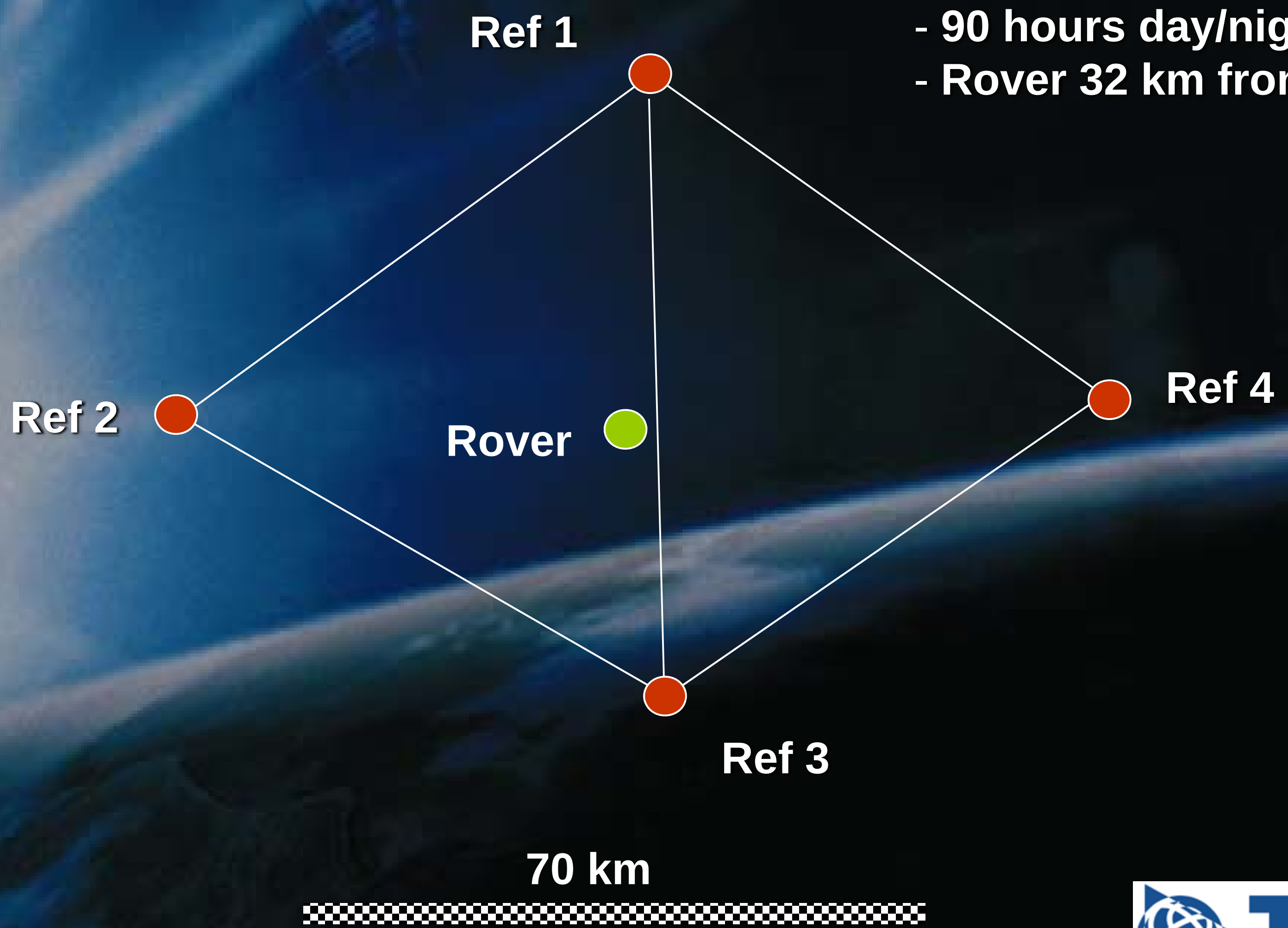
Real-Time Test Setup in the Network

- Operation of rover (32 km from the nearest reference station)
- After each fix the RTK system outputs position data for 30 seconds
- After that the RTK system initializes the ambiguity search again, no data from the past is used
- All position output is stored on an extra PC and analyzed statistically

VRS Performance Analysis

- 90 hours day/night
- Rover 32 km from Ref 3



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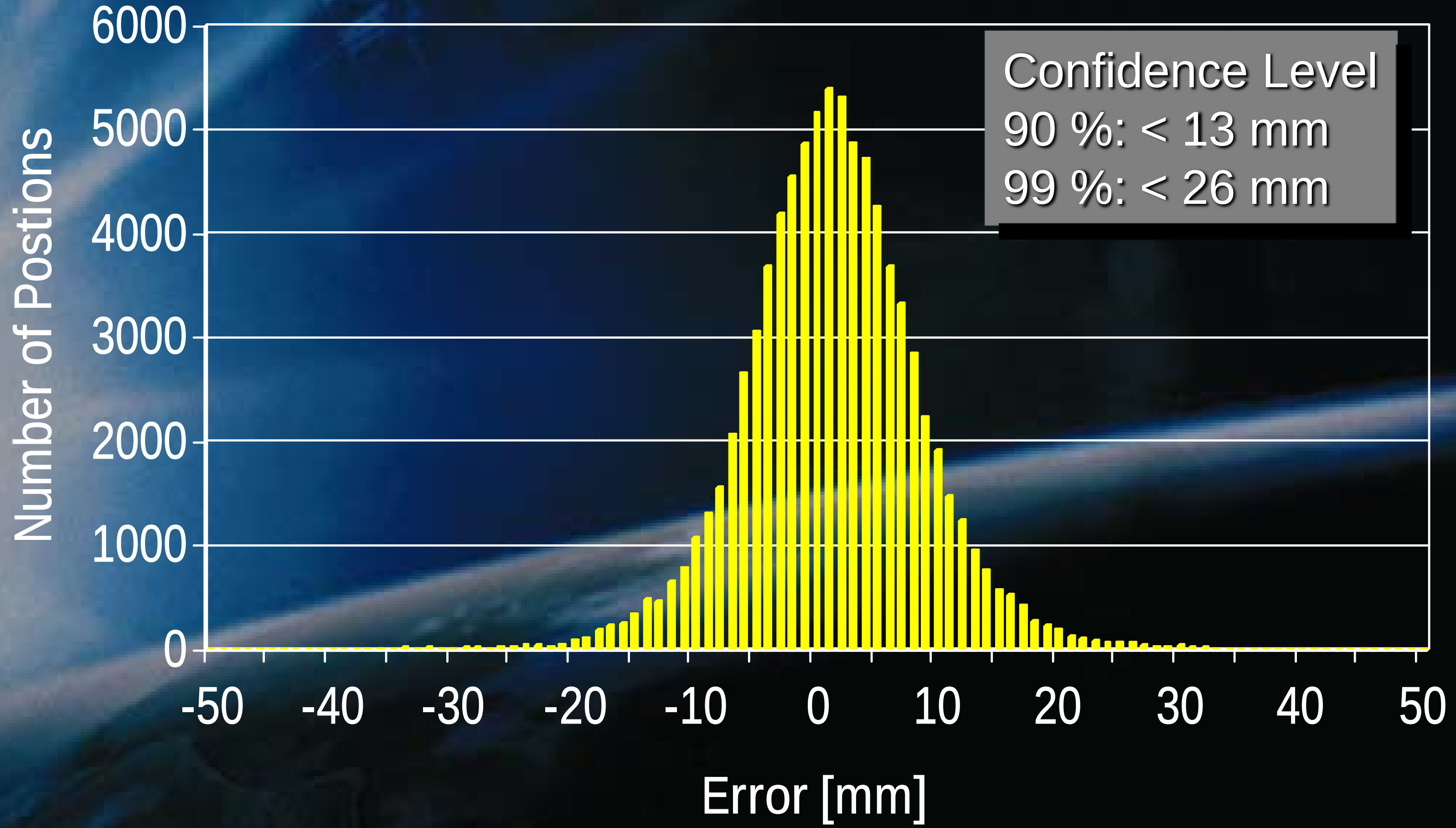
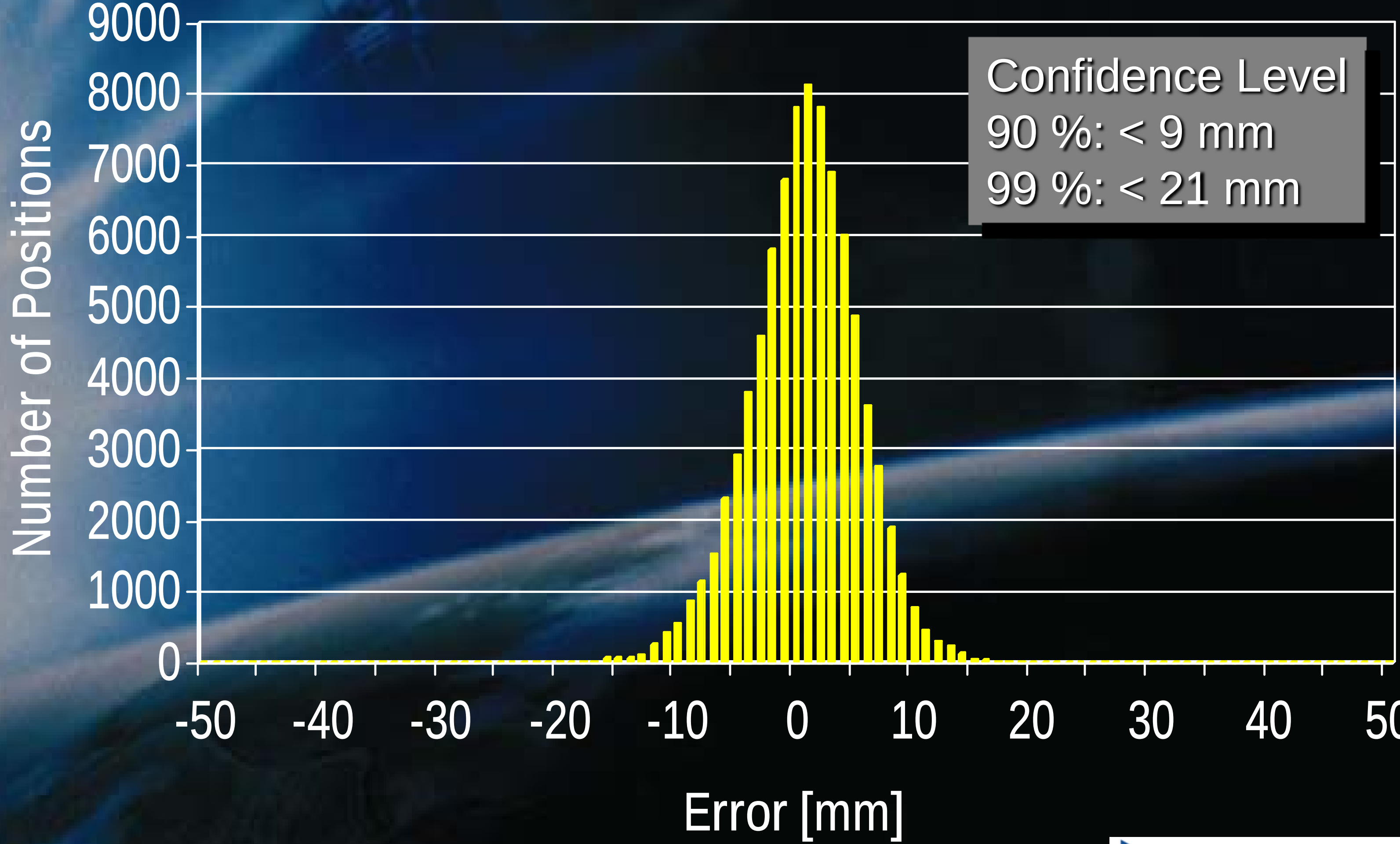
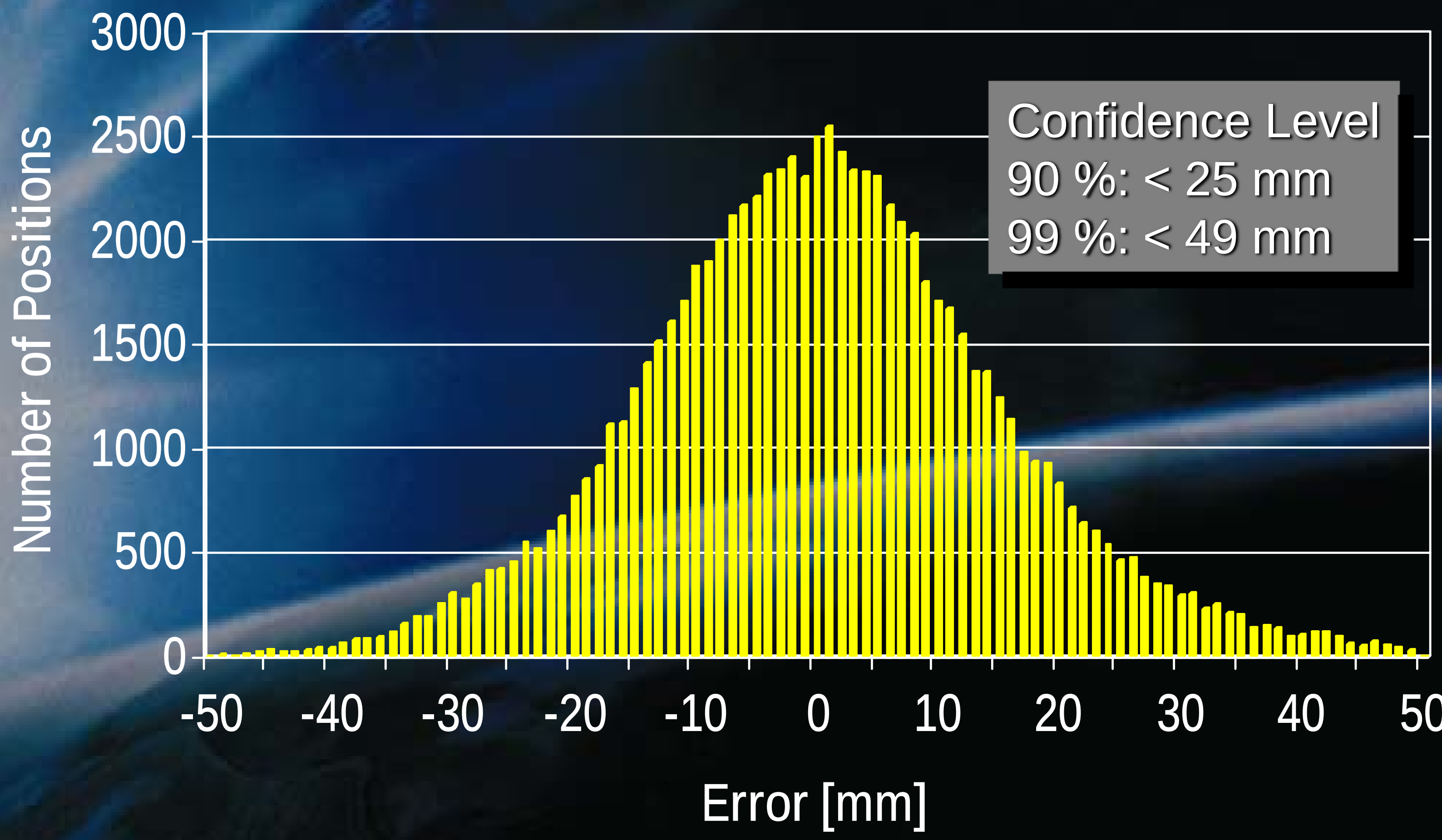
Error in North – 32 km Baseline



Error in East – 32 km Baseline



Error in Height – 32 km Baseline



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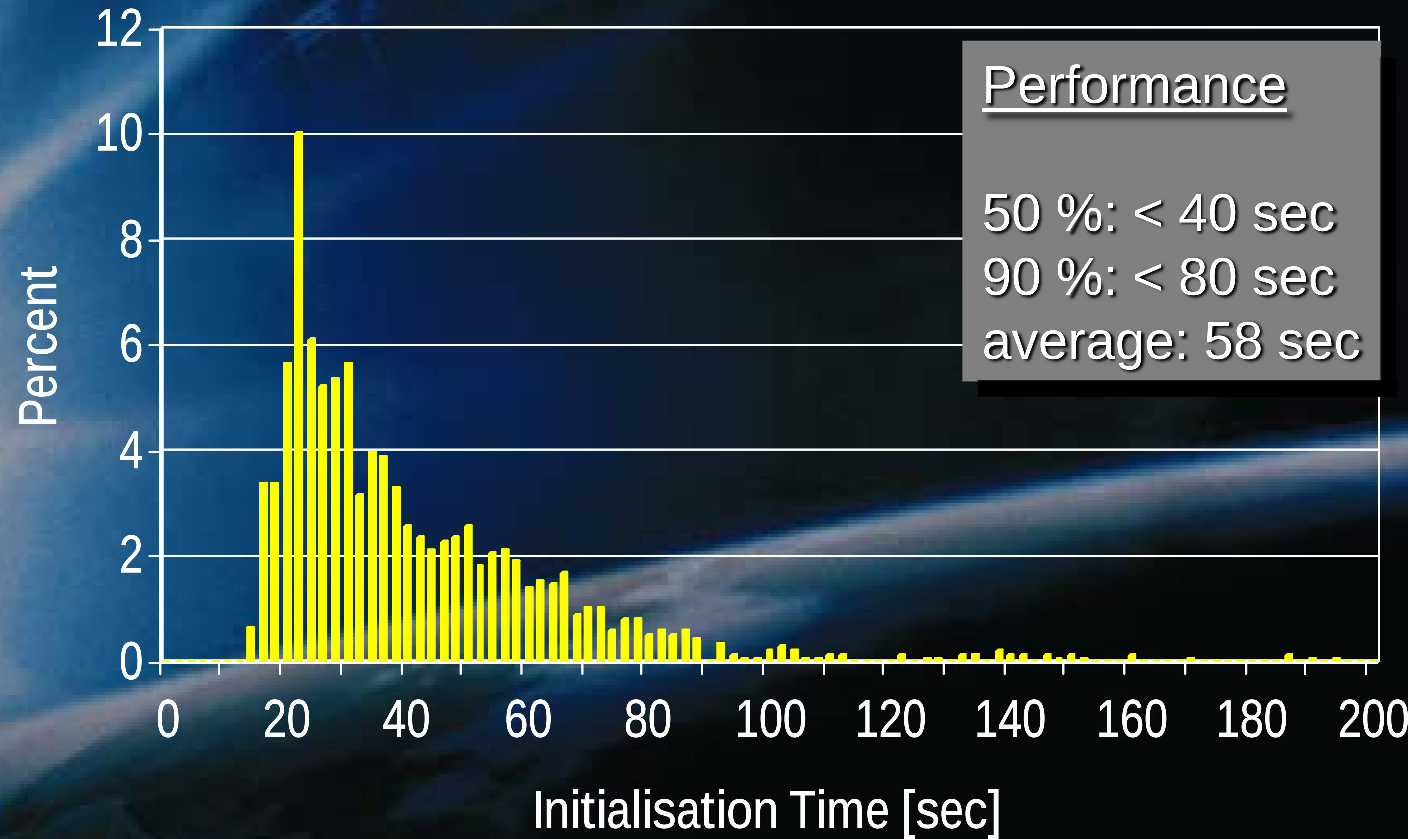
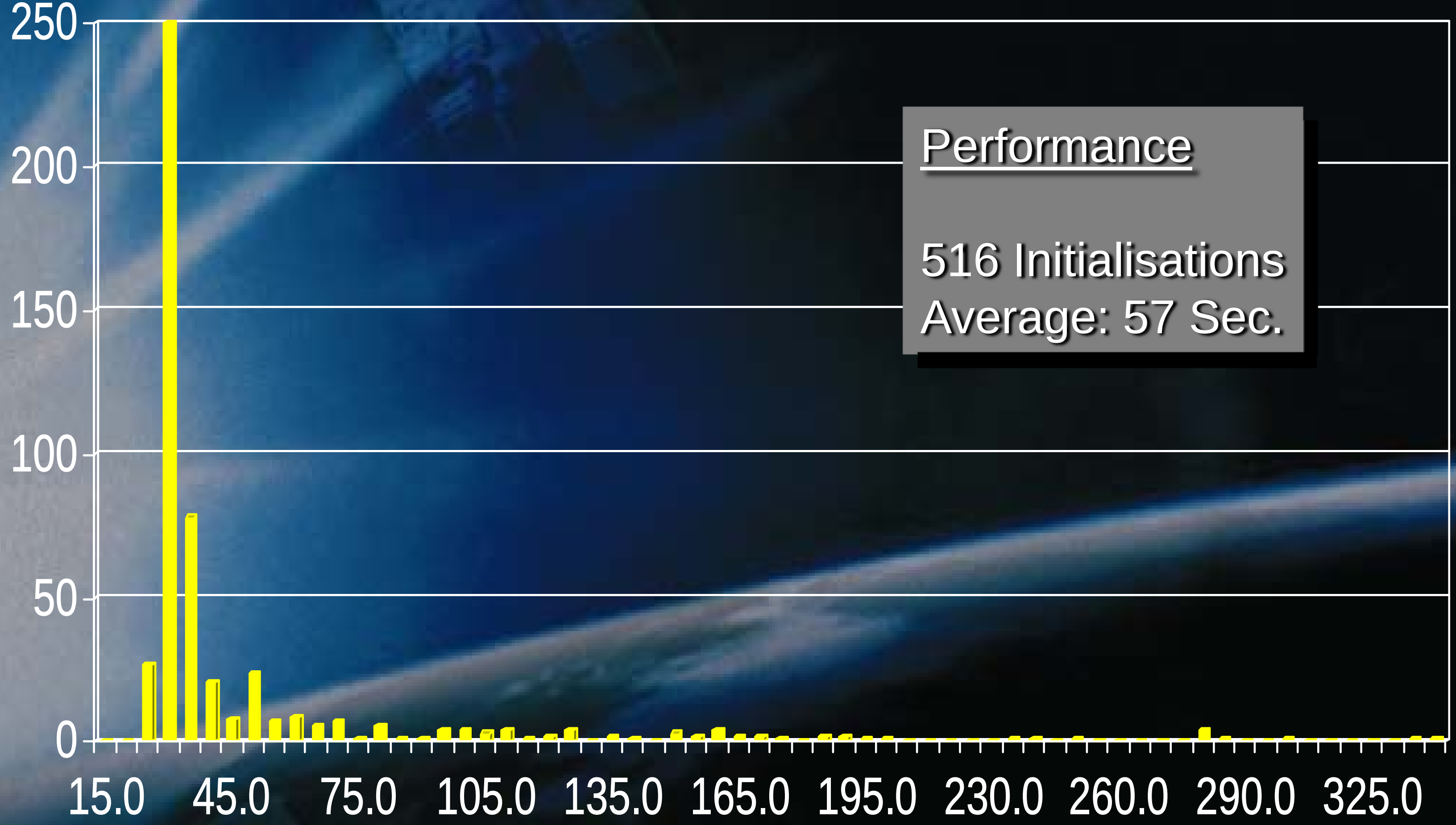
RTK Initialization – 32 km Baseline



Initialisation Times in the SAPOS Network



Advantages of VRS/RTN™

- Extended operating range with improved initialisation and accuracy
- Increased productivity
- Eliminates need to establish reference station
  - Set-up, power, physical security become non-issues
- Provides integrity monitoring
- All users in common, established coordinate frame
- Eliminates dependency on single reference station
- Uses established communications Cellular data

GPS Deformation Monitoring

- Purpose:
  - To monitor and model the movement of man made and natural structures to prevent and warn against potential catastrophes using GPS and integrated sensors.
  - To monitor the integrity of high order geodetic networks

GPS Deformation Monitoring

- Target Markets
  - Oilfield Subsidence
  - Dam deformation monitoring
  - Landslide monitoring
  - Volcano monitoring
  - Geodetic network monitoring