Welcome to Space Geodesy in Saudi Arabia

Saudi Arabia Laser Ranging Observatory **SALRO**

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Saudi Arabian Space Geodesy Program Plan

For

SALRO to became a Global Geodetic Core Station

By means of

Co-locating multiple geodetic instruments, each providing for a different measuring technique allowing for data to be correlated thus providing improved accuracy and integrity

Saudi Arabian Space Geodesy Program

Geodetic Instruments for National and Global Reference Frames, Geodetic Research, Earth Science Studies and Space Exploration

- **L**unar **L**aser **R**anging – **LLR**
- **S**atellite **L**aser **R**anging – **SLR**
- **S**pace **D**ebris **T**racking – **SDT**
- **G**lobal **P**ositioning **S**ystem – **GPS**
- **V**ery **L**ong **B**aseline **I**nterferometry – **VLBI**
- **C**ontinuous **O**perating **G**NSS **Net**work– **COGNET**

Program Active **Future Plans**

Lunar Laser Ranging – **LLR**

*** Function**

The LLR is a geodetic instrument capable of measuring the distance between our Planet Earth and the Moon with a high degree of accuracy

*** Operation**

High energy laser pulses are transmitted to the Lunar surface and reflected back to the LLR-Observatory (Earth Station) from the retroreflector placed on the Moon during the Apollo Space Missions to measure the Time of Flight (TOF)

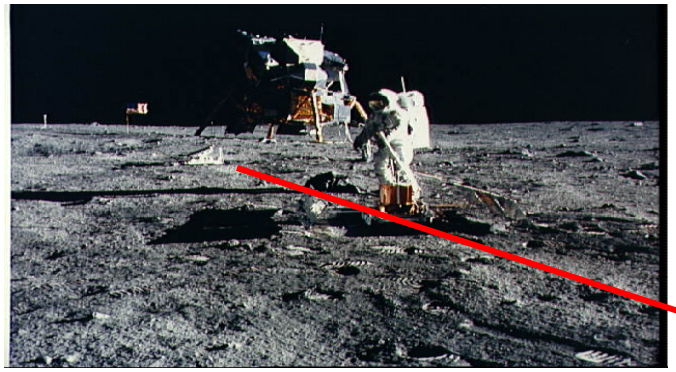
*** Measurement**

The LLR measures the Time Of Flight (TOF) of very short laser pulses traveling from the station to the Moon and back.

Application

LUNAR science, geodynamics, gravitational physics , astronomy and many more

Lunar Laser Ranging – LLR



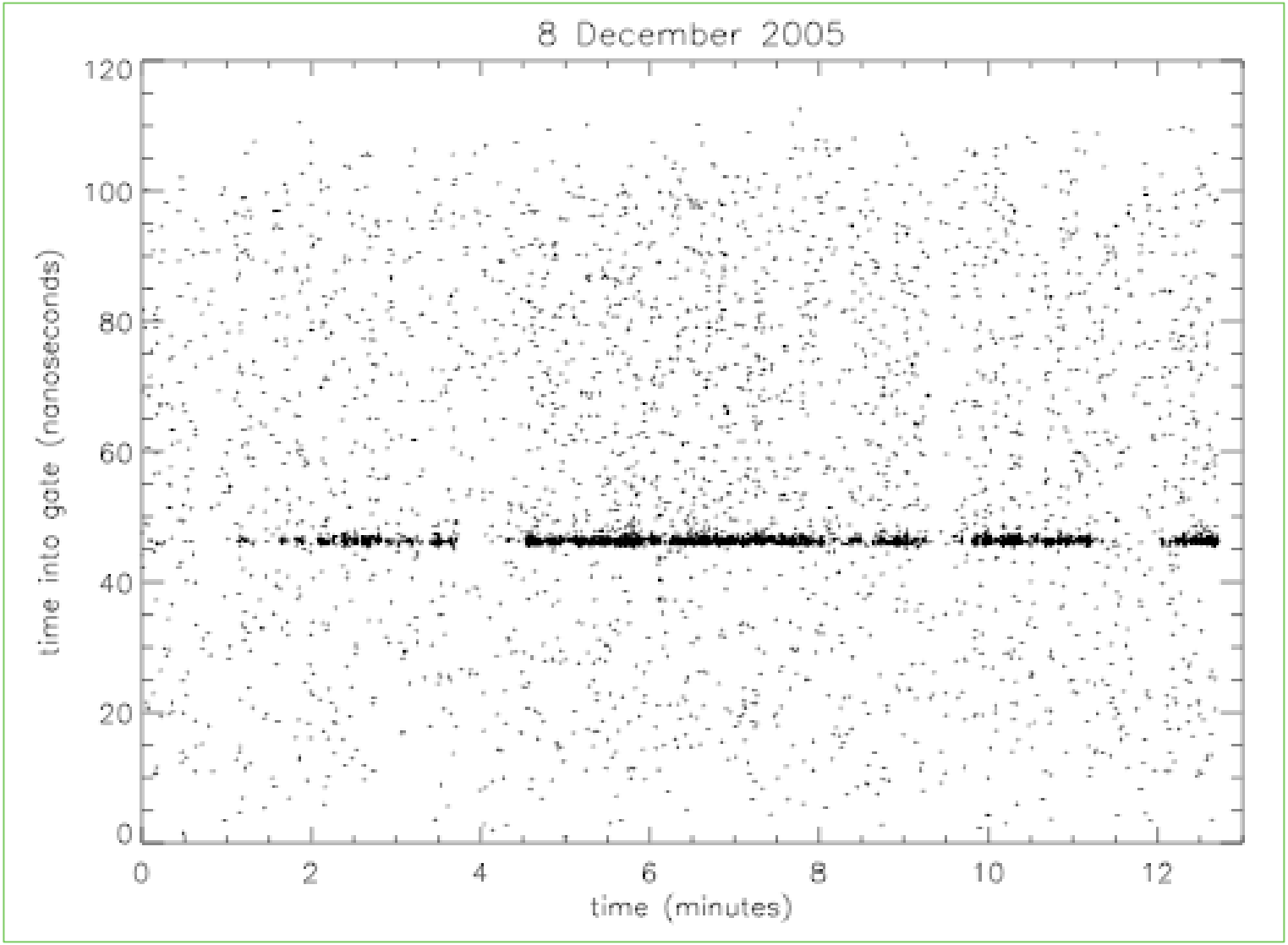
NASA photo of Apollo Mission

Laser Ranging Retro-Reflector

Picture of an LLR Observatory in New Mexico ranging to the Moon

The distance between the Earth and the Moon is calculated with a high degree of accuracy from the TOF Equation: ***d = c x t / 2***
d *distance,* ***c*** *formula for speed of light and* ***t*** *round-trip of time of flight*

Plot: LLR return signals



Credit: The Apollo Lunar Ranging Collaboration

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Satellite Laser Ranging – **SLR**

*** Function**

The SLR System is an instrument that forms part of a global network of stations measuring the orbital paths of geodetic satellites

*** Operation**

SLR transmits short laser pulses to geodetic satellites orbiting the Earth as they pass through the SLR Station field of view, these pulses are then reflected back from the satellites to the SLR System for Time Of Flight (TOF) measurements

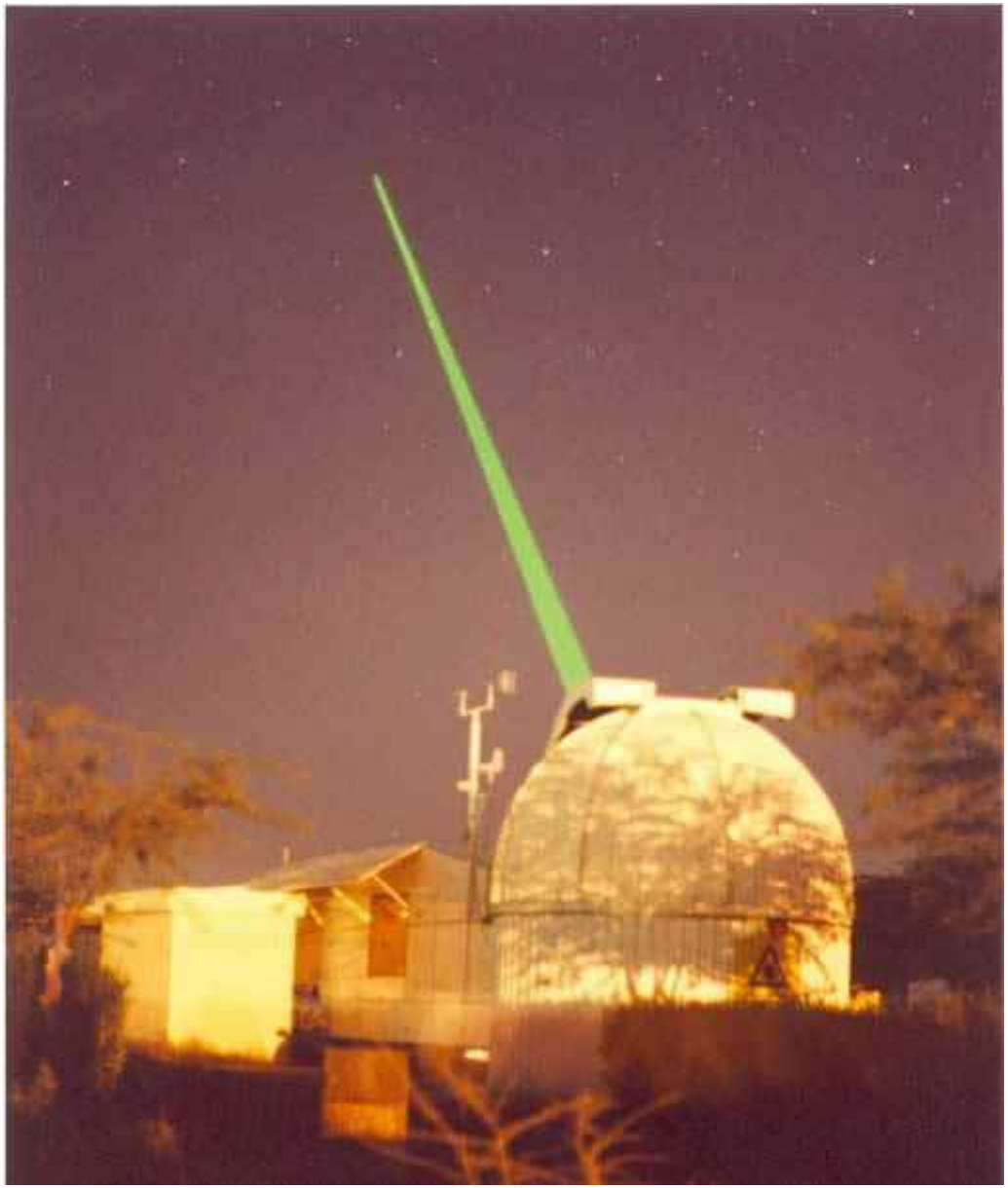
*** Measurement**

TOF measurements are used to compute instantaneous range measurements to satellites with sub centimeter accuracy

*** Application**

Planetary Geodynamics supporting the International terrestrial reference frame (ITRF), scientific studies of the Earth its atmosphere and the oceans

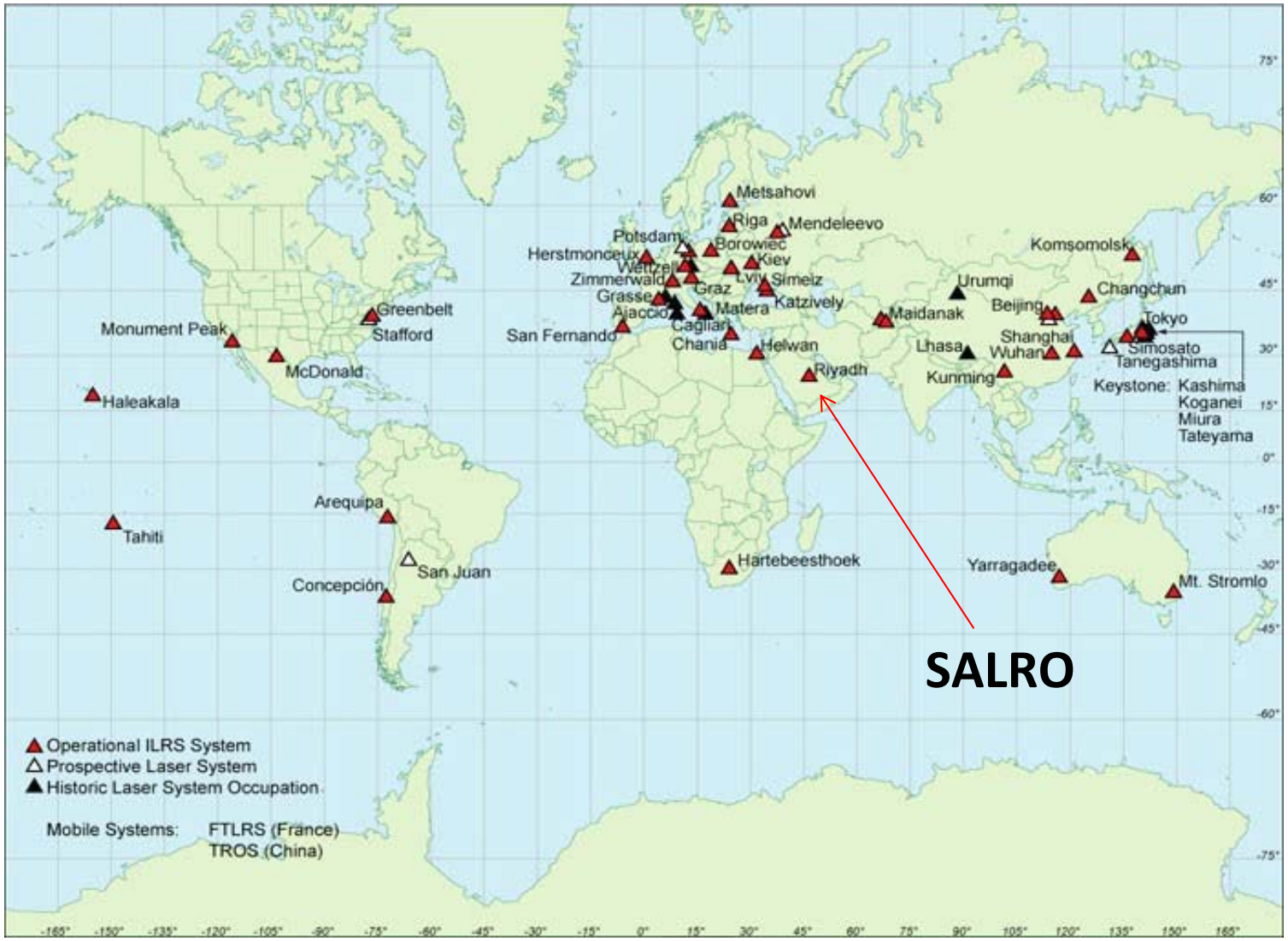
SALRO ranging to satellite in orbit



What appears to be a continues laser beam is actually a train of very short pulses of less that 200 pico seconds

The exact time of each pulse leaving the station and returning back is measured to determine the time of flight that is used to determine the distance between the station and the satellite

Global Network of SLR Stations



Saudi Arabian Space Geodesy Program

Space Debris Tracking – SDT

*** Function**

The Space Debris Tracking System is an instrument able to detect, identify and track space debris objects orbiting our Planet

*** Operation**

Different techniques are used for debris tracking: Like Space Optical Image Tracking, RADAR Tracking and LASER Tracking. Saudi Arabia is planning to make use of a Multimode LASER Tracking System

*** Measurement**

Different measuring techniques are used, with a multimode laser tracking system installed (SDT, LLR and SLR) Saudi will benefit from significantly enhanced data quality and integrity by correlating data obtained from the multiple techniques referenced to the same reference position (Monument)

*** Application**

To identify and track space debris (natural and man made) and to catalogue them in support of current and future space programs , space exploration and efforts to remove the debris

Satellites and Debris orbiting the Earth

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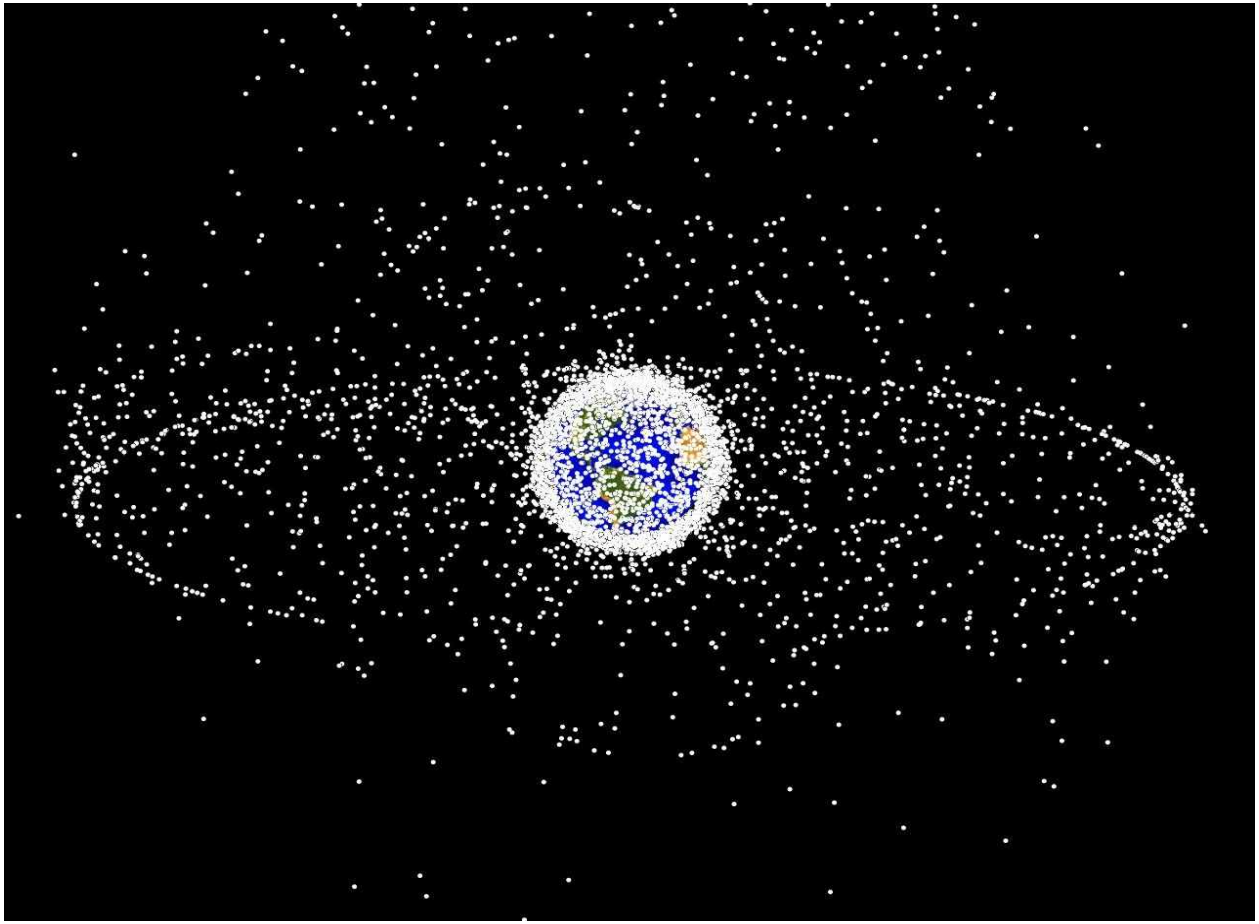
View from outside geosynchronous orbit



Natural Debris:
Small pieces of meteorites, coming from our solar system and originate from asteroids and planetoids orbiting the Earth

Artificial Debris:
Man-made objects like remains of spacecrafts, their payloads and hardware including fragments from collisions

Global **P**ositioning **S**ystem – **GPS**

*** Function**

A constellation of satellites that provides for radio signals to GPS receivers enabling them to calculate their positions

*** Operation**

GPS signals are received by the receivers, they processed these signals to determine their location in three dimensions

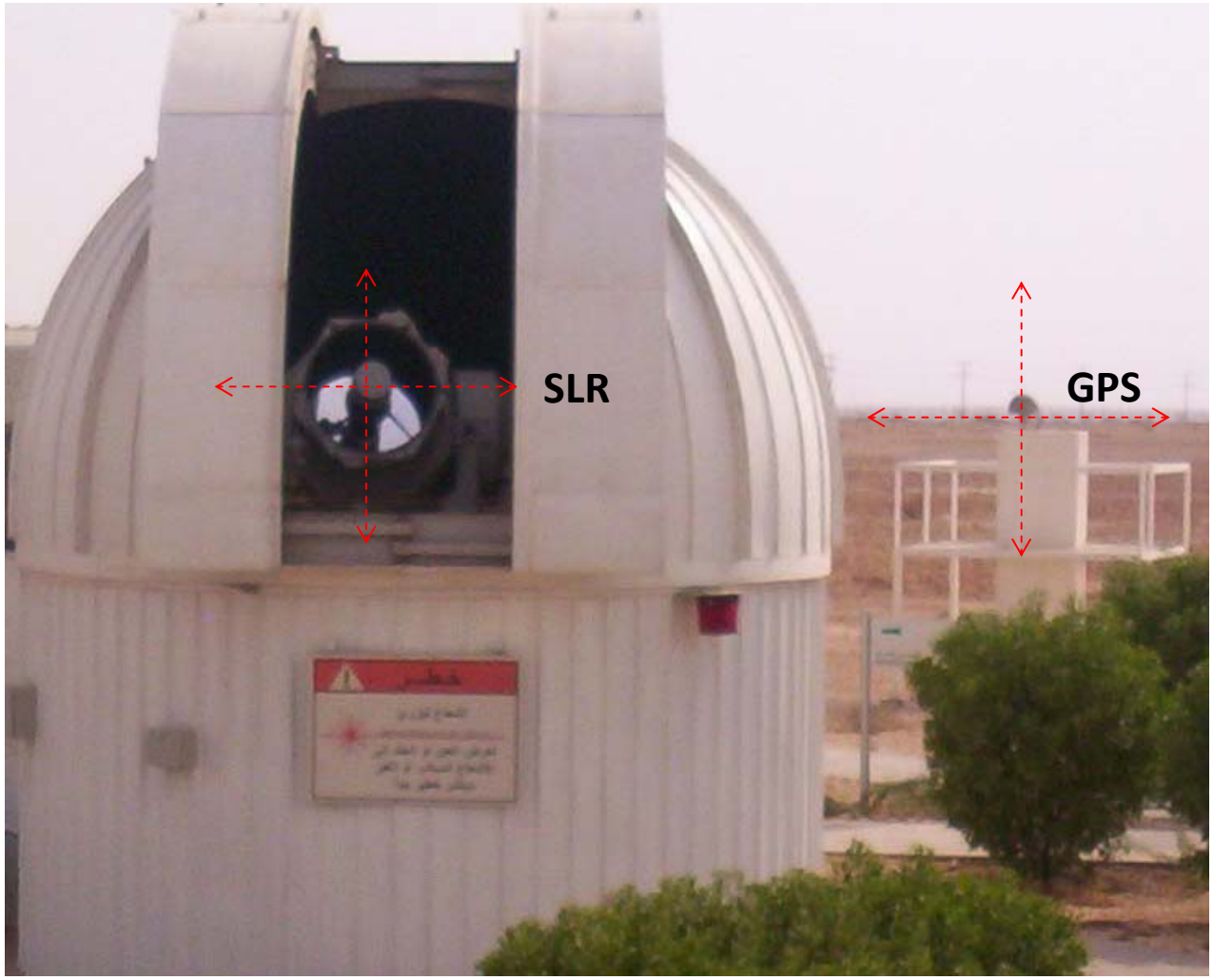
*** Measurement**

GPS satellites are equipped with high accurate timing systems synchronized to facilitate simultaneous transmission of position information. This information arrive at the at the GPS receiver at slightly different times. The receiver then measures and compute the phase relationship of these signals to determine its position with a high degree of accuracy

***Application**

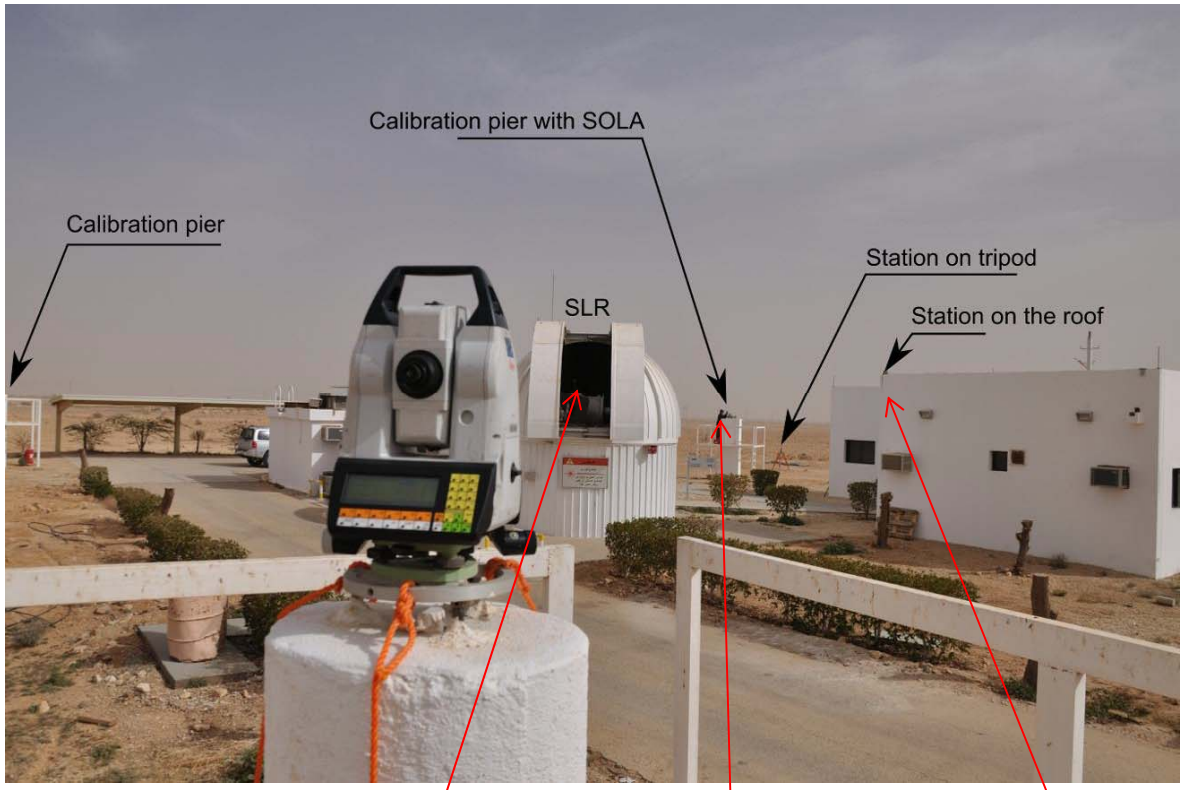
Navigation, Global terrestrial reference frame, mapping, monitoring of geodetic reference monuments, tracking and guiding of moving objects and many other geodetic applications

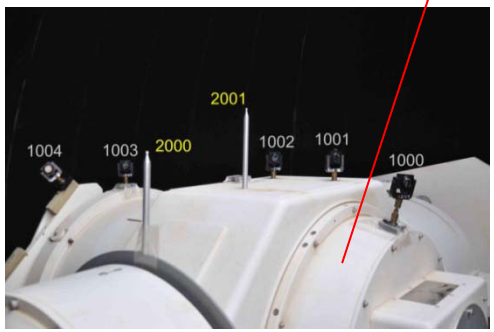
Geodetic Instruments co-located at SALRO

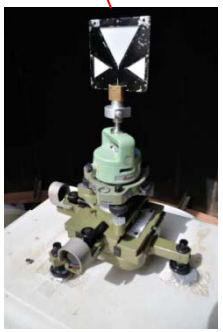


Co-locating of space geodesy instruments adds value to the integrity of the data produced

SALRO-IGN “Tie-in” (*Surveying Mission 2012)*







Monuments, benchmarks and calibration piers have been surveyed with a high degree of precision as part of the “tie-in” solution for the SALRO co-located SLR and GPS (SOLA) instruments

Very Long Baseline Interferometry – **VLBI**

*** Function**

The VLBI System is a radio telescope (Astronomical Interferometry Instrument) that allows for image observation of distant cosmic radio sources

*** Operation**

When the VLBI data is correlated with data collected from other Radio Telescopes simultaneously recorded they produce an image size of equal to the maximum separation between the telescopes serving as one giant telescope

*** Measurement**

VLBI Systems have very accurate timing systems typically hydrogen maser clocks to facilitate accurate measurements of the time differences between the arrival of cosmic radio sources (phase angle of the radio waves) at the separate observatories

*** Application**

Radio Astronomy, tracking of spacecrafts and many space geodesy science applications

VLBI observing a point source *(Extra Terrestrial Radio Signal)*

Extra terrestrial radio emissions comes from a variety of sources like the Sun, the Galactic center, Supernova, Pulsars, Quasars and many more objects in outer space

Saudi Arabian Space Geodesy Program

Continuous **O**perating **G**NSS **Net**work– **COGNET**

*** Function**

COGNET is a network of GPS receivers that measures the differential positioning of various fixed terrestrial reference points

*** Operation**

Satellite navigation systems provide autonomous geo-spatial positioning signals with global coverage, these signals when received by the GPS receiver are processed to produce positioning data

*** Measurement**

Carrier phase measurements are used in addition to pseudo ranges due to their superior accuracy to provide for accurate positioning data

*** Application**

To define the International terrestrial reference frame, for land, ocean and airspace navigation, steering and controlling of machine and man-made moving objects, mapping and many other applications

COGNET - Overview

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KSA-COGNET will serve as the backbone GNSS Network in the Kingdom providing a platform for high precision geodesy and Earth science applications.
It will be compatible and in agreement with the International Terrestrial Reference Frame (ITRF) standards thus becoming part of the Global Network of GNSS Stations

KSA-COGNET Scouting Mission

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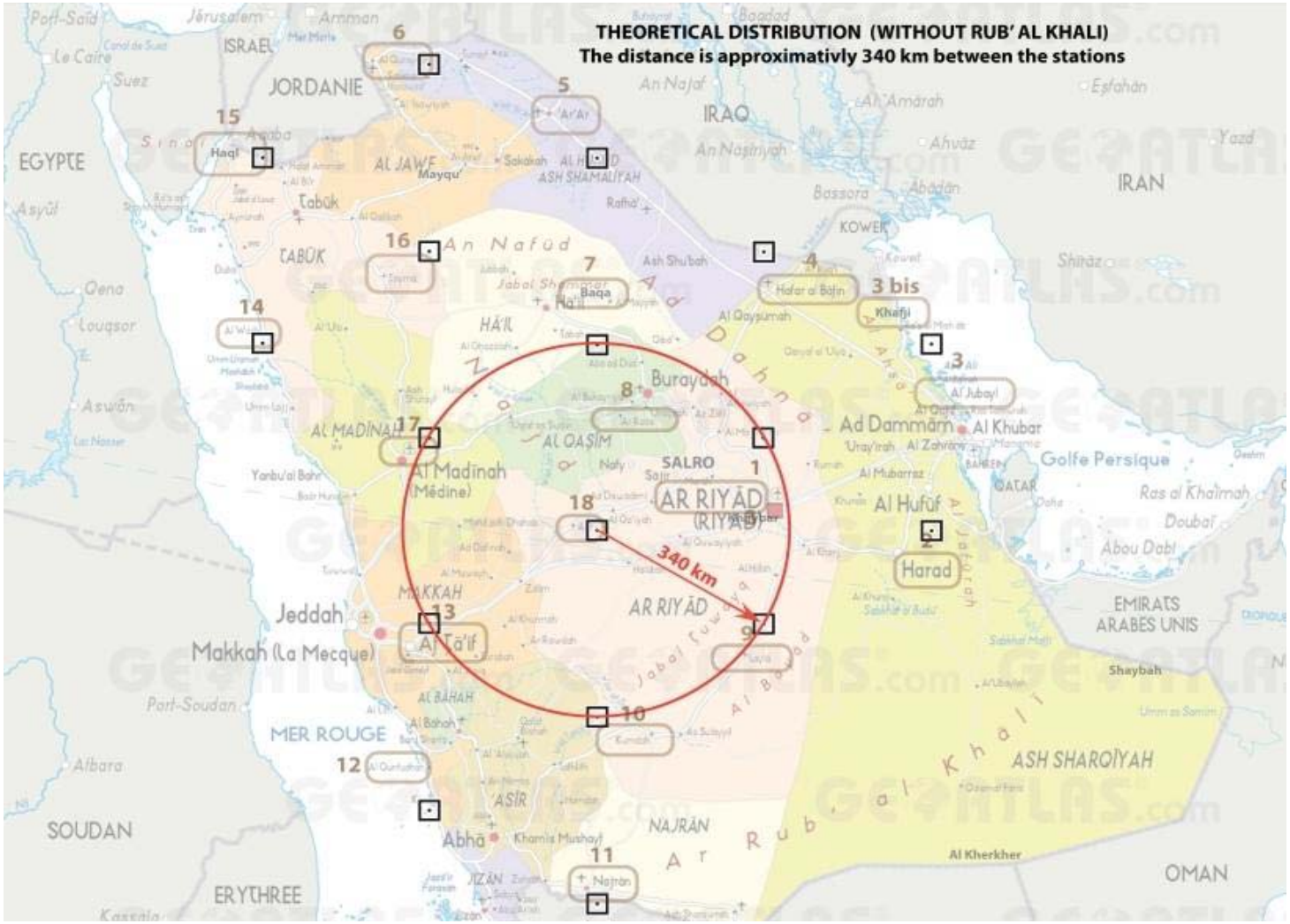


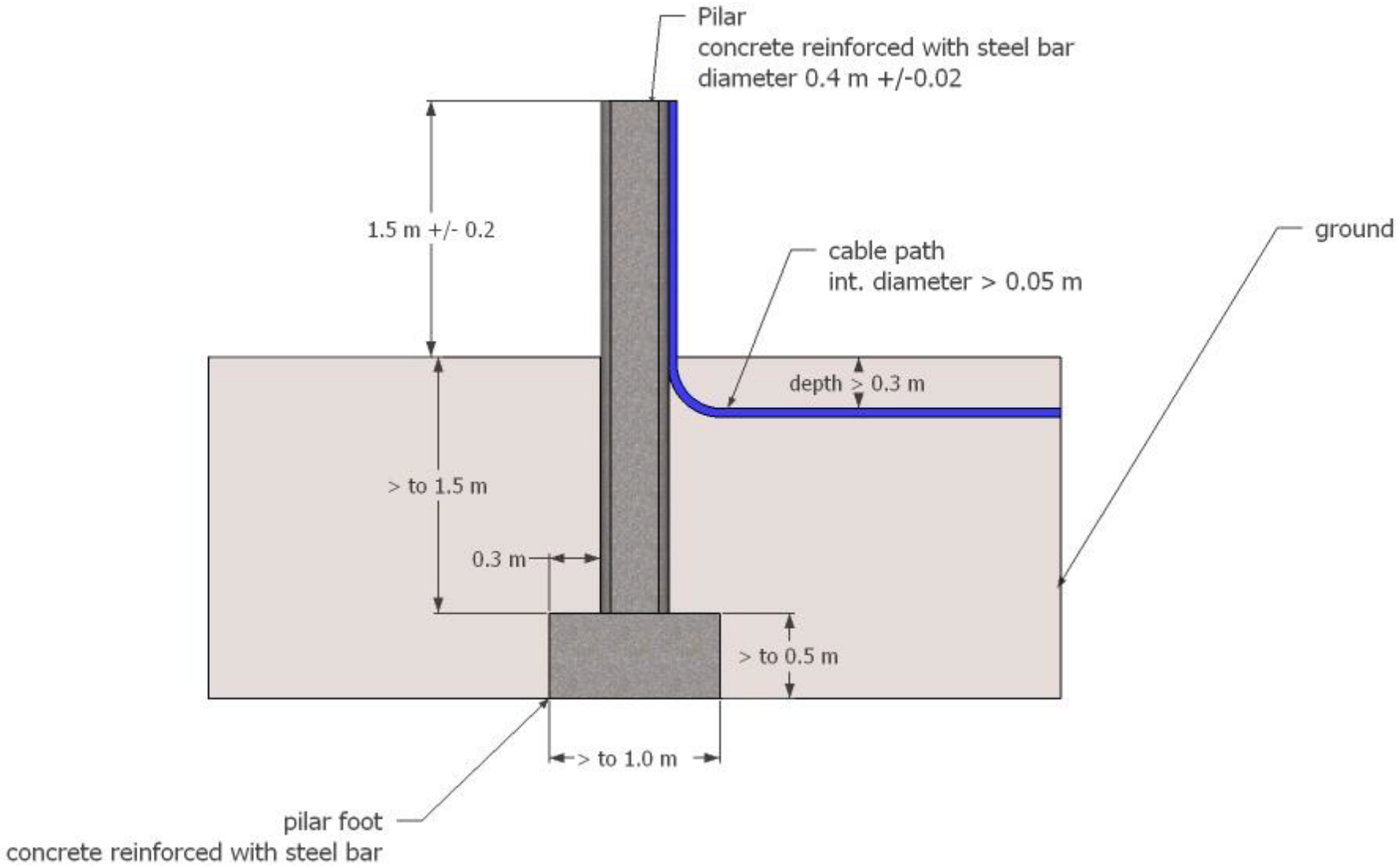
The mission after theoretical calculations was to identify 16 sites for the COGNET infrastructure, in order to meet with the minimum density for a National CORS network.
In addition to this we have selected 2 more sites to avoid any possible site related problems

KSA-COGNET Scouting Mission

Many factors were taken into consideration for selecting the best sites for the network, below is a brief list of some of the criteria taken into account during the scouting mission

* *Durability*
* *Long term satellite visibility*
* *Monument stability*
* *Availability of power*
* *Internet connectivity*
* *Non-interference signals*
* *Low risk of future obstructions*
* *Installation costs*
* *Accessibility*
* *Security*

Monument Specification for site installation



Saudi Arabian Space Geodesy Program

Data Processing with **MicroCosm** Software

Instrument Error Correction

- Instrument Clock and Timing
- Instrument Biases
- Monument Shift
- Measurement Ambiguities
  - Calibration
  - Noise
  - Jitter

Models

- Earth Rotation
- Earth Gravitation
- Tropospheric Refraction
- Earth Precession
- Solar Radiation Pressure
- Atmospheric Drag
- Tectonic Plate Motion
- Polar Motion
- Solid Earth Tides
- Ocean Tides
- Ocean Loading

Geodetic Instruments

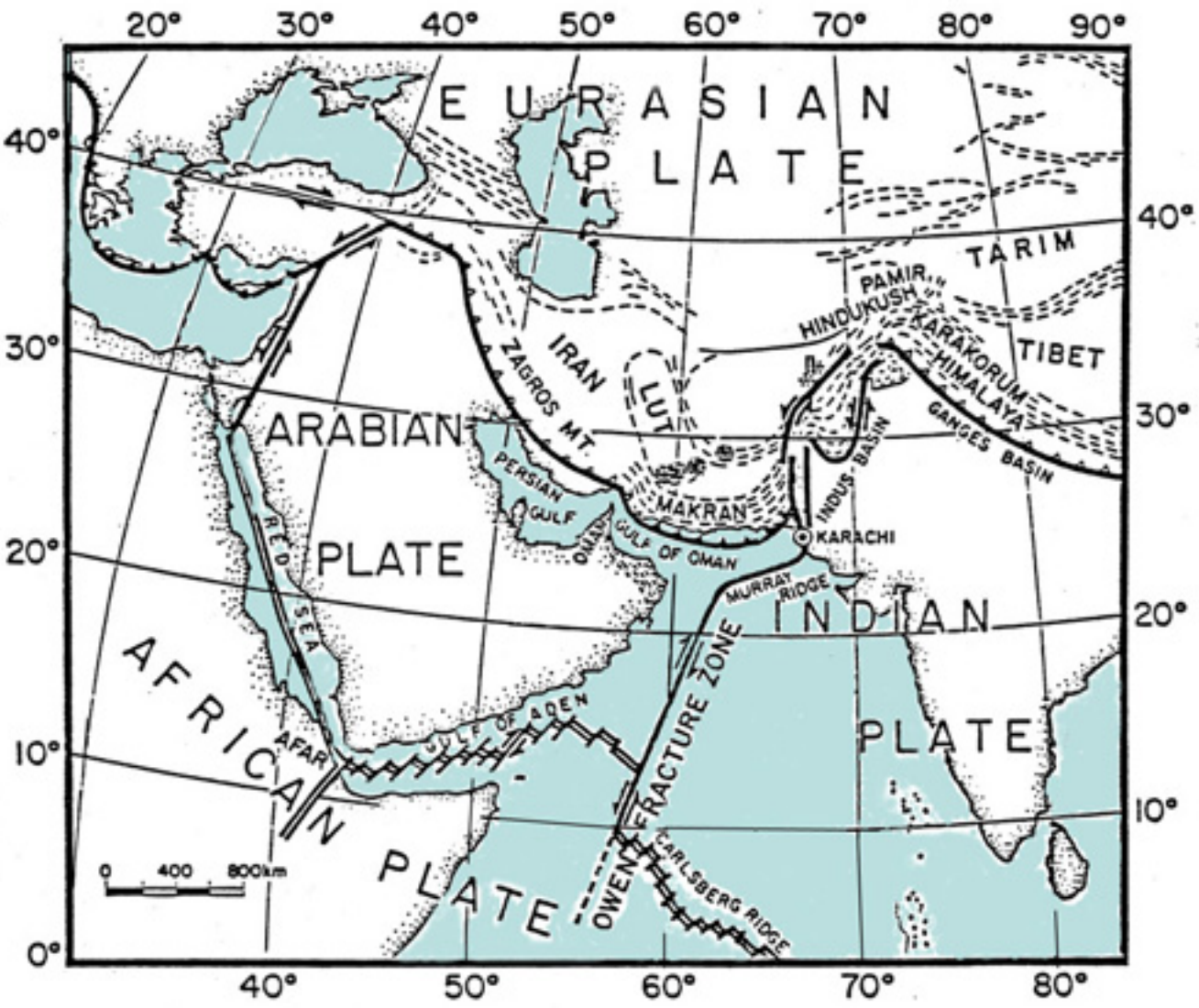
- SLR
- LLR
- GNSS
- TDRS
- DORIS
- Radar Alt.

Microcosm geodetic parameter determination

Some of the key capabilities:

Numeric integration of satellite parameters of motion for orbit prediction
State vector estimation
Atmospheric drag
Solar radiation
Time tag biases and station clock polynomials
Tropospheric refraction
Lunar, solar and planetary gravitational efficiencies
Station coordinates
Polar motion and Earth rotation
Solid Earth and ocean tides
Tectonic plate movement
Simultaneous processing of multiple satellites per data arc

Saudi Arabia and its adjacent tectonic plates



Map: Illustrating the relationship between the Arabian and adjacent African, Indian and Eurasian tectonic plates

Geodetic data needs to be processed to support scientific studies tin order o fully understand the tectonic plate activities and predict the influence it will have on man kind

Patents

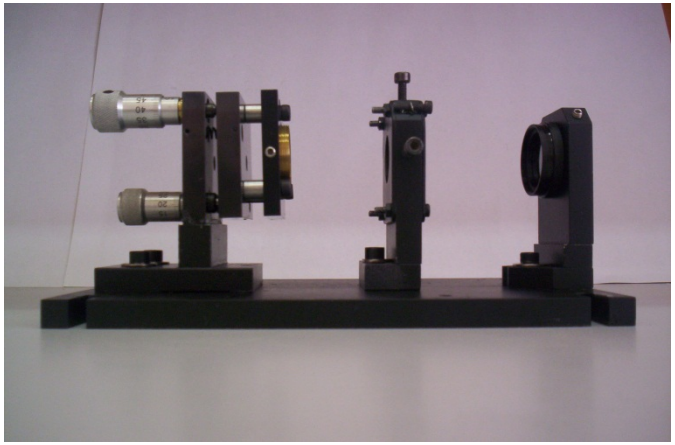
SALRO (SLR System) → Patents pending

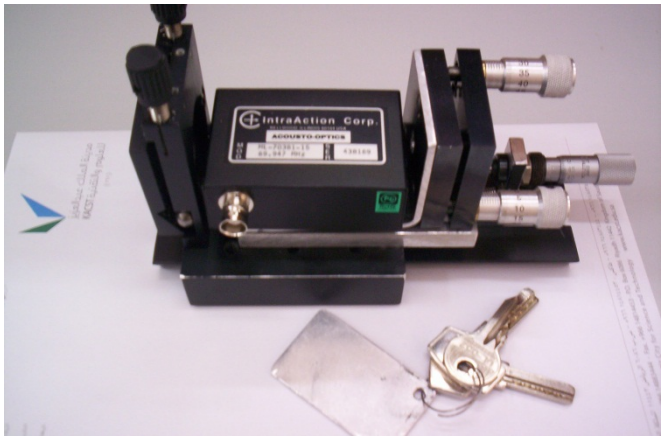
Mechanical Design →
* Precision optical mounts
* High voltage enclosures
* Special-to-type fixtures

Electronic Design →
* High voltage power supplies
* Control and logic circuits
* Fast photon detection circuits
* Q-switch control circuitry
* Avalanche switching devices

Optic and Laser Design →
* Laser optical sub-systems
* Laser System

Mechanical Design





Pictures of some of the precision mechanical mounts locally developed and manufactured. This was to meet with laser specific requirements

Electronic Design

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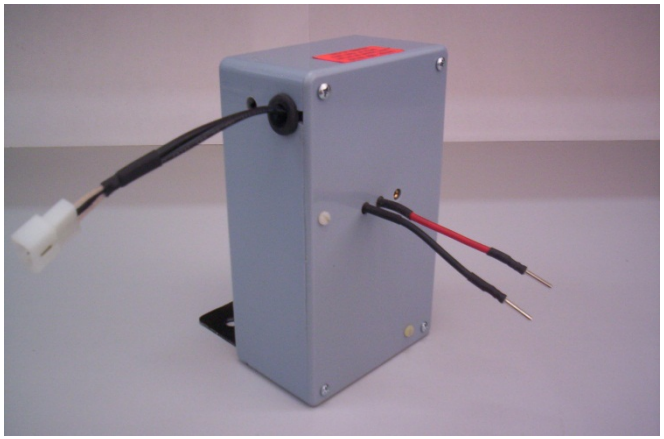

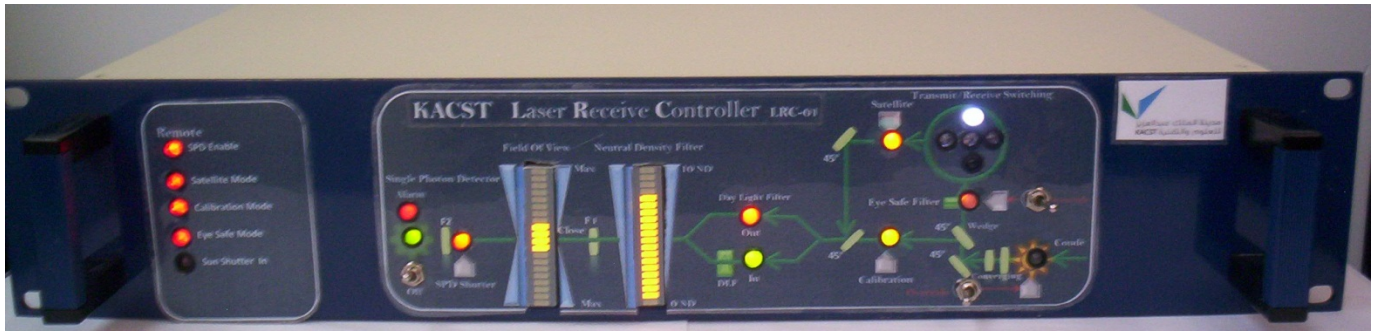

Pictures of some of the electronic equipment locally developed

Top left is 2 high voltage power supplies, in the middle is the new laser safety security system and at the bottom the new laser receive controller

Laser and Optical Design

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Laser and optical development includes photo detection, mode-locking, q-switching and optical sub-systems .
Regret no pictures

Thank you

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