



# GWFF

GEOSPATIAL WORLD FORUM

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**GEOSA**

الهيئة العامة للمساحة  
والمعلومات الجيومكانية  
General Authority for Survey  
and Geospatial Information



Saudi Arabia National Geodetic Infrastructure (NGI)

SULTAN AL-SHAHRANI

24/04/2026



بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

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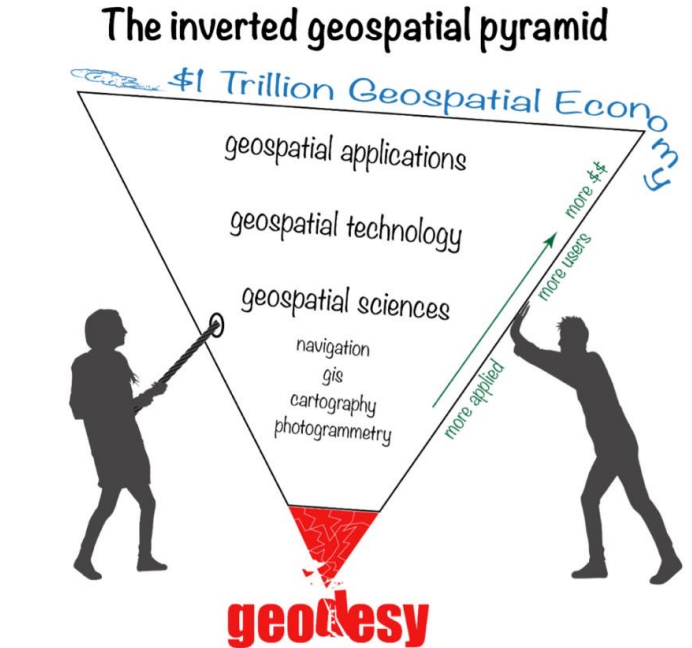
# Role of Geodesy

“The Fourth Industrial Revolution (4IR) is giving rise to a new world of discovery and opportunity with advancements in, and the adoption of, frontier technologies like **Artificial Intelligence (AI), Machine Learning (ML), Big Data, Advanced Robotics, the Internet of Things (IoT), 5G, etc.** The digital economy, enabled by these technologies, often results in the merging of human, physical, and digital environments, thereby leading to unprecedented societal changes. **Many of the world’s greatest challenges are time and place related, and much of the data integration required to solve these challenges is also anchored by location,** which makes geospatial data and technologies central to the 4IR and the digital economy. Geospatial information and technologies are now being utilized across diverse industry sectors and across several functions and processes of business workflows, significantly impacting sectoral outputs and thereby contributing directly to the growth of national economies. The geospatial ecosystem is thus growing and evolving, is more expansive than ever and is having a major impact on the wider digital ecosystem”

GEOSPATIAL KNOWLEDGE INFRASTRUCTURE  
READINESS INDEX AND VALUE PROPOSITION IN WORLD  
ECONOMY, SOCIETY, AND ENVIRONMENT

Geodesy is the foundation of all the geospatial products and services

“The inverted geospatial pyramid” graphic depicts how the entire \$1 trillion geospatial economy is supported and dependent on geodesy, and how it’s close to collapsing without an increase of support for geodesy.



**The entire geospatial economy is supported by geodesy!**

Image: Dana Caccamise II

The inverted geospatial pyramid shows our vulnerability, By David B. Zilkoski  
<https://www.gpsworld.com/>

# Role of Geodesy

## The geospatial economy

The geospatial revolution began to develop explosively around the time that the Global Positioning System (GPS) achieved operational status in the early 1990s. Today, about 3.5 billion people worldwide use one or more Global Navigation Satellite Systems (GNSS), including GPS, via their smartphones, every day. The global geospatial **economy has a value of at least \$ 1 trillion per year** (\$ 1012 / yr), and perhaps significantly more. It comprises the 'Fourth Industrial Revolution'. It is arguably the most important economic and technological development since the internet, and it is still accelerating. Its military significance is comparable to its economic significance

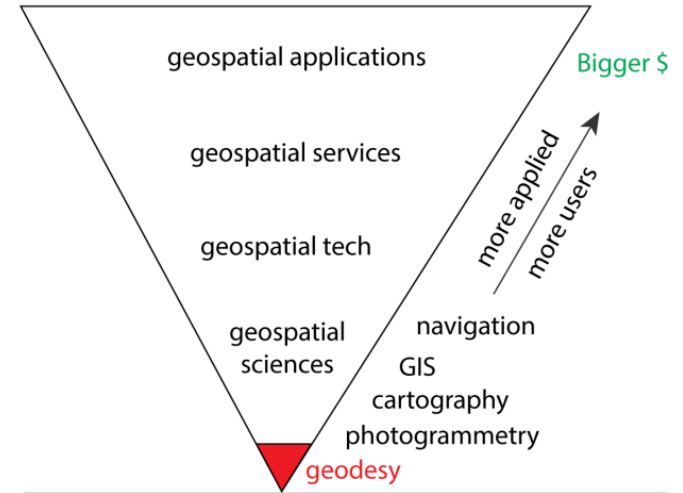
**Geodesy** is the most fundamental science of geospace

Geodesy provides the mathematical and physical infrastructure for the other geospatial sciences, technologies and services, and thereby underpins the entire geospatial economy.

Geodesy focuses on **the representation and measurement of space, mass and time**; reference systems, coordinates, and orientation; gravity, rotational dynamics, and orbital mechanics; and how these quantities, processes, and systems evolve over time.

The U.S. geodesy crisis  
Michael Bevis (Division of Geodetic Science, Ohio State University)  
<https://www.fdot.gov/nasac/meetings/september-2022/geodesy-presentation-nasac-sep-2022.pdf>

## The inverted geospatial pyramid



The entire geospatial economy is supported by geodesy!

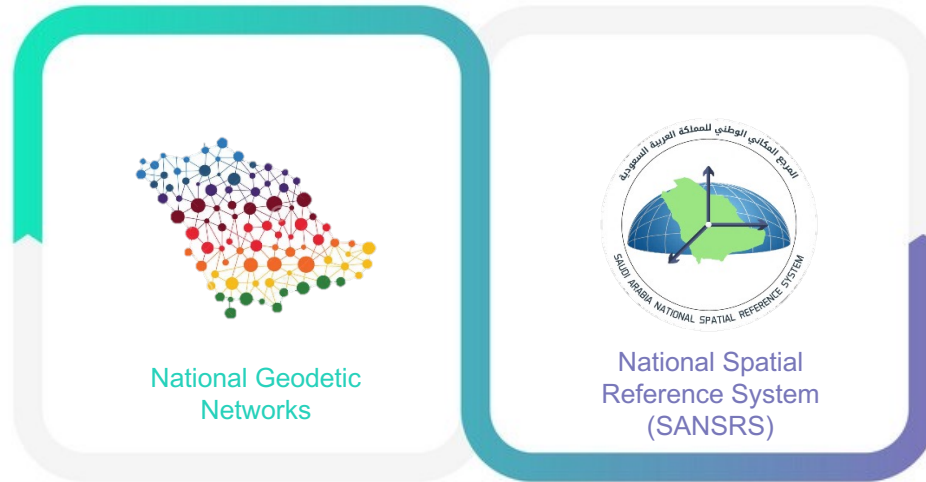


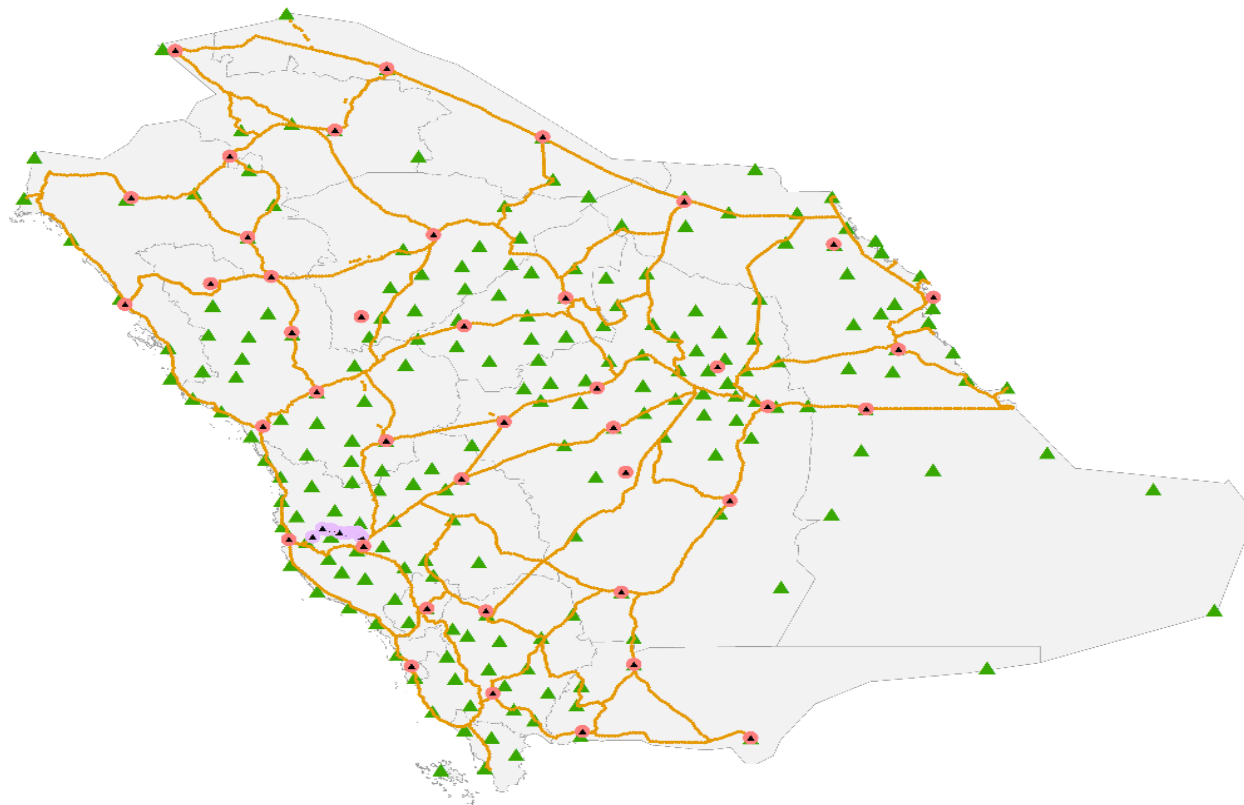
# Saudi Arabia (SA) National Geodetic Infrastructure

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It is a combination of the Saudi Arabia National Spatial Reference System and National Geodetic Networks which contribute in establishing and supporting positioning applications in horizontal and vertical directions with high quality & accuracy and national coverage

It is considered the foundation of National Spatial Data Infrastructure (NSDI)







# Saudi Arabia (SA) National Geodetic Infrastructure | National Geodetic Networks



They are a group of different geodetic networks – major components KSA-GRF and KSA-VRF - which were established to provide the necessary geodetic data for different projects and land surveying activities in KSA.

## KSA-CORS Network

209 CORS

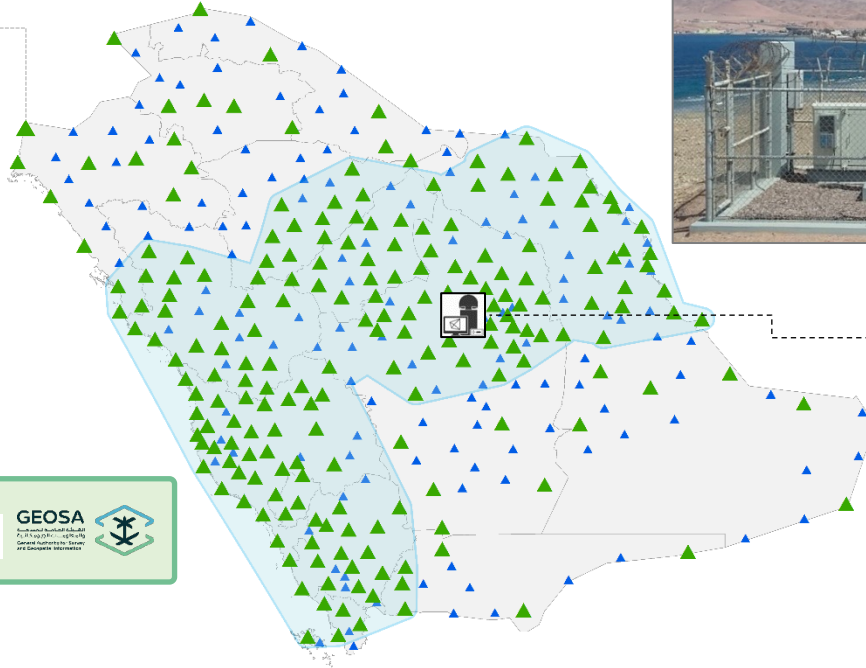


KSA-CORSNRTK Coverage



**Main task:** Provide reliable positioning services and to be used as core stations to compute National Geodetic Reference Frame.

Planned  
132  
CORS



**Network Control Center (NCC)**  
to control and monitor KSA-CORS network.



# Saudi Arabia (SA) National Geodetic Infrastructure | National Geodetic Networks



They are a group of different geodetic networks – major components KSA-GRF and KSA-VRF - which were established to provide the necessary geodetic data for different projects and land surveying activities in KSA.

## National Vertical Network (NVN)

~4000 BM

**Main task:** Provide a precise and unified vertical datum for Orthometric heights determination over the KSA.

- Benchmarks: 3893
- Leveling lines: 88
- Average distance between benchmarks: 6 km
- Total length of network: 22869 km
- Provisional Accuracy:  $1.03 \text{ mm} \cdot \sqrt{S}$ , where S is in [km]



NVN has an accuracy better than Second order/Class I according to NGS Standard



## National Gravity Network (NGrN)

**Main task:** to establish the gravity reference system of KSA as part of the SANSRS and to support the realization of gravity standard over the KSA

- ▲ **41 Absolute Gravity Station** with an accuracy better than  $10 \mu\text{Gal}$ .
- ▲ **12 Gravity Calibration Baseline** with an accuracy better than  $10 \mu\text{Gal}$ .
- **~4000 Relative Gravity Station** with an accuracy better than  $20 \mu\text{Gal}$ , mostly coincident with the existent NVN benchmarks



NVN has an accuracy better than Second order/Class I according to NGS Standard



# Saudi Arabia (SA) National Geodetic Infrastructure | SANSRS



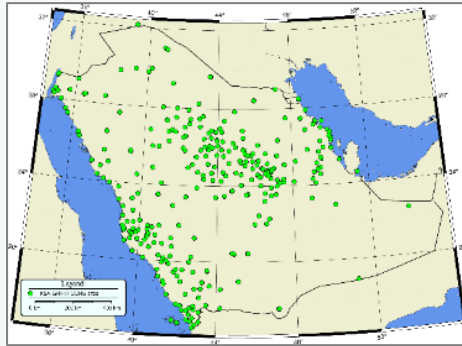
Spatial Reference System (SRS) is a regional or global reference system which is used in all positioning applications in both dimensions - horizontal and vertical - and also all existing geo-spatial products are reference to it.

These geodetic components are defined based on data and information from different geodetic networks.



SANSRS

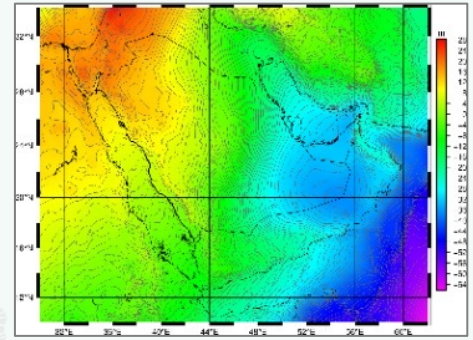
A consistent reference system that defines Cartesian coordinates, longitude, latitude, height, scale, gravity and orientation throughout the Kingdom of Saudi Arabia.



KSA-GRF17



KSA-VRF14



KSA-GEOID21





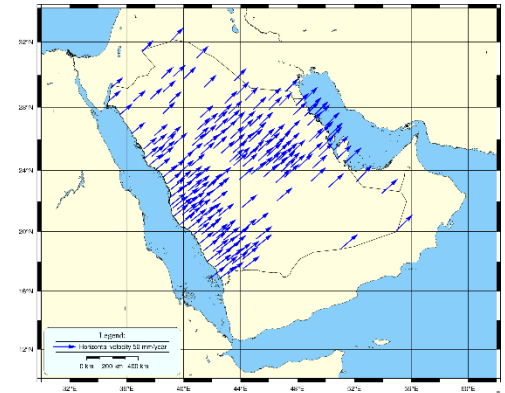
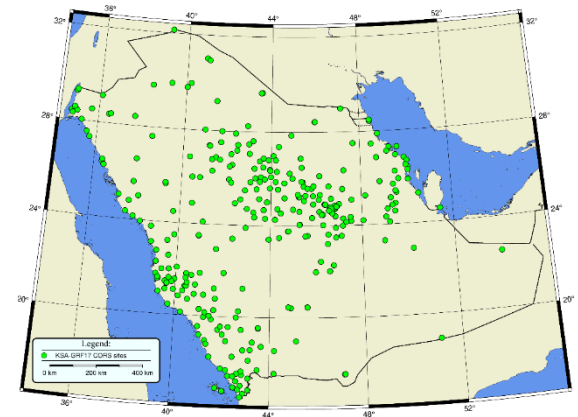
## KSA-GRF17

- ❑ The Kingdom of Saudi Arabia established the unified National Geodetic Reference Frame KSA-GRF17.
- ❑ KSA-GRF17 was computed based on ITRF2014/IGS14 epoch 2017.0. using observations of 51+14 IGS stations used also in definition of ITRF2014.
- ❑ Defined in such way that: it coincides with ITRF2014 at epoch 2017.0.
  - it is moving consistently with the stable part of the Arabian tectonic plate.
  - general transformation formula linking KSA-GRF17 to the ITRF2014, for station positions is given by the following equation:

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix}_{KSA-GRF17}(t) = \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}_{ITRF2014}(t) + \begin{pmatrix} 0 & -\dot{R}_z & \dot{R}_y \\ -\dot{R}_z & 0 & -\dot{R}_x \\ \dot{R}_y & \dot{R}_x & 0 \end{pmatrix} \times \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}_{ITRF2014}(t) \cdot (t - 2017.0)$$

For station position at any epoch  $t$ :

where:  $R_x$ ,  $R_y$ ,  $R_z$  are the three components of the Arabian plate rotation pole (or angular velocity) expressed in ITRF2014.





## KSA-VRF14

KSA Vertical Reference Frame Jeddah'2014

**KSA-VRF14** is based on in-situ observations from tide gauge stations, precise levelling, gravity data, satellite altimetry and GOCE data.

**KSA-VRF14** is the latest realization of National Vertical Reference System (NVRS). **The main characteristics of KSA-VRF14 are as follows:**

Height system type:	Helmert-orthometric Above Mean Sea Level at JEDDAH Tide Gauge
Least-Square Adjustment type:	Fixed geo-potential number above MSL of Jeddah TGBM-B
Physical Realization through Benchmarks:	National Vertical Network (NVN)
Physical Realization through Grid Interpolation:	KSA-GEOID21/KSA-GRF17
Tidal system:	Tide Free
Primary Bench Mark:	Jeddah TGBM-B
Latitude:	21.49981 [degree]
Longitude:	39.16161 [degree]
Fixed height above Mean Sea Level of Jeddah TGBM-B:	1.7446 [m]
Epoch:	2014.75 [year]



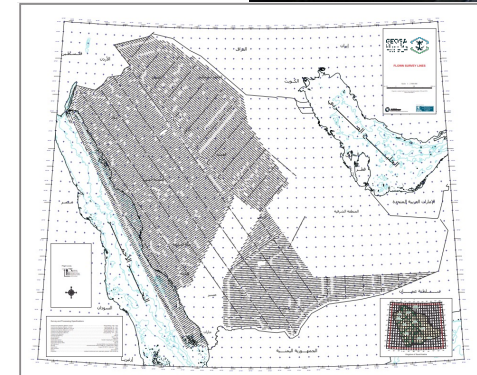
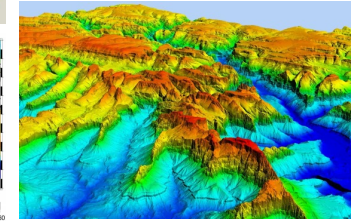
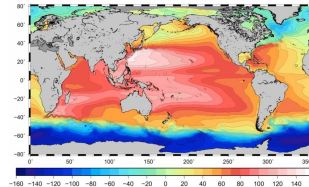
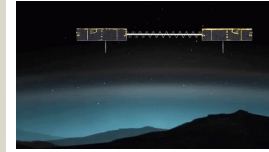
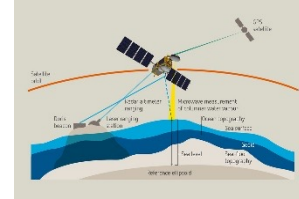


## KSA-GEOID21

The *KSA-GEOID21* model is based on a gravimetric geoid, which is using:

*EGM XGM2019e* reference field (incorporating *GOCE*, *GRACE* and *LAGEOS* satellite data).

- New **DTU18** satellite altimetry data offshore.
- More than 760 000 land gravity data and more than 158 000 marine gravity data
- New dataset of airborne gravity data covering almost 68% of the KSA territory.
- The gravimetric geoid is fitted to the new **KSA-VRF14** through a set of 3522 *GEOSA* GPS/levelling points along the **NVN**.
- The fitted geoid **KSA-GEOID21** has the following expected precision *w.r.t. the Corrector Surface (CS)*:
  - ✓ 1.5 cm along the levelling lines;
  - ✓ 2.5 cm between the levelling lines.

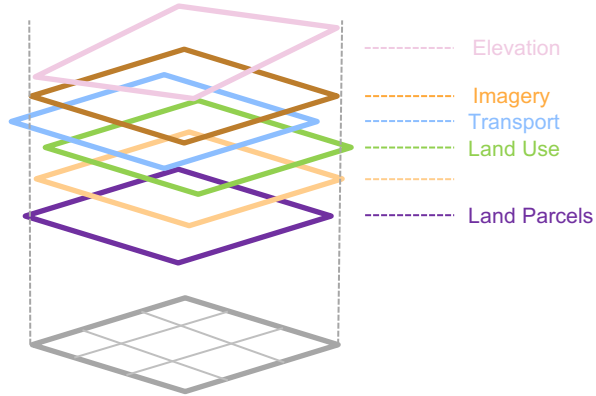


# REGULATION OF GEODESY (BEYOND DATA COLLECTION)



GEOSA is the National Authority responsible for Surveying and Geospatial Information in Saudi Arabia.

One of its roles is to **REGULATE** the sector in the Kingdom, which includes but not limited to



Establish, Maintain, and Update  
**A UNIFIED**  
Spatial Reference System



Setting and updating **rules and standards** relating to the Sector



conducting Sector-related **studies and research**



Proposing the Sector's relevant **laws**



**Licensing** Sector activities, overseeing the training and **classification of practitioners**



**Coordinating and cooperating** with its counterparts in other countries



# REGULATION OF GEODESY (BEYOND DATA COLLECTION)



Link between regulations & Quality of Foundations of Geospatial Information and Stability & Sustainability of Socio-Economic Sectors

THE ROLE OF FOUNDATIONS OF  
SURVEYING & GEOSPATIAL INFORMATION SECTOR



NATIONAL SOCIO-ECONOMICAL  
SECTORS (15)

NATIONAL SOCIAL  
LIFE AND SECURITY

NATIONAL ECONOMY (NE)

National Infrastructure (NI)

(roads & railways, energy & electrical networks, hydrological & water infrastructure, communication & satellite infrastructure and etc.)

National Scientific Infrastructure (NSI)

(National Science: Theories & Applications; Research & Development & Innovations; Scientific Analysis and Synthesis and etc.)

National Data Infrastructure (NDI)

KSA SURVEYING & GEOSPATIAL INFORMATION SECTOR

Spatial Data Infrastructure (SDI)

Geospatial Information (GI) [data & information sharing]

FOUNDATIONS OF GEOSPATIAL INFORMATION [FGI]  
Geospatial Survey (Surveying) [GS] [Geo-referencing & enabling]

Geodetic & Hydrographic Infrastructure [Fundamental  
Spatial Reference Systems [Pillars]





# National VISION AND STRATEGY



## NATIONAL SOCIO-ECONOMICAL SECTORS (15)

NATIONAL SOCIAL LIFE AND SECURITY

NATIONAL ECONOMY (NE)

National Infrastructure (NI)

National Scientific Infrastructure (NSI)

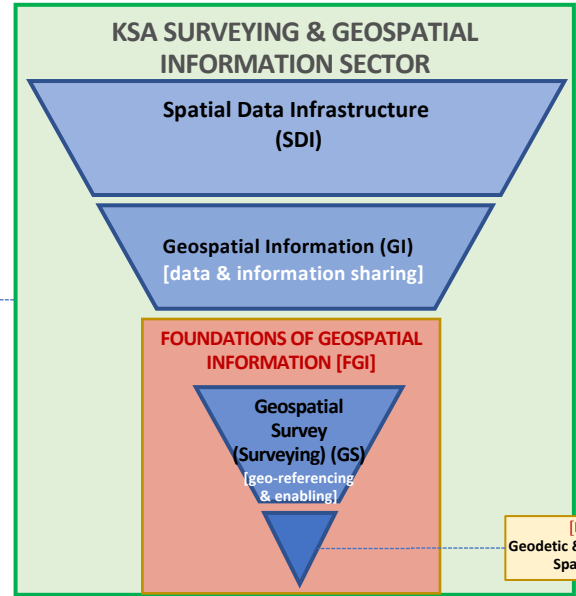
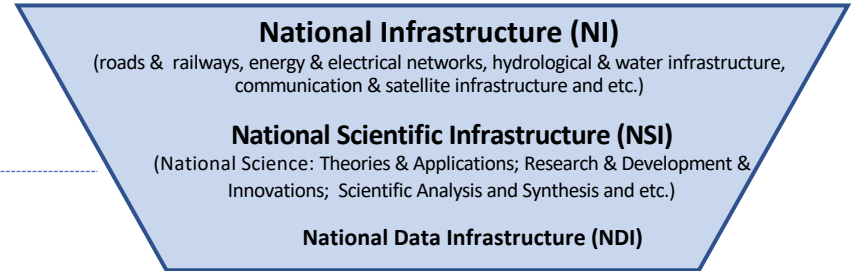
National Data Infrastructure (NDI)

Spatial Data Infrastructure (SDI)

Geospatial Information (GI)

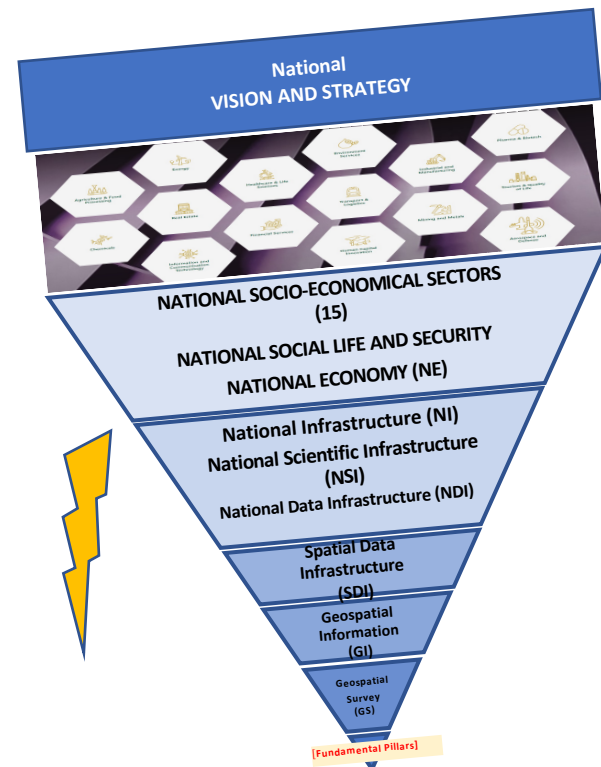
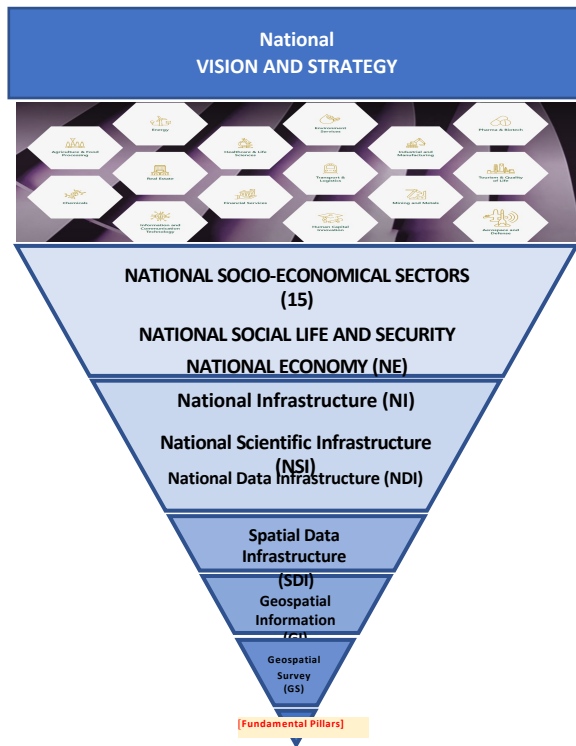
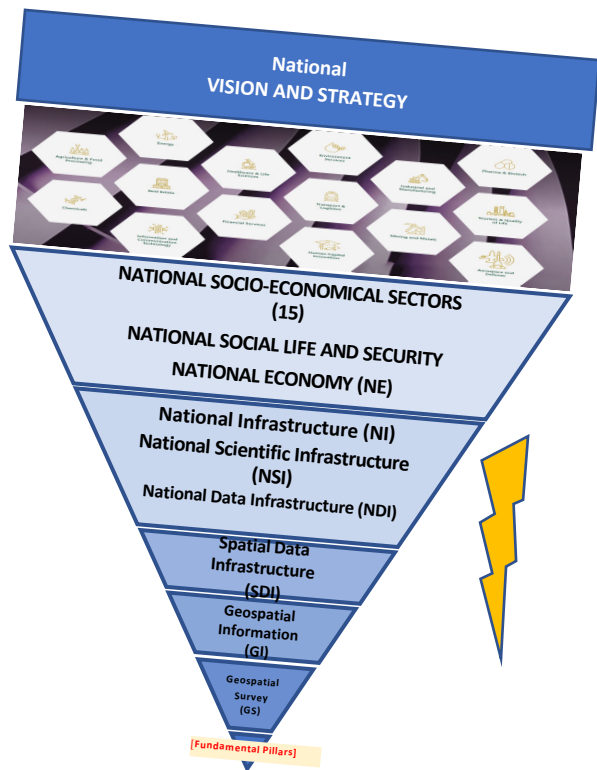
Geospatial Survey (GS)

[Fundamental Pillars]



[Fundamental Pillars]  
Geodetic & Hydrographic Infrastructure  
Spatial Reference Systems

**Link between regulations & Quality of Foundations of Geospatial Information and Stability & Sustainability of Socio-Economic Sectors**



**100% REGULATIONS, BUT NOT ACCURATE  
AND NOT RELIABLE SPATIAL REFERENCES &  
INFRASTRUCTURES  
UNSUSTAINABLE**

**OPTIMAL REGULATIONS, ACCURATE &  
RELIABLE SPATIAL REFERENCES &  
INFRASTRUCTURES  
STABLE & SUSTAINABLE**

**NO REGULATIONS, MANY DIFFERENT  
SPATIAL REFERENCES &  
INFRASTRUCTURES  
VERY UNSUSTAINABLE**

# Geodesy in Future | Applications

Autonomous vehicles



Constructions



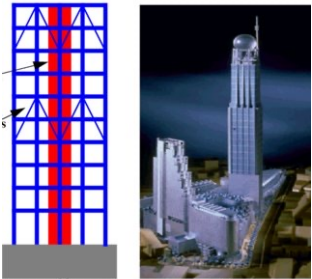
Smart Farming



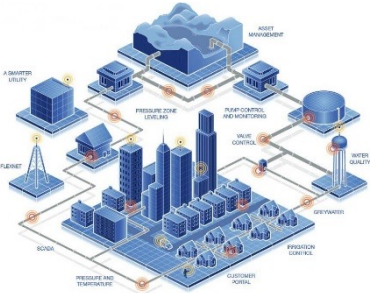
Machine control



Monitoring of High-rise buildings deformation



Utilities management



**Transition from STATIC to DYNAMIC/TIME VRYING Reference System** - Currently, GEOSA is working on developing a concept for transition from static to dynamic/time varying SANSRS & the following SANSRS components will be considered:

- **Transition of KSA Geodetic Reference Frame (KSA-GRF)** - from static reference frame w.r.t. to Arabic plate to reference frame including interplate and areas with natural & technogenic motions
- **Transition of KSA Vertical reference frame (KSA-VRF)**
  - National Tide Gage Network (TGN) -monitoring the effect of Mean Sea Level and its rate on changes in geo-potential of TG stations
  - National Vertical Network (NVN) – monitoring the effect of geometric movements of Tide Gauge stations, Ground CORS stations and specific areas of interest (Tectonic and technogenic active zones, seismic active, subsiding areas, etc.) on geo-potential changes and separation of pure geometrical movements from physical gravity field changes;
- **Transition of KSA Geoid**
  - National Gravimetric Network – campaign based and permeant Absolute gravity observation
  - Time varying gravity field from old, current and future satellite gravity mission
  - Dynamic KSA Geoid – determination and validation
- **Developing new geodetic earth observation applications over KSA (InSAR, SLR, VLBI and etc.), supporting the transition to time-varying SANSRS and those utilizing it**
- **The Concept of transition from static to dynamic/ Time-varying SANSRS - part of the National Geodetic Program (NGP), currently under development** by Executive Directorate of Geodesy (EDG), GEOSA.

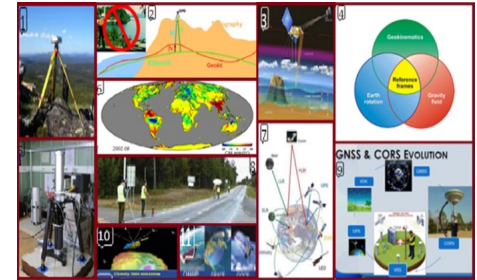


# Conclusions and Recommendations

- ❑ **All geodetic activities** at Executive Directorate of Geodesy (EDG), General Authority of Survey and Geospatial Information (**GEOSA**), and its up to date infrastructure **can be considered as a very good background start, which could support different geodesy-linked activities:**

*KSA-GRF/KSA-VRF/KSA-GEOID is the common geodetic infrastructure for applications linked to Geo-referencing, the Earths' gravity field, geophysics, oceanography, hydrography, hydrology, water flow studies, surveillance of coastal areas and etc.*

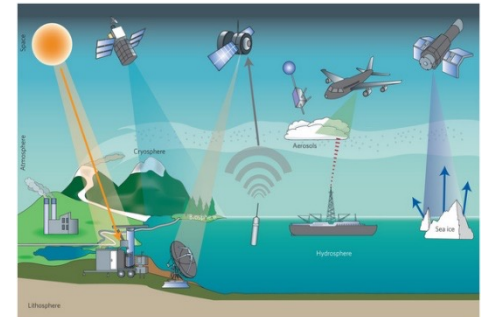
- ❑ **General and specific issues** regarding future cooperation with different governmental/international organizations, professional and scientific communities – geodetic data and information stakeholders.
- ❑ **Different forms of cooperation** between **GEOSA** and other communities can be established – bilateral or multi-partner working groups.
- ❑ **Different joint activities** (workshops, seminars, common projects and etc.) during major conferences and meetings can be planned.
- ❑ **In the future; SANSRS includes transforming from Static (3D) to Dynamic (4D) System,** which will allow any product, service or application described time wise.



GEODETIC APPLICATIONS



GEODETIC DATA AND INFORMATION STACK HOLDERS



<http://www.nature.com/nclimate/journal/v3/n10/full/nclimate1908.html>



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General Authority for Survey  
and Geospatial Information



Thanks