وزارة الشؤون البلدية و القروية

Ministry of Municipal & Rural Affairs

برنامج التحول البلدي

جزء من رؤية ٢٠٣٠

وزارة الشؤون البلدية و القروية
Ministry of Municipal & Rural Affairs

THE KINGDOM OF SAUDI ARABIA
GNSS REAL TIME KINEMATIC NETWORK (MRTN)
AND BEYOND

OUTLINES

- **HIERARCHY OF THE Ministry Of Municipality and Rural Affair (MOMRA) Terrestrial REFERENCE FRAME (MTRF)**
  - **MTRF-2000 DATUM DEFINITION**
  - **MOMRA Real Time Network (MRTN)**
    - **OBJECTIVE**
    - **DESIGN – COMPONENTS**
    - **MONUMENTS**
    - **HARDWARE**
    - **ESTABLISHMENT**
    - **DATA CONTROL CENTER**
    - **SERVICES**
    - **TESTING**
    - **CHALLENGES**
    - **CONCLUDING REMARKS**

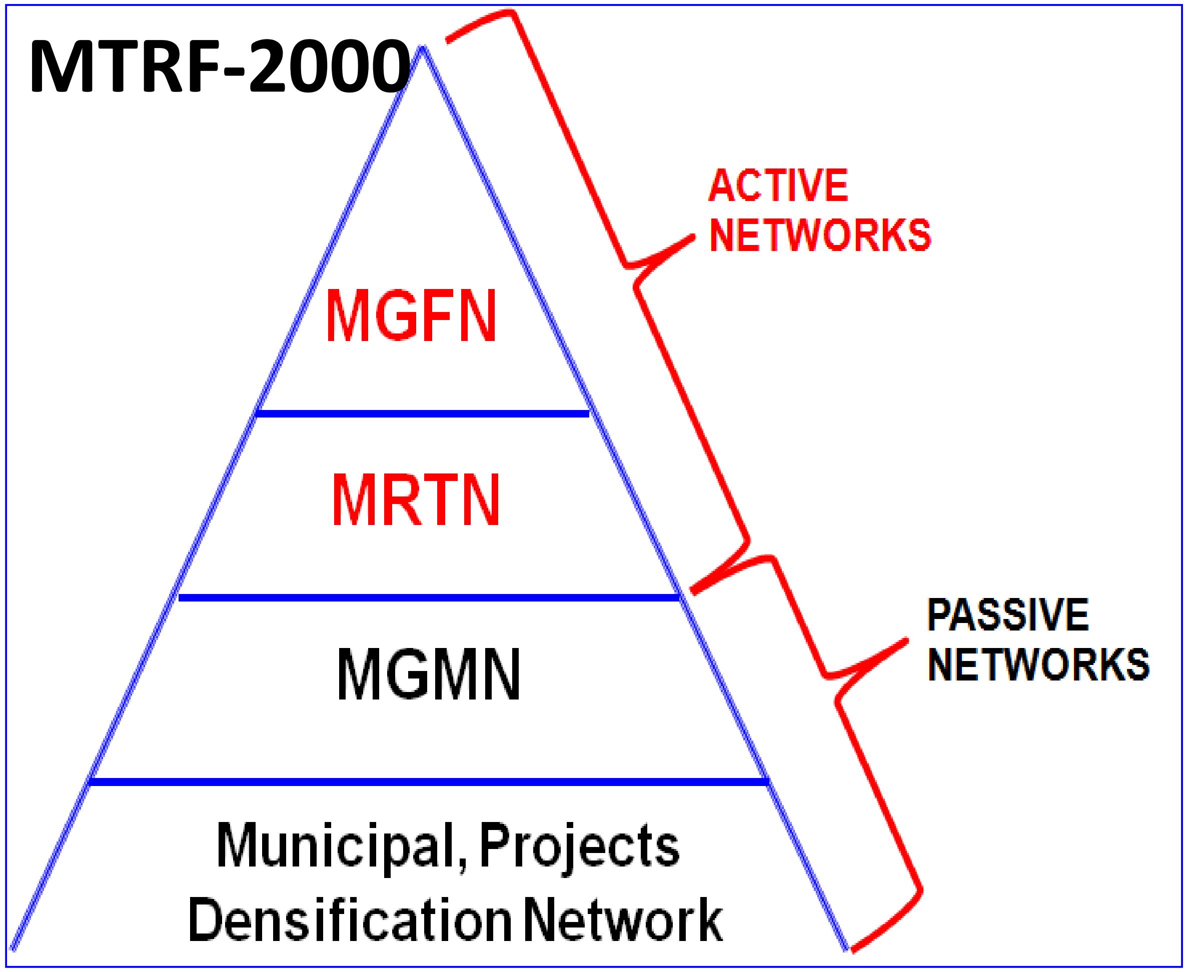
HIERARCHY OF THE MTRF

❑ The MTRF hierarchy is divided into ACTIVE and PASSIVE components.

❑ The active component consists of networks of continuously operating GNSS receivers

❑ The passive component is comprised of more traditional monumented control points that users can occupy with their own equipment.

❑ At the heart of the MTRF is the MOMRA GEODETIC FIDUCIAL NETWORK; a network of continuously operating GNSS receivers.



❑ MRTN data support positioning accuracy at the centimeter-level for legal surveys.

- Broadcast corrections - Post processing

❑ MGFN data support positioning accuracy at the millimeter-level for datum definition and measuring of crustal motion.

Post processing

MTRF-2000 DATUM DEFINITION
(MRTN is tied to MTRF-2000)

Datum	MOMRA TRF Datum 2000 (MTRF-2000)
Reference Frame	ITRF-2000 (International Terrestrial Reference Frame 2000)
Coordinate Epoch	2004.0
Ellipsoid	GRS80
Semi-major axis (a) Inverse flattening (1/f)	6,378,137.0 meters 298.257222101
Grid coordinates (Universal Transverse Mercator)	Map Grid of MTRF Datum 2000

OBJECTIVE

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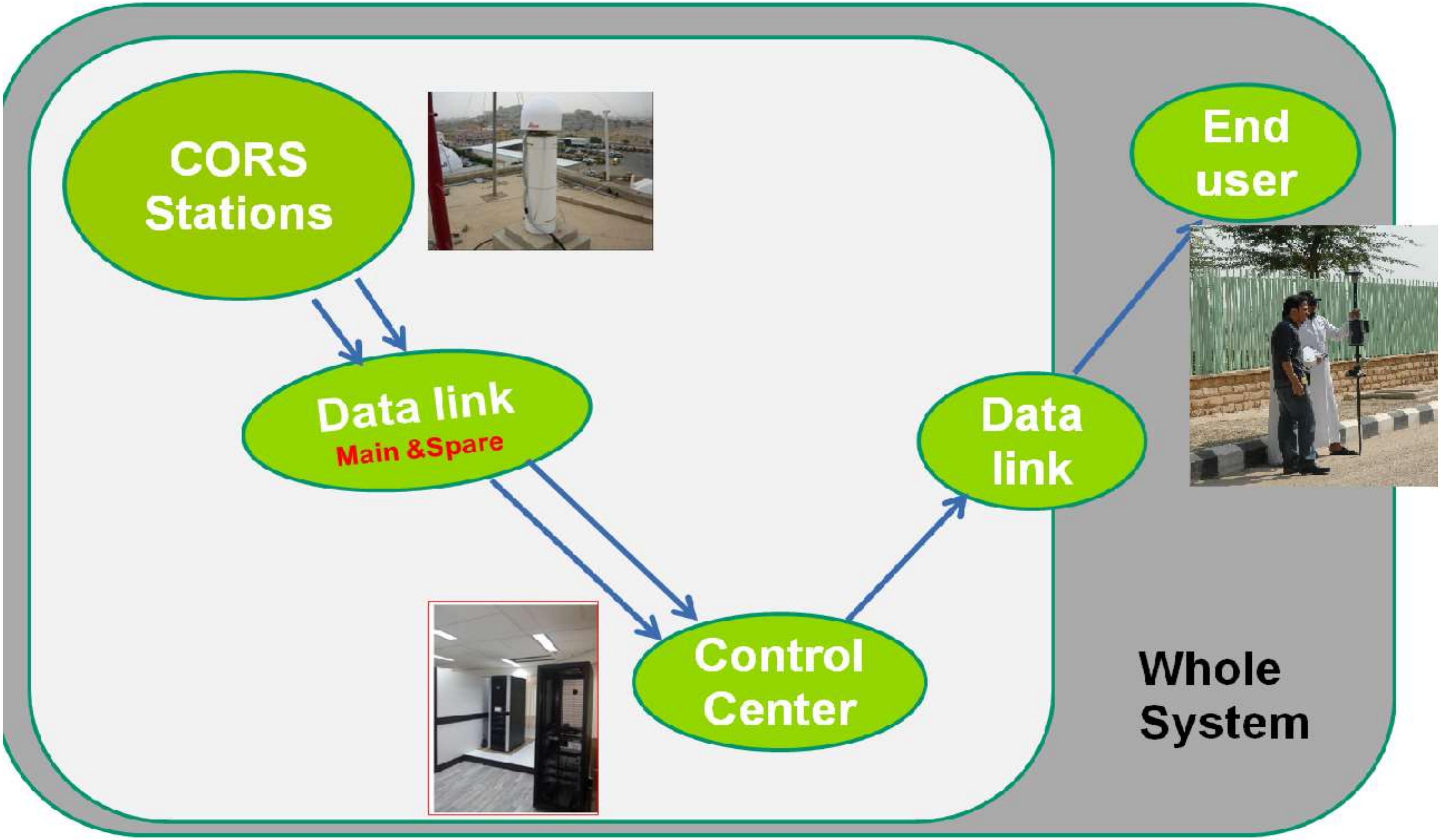
MRTN has been designed with the following objectives in order to take full advantage of the real-time capabilities of the RTK network in 3D cadastral development system and land survey.

- To establish a network of permanently running GNSS base stations, at a spacing of 20 to 75 km, feeding GNSS data to a processing centre via frame-relay Saudi Telecommunications infrastructure network.

- To establish a central facility that will model the spatial errors which limit GNSS accuracy through a network solution and generate corrections for roving receivers positioned anywhere inside the network with an accuracy better than a few centimeters (dense network) to a few decimeters (sparse network) in real time.

- To establish an archive that will make available reference station data (24 hours) to the clients for post-processing throughout the country.

DESIGN - COMPONENTS

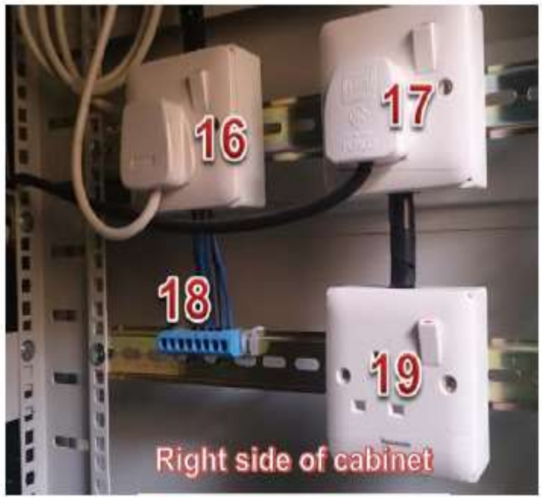


MONUMENTS

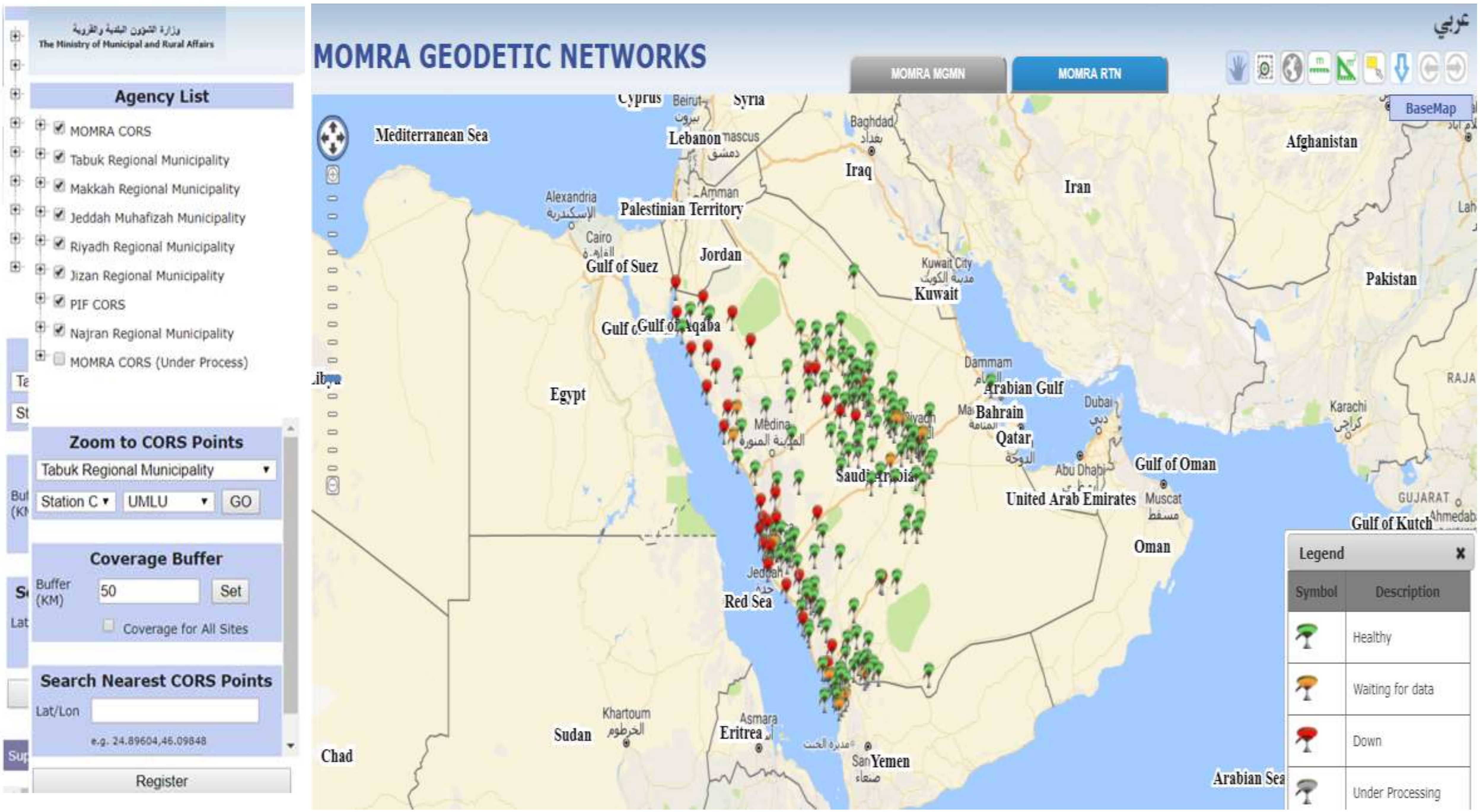
- On rooftop of building as concrete and iron pillar
- In the range of 20-75km.
- Data cable is protected from high temperature

HARDWARE

No	Name
1	Trimble NetR9 Ti-1 GNSS Receiver
2	Router
3	Battery Protector
4	Grounding
5	8 way blue DIN mount terminal
6	8 way grey DIN mount terminal
7	Enclosure AC cooling fan
8	Surge Arrestor
9	Power adapter for router
10	AC Battery with battery connector (12 V 90Ah)
11	16 way green DIN mount terminal
12	Terminal Blocks 10 Way Strip Electrical Wire
13	AC cooling fan
14	10A Input Breaker
15	10A Input Breaker
16	Mounted Mains Socket
17	Mounted Mains Socket
18	8 way blue DIN mount terminal
19	Mounted Mains Socket



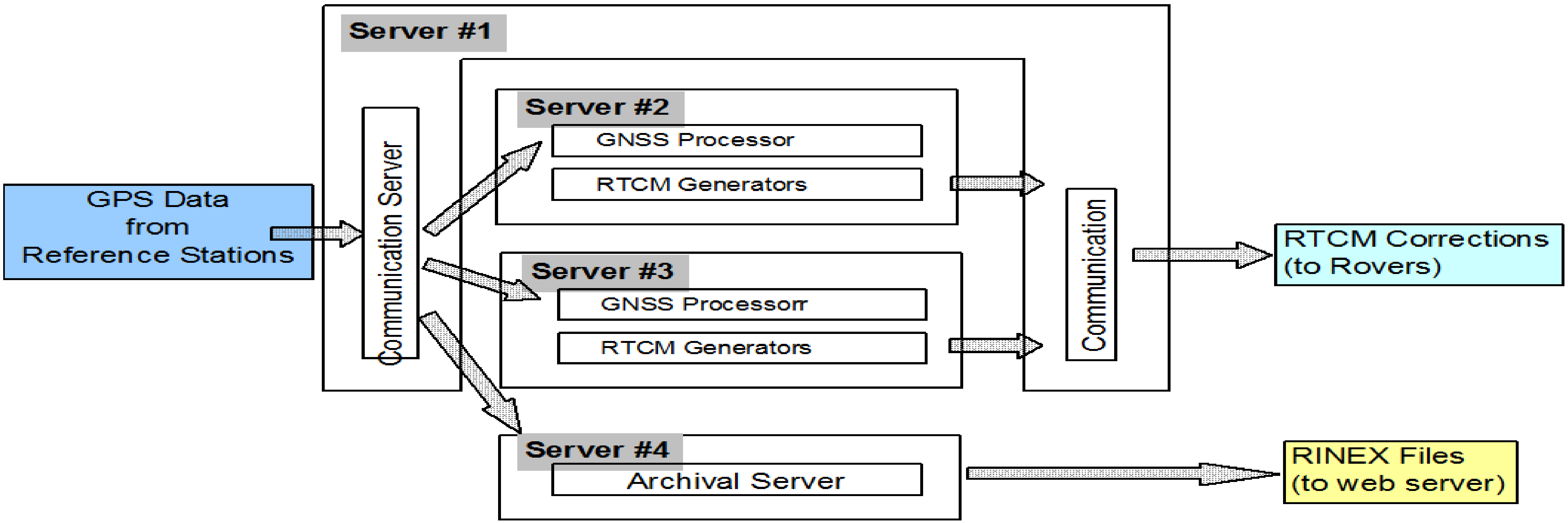
ESTABLISHMENT



DATA CONTROL CENTER

The main activities of Data Control Center (DCC) consists of :

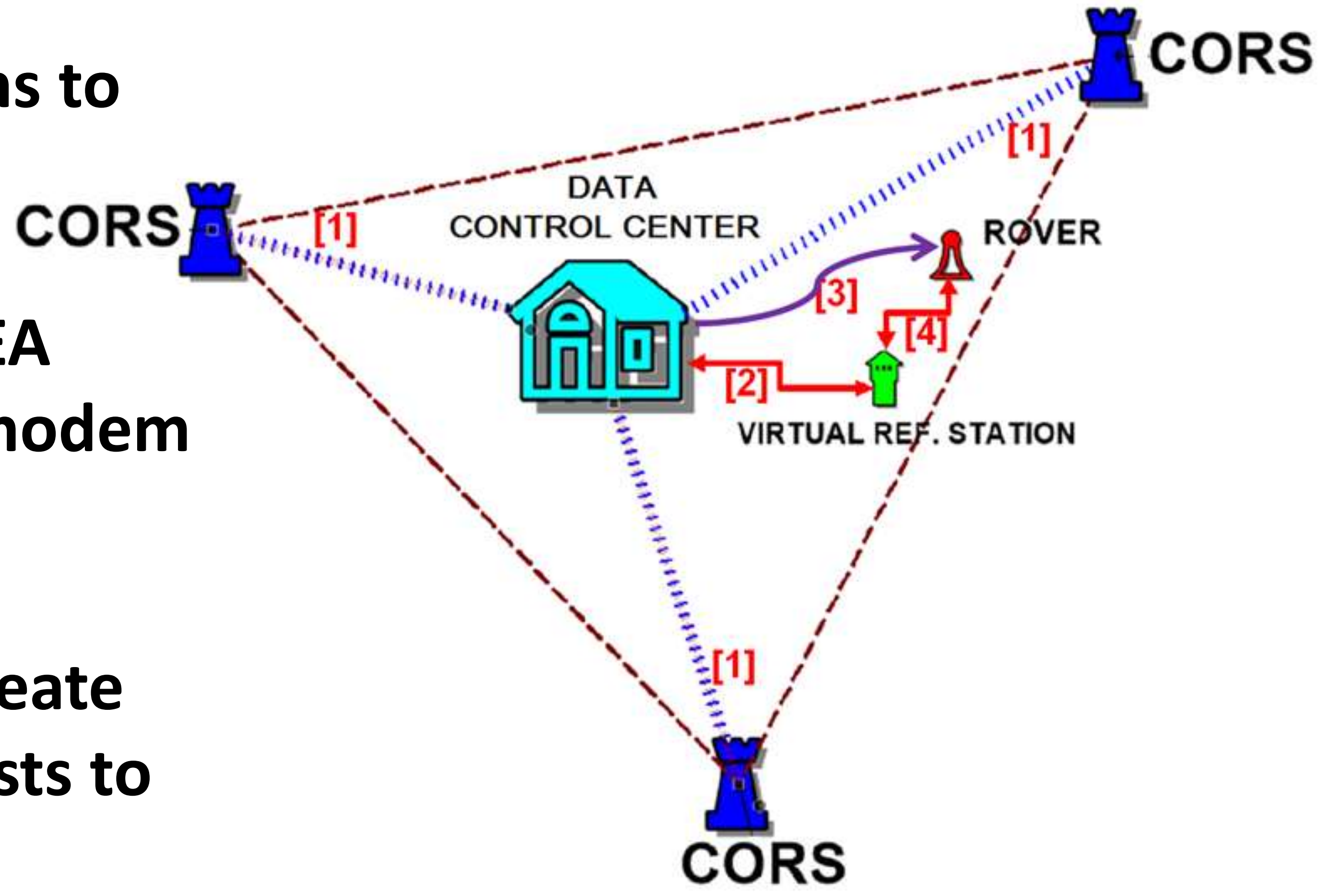
- **Providing communication with GNSS-CORS and rover receivers;**
- **Getting data from GNSS-CORS receivers;**
- **Modeling errors;**
- **Calculating VRS corrections;**
- **Archiving;**



SERVICES

Virtual reference station (VRS) Overview

- [1] Reference Station data streams to DCC server through Internet
- [2] Roving receiver sends an NMEA string to DCC server using cellular modem (VRS position is established)
- [3] Server uses VRS position to create corrected observables and broadcasts to rover
- [4] Rover surveys as in normal RTK survey but getting data as if coming from the VRS



SERVICES (Continue)

VRS Correction

MRTN provides VRS GNSS corrections with an accuracy of 1 to 3 cm horizontally and 3 to 6 cm vertically. Distance dependent errors are considerably minimized, thereby achieving increased accuracy and reliability.

Static RAW Data

MRTN solutions provides data for post-processing of static survey sessions, enabling positioning in the order of millimeter limit. The data is provided on demand in the standardized RINEX format. Information with a data rate of 1-30 seconds is stored indefinitely. Post-processing provides the highest accuracy and is suitable where increased precision is required.

SERVICES (Continue)

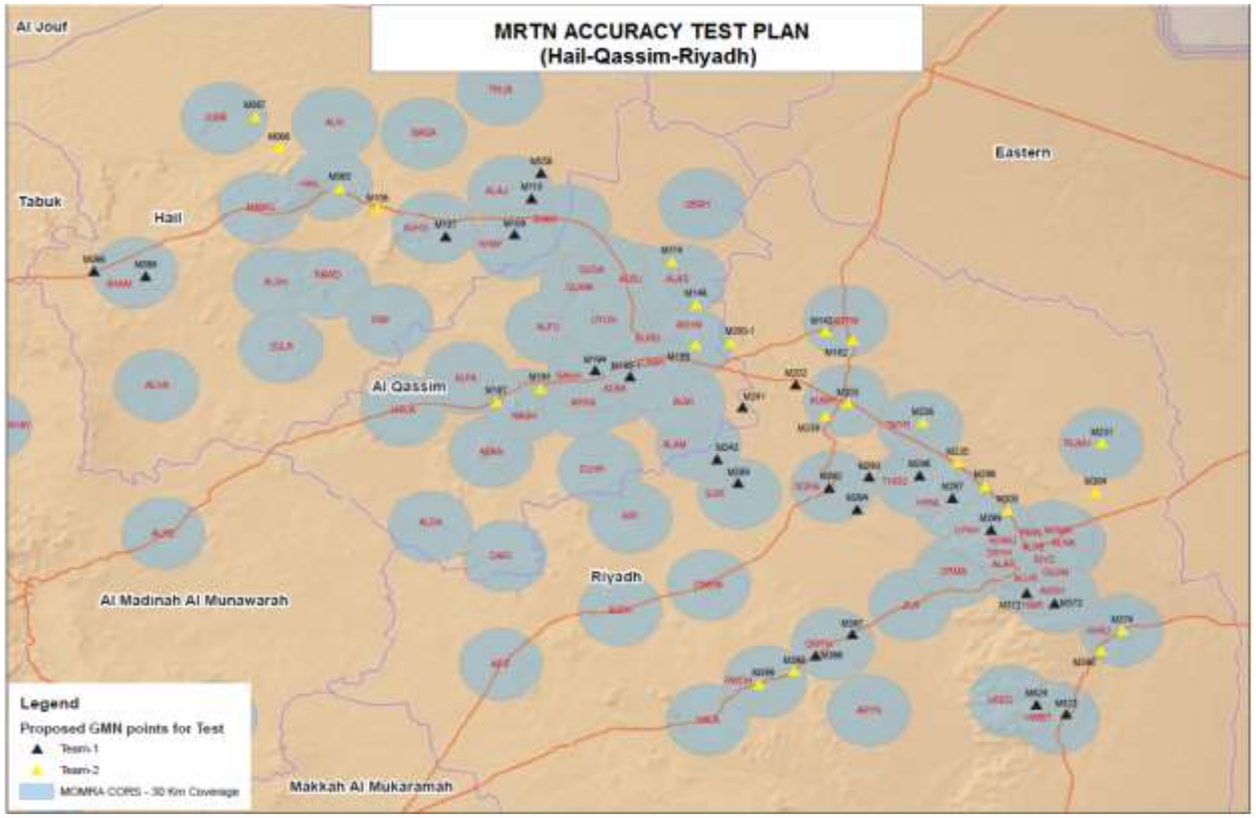
Field Applications

- Cadastral survey,
- Engineering Survey (i.e Riyadh metro network Project),
- Topographic Survey,
- Boundary Survey,
- Construction Staking,
- Utility Extension Survey,
- Flood Survey Study and Analysis,
- GIS Applications,
- Control surveys for monumentation,
- Mapping survey,
- Aerial Imagery.

TESTING

VRS Correction Test

- Comparison MTRF observed coordinates using VRS correction with their corresponding published MTRF geodetic values,
- Trimble R10,
- Two months,
- Distances between MGMN and nearest network station varied in the range of 30 km.



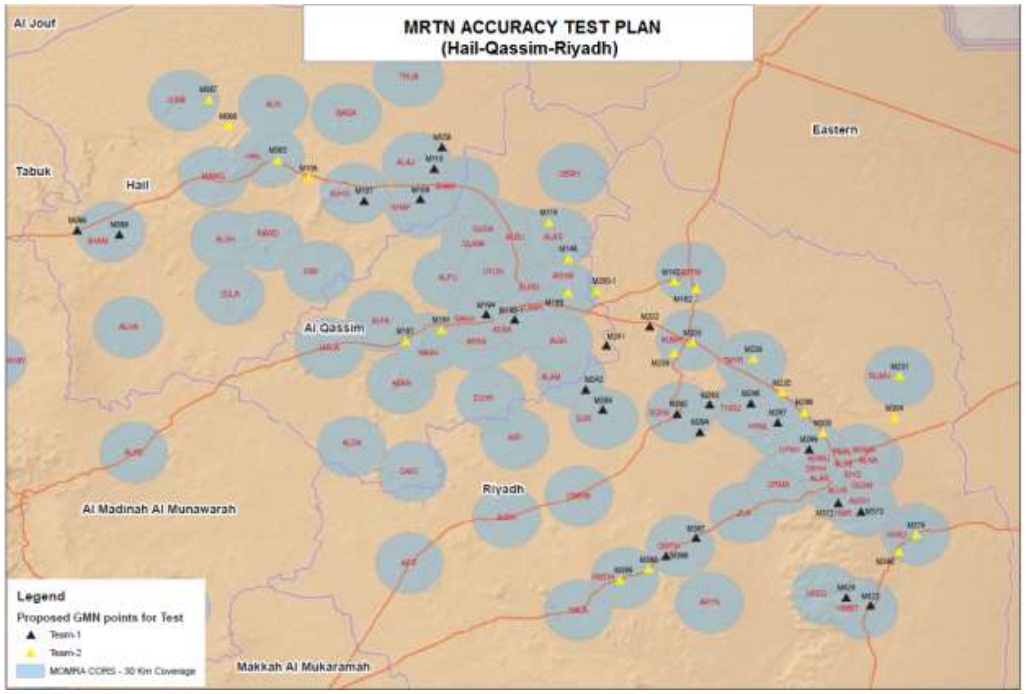
Measurement Related Factors

- Minimum five common satellites,
- Maximum GDOP value of 8,
- Make repeated measurements,
- Obstacle-free horizon, etc.

TESTING

VRS Correction Test

No	REGION Name	STATION	MGMN Coordinates			MRTN Measured coordinates			Diff. (m)		
			Northing	Easting	Height	Northing	Easting	Height	DX	DY	DZ
1	QASSIM REGION	M191	915.823	417.811	35.509	915.808	417.793	35.534	0.015	0.018	-0.025
2		M194	193.880	558.439	87.133	193.881	558.444	87.115	-0.001	-0.005	0.018
3		M195-1	249.457	591.726	66.057	249.371	591.744	66.079	0.086	-0.018	-0.022
4		M114	910.804	437.451	75.340	910.781	437.447	75.389	0.023	0.004	-0.049
5		M199	792.691	393.306	28.856	792.702	393.289	28.856	-0.011	0.017	0.000
6		M241	696.615	850.392	87.800	696.639	850.377	87.776	-0.024	0.015	0.024
								RMS_{QASSIM}=	0.038	0.014	0.027
7	HAIL REGION	M065	112.368	70.993	11.716	112.384	70.984	11.596	-0.016	0.009	0.120
8		M066	372.624	983.663	9.400	372.694	983.676	9.335	-0.070	-0.013	0.065
9		M067	798.994	894.592	87.262	798.955	894.562	87.187	0.039	0.030	0.075
10		M098	257.858	286.800	22.669	257.845	286.798	22.617	0.013	0.002	0.052
11		M096	945.220	953.668	52.630	945.217	953.684	52.581	0.003	-0.016	0.049
12		M106	433.890	482.998	68.270	433.898	483.011	68.280	-0.008	-0.013	-0.010
13		M107	525.995	729.887	92.607	525.980	729.865	92.700	0.015	0.022	-0.093
14		M109	779.740	42.924	33.399	779.729	42.901	33.382	0.011	0.023	0.017
15		M110	492.902	113.358	40.566	492.915	113.350	40.548	-0.013	0.008	0.018
								RMS_{HAIL}=	0.029	0.017	0.066



TESTING (Continue)

Other Tested Factors

- **Time to Fix Ambiguity** (TTFA) ---→it is limited at first to 10 minutes but after a week it was decreased to 7 minutes.
- **Baseline Length** ---→ Distances varied from 2 to 50 km and total of 100 observations were included in the test. The results shows that the distance to nearest base station seems not to influence on horizontal accuracy at all and only a slight degradation of height accuracy and prolongation of initialization time. This indicates to successful modeling of errors.
- **Rover Position**---→ There is no difference whether the measurements are performed inside or outside the network (10 km further away from the reference station) where as, for initialization times, correlation is seen when measuring on extrapolation area.
- **Number of Satellites and DOP**---> Increasing number of satellites decreases the RMS of observations and initialization times get shorter when more satellites are visible.
- **Number of Epochs**---> At every point five-epoch and ten epoch observations were collected. However from the results we can say that using 10 epochs instead of 5 gives no additional value for the accuracy.

CHALLENGES

Surroundings

MGMN points were chosen as reference. Each point was measured twice under different satellite geometry. Every time signal is blocked by obstacles a new integer ambiguity for the satellite need to be resolved. This prolongs the initialization time but no big influence on accuracy.

Temporal Variation of Fixed Solution

Test was carried out by performing five longer fixed solutions. Duration of the solutions varied from one 10 minutes to 20 minutes and the observations were recorded with frequency of 1 second. The results show that the changes in number of satellites during the period is not affected the accuracy. Instead there is clear correlation between accuracy and PDOP. Therefore measurements during poor satellite geometry should be avoided.

CHALLENGES (Continue)

GSM connection

GSM connection was stuck few times needing a manual reset of GSM modem in computing centre. This may be caused by GSM modems themselves or weak GSM signal.

Missing Satellite Data

Another subject that caused problems was missing satellite data from distributed correction. This was caused by unsuccessful modeling or resolving of satellite data in computing centre.

Loss of Fixed Solution

Loss of fixed solution occurred few times causing a need for new initialization. Losses may be caused by obstacles, sudden changes in atmosphere or multipath.

CONCLUDING REMARKS

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- The MRTN infrastructure uses **advanced hardware and software**

- MRTN supports **multi-GNSS constellation**

- Industry standard correction formats (**CMR, RTCM 2.1, RTCM 2.3, RTCM 3.1**) are supported with real-time correction streaming of **up to 1Hz.**

- Output data formats supported are also industry standards like **RINEX v2.10, RINEX v.2.11 and RINEX v3.02.**

- The system has RTK stations with spacing of between **20 to 75 km**, forming the network as a first phase that covering the Major cities in The Kingdom.

- The MRTN system was **expanded and upgraded by including the** densifications **CORS stations of local municipalities**.

CONCLUDING REMARKS (Continue)

- VRS Correction test is carried out using MRTN at MOMRA Terrestrial Reference Frame (MTRF) pillars stations to compare MTRF observed coordinates with their corresponding published MTRF geodetic values.
- The results show that the accuracies in the horizontal and height component were less than 3 cm and 6 cm respectively.
- MRTN services can be used for various surveying applications such as engineering (i.e Riyadh metro network Project), boundary and cadastral survey.
- Under this project, services provided are free of charge throughout the country for all clients.
- The Virtual Reference Station technique has proven some of its performance in MRTN network as well.
- The web portal (www.momracors.com) can be visit, to observe and have brief idea about MRTN.

شكراً لكم

Teşekkür Ederiz

Thank You

Any Question

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