

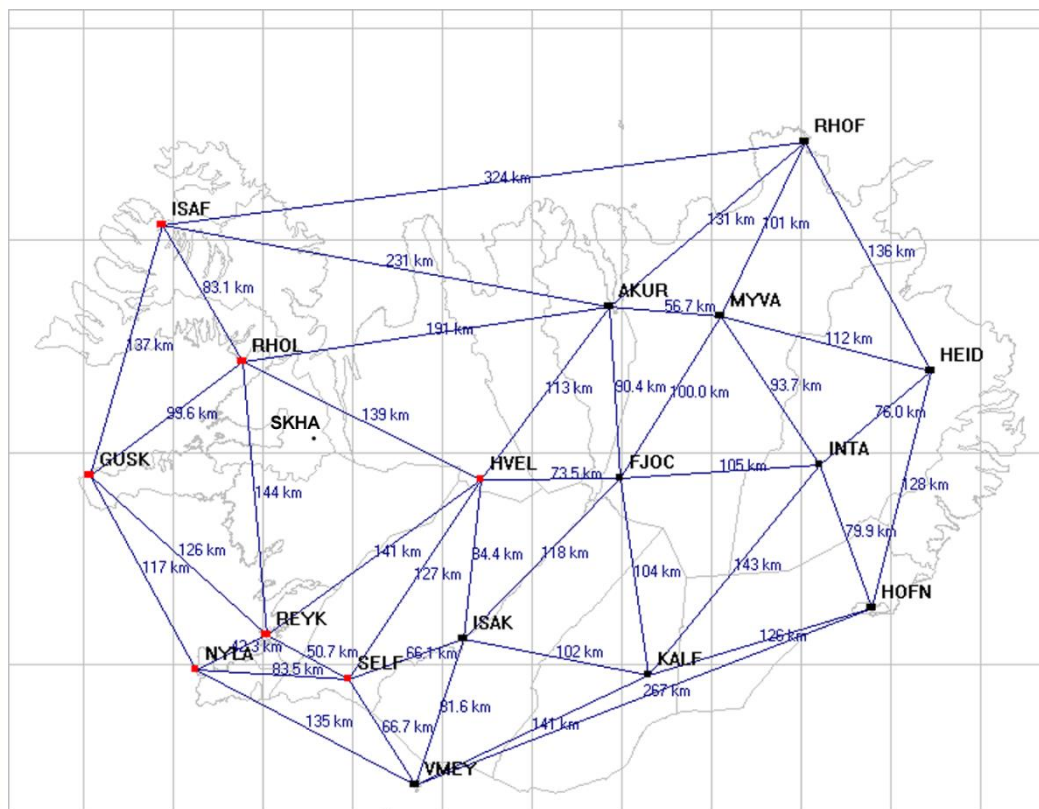
Appliance of IceCORS network 2017

by Dalia Prizginiene

The network configuration

STATIONS LIST

| 4-ID | DOMES | NAME | |
|------|-----------|--------------------------|-------------|
| AKUR | 10206M001 | Akureyri University | GPS+GLONASS |
| FJOC | 10212M001 | Fjordungsalda | GPS |
| GUSK | 10207M001 | Gufuskalar | GPS+GLONASS |
| HEID | 10208M001 | Heidarsel | GPS+GLONASS |
| HOFN | 10204M002 | Hofn i Hornafjordur | GPS+GLONASS |
| HVEL | 10218M001 | Hveravellir | GPS |
| INTA | 10213M001 | Inntakshus (Karahnjúkar) | GPS |
| ISAF | 10209M001 | Isafjordur | GPS+GLONASS |
| ISAK | 10214M001 | Isakot | GPS+GLONASS |
| KALF | 10215M001 | Kalfafell | GPS |
| MYVA | 10205M001 | Myvatn | GPS+GLONASS |
| NYLA | NYLA | Nylenda | GPS |
| REYK | 10202M001 | Reykjavik University | GPS+GLONASS |
| RHOF | 10216M001 | Raufarhofn | GPS+GLONASS |
| RHOL | 10210M001 | Reykholar | GPS+GLONASS |
| SELF | SELF | Selfoss | GPS |
| SKHA | 10211M001 | Skardshamrar | GPS+GLONASS |
| VMEY | 10217M001 | Vestmannaeyjar | GPS+GLONASS |



Requirements for the COR stations

Foundation:

Bedrock or mass concrete base
Competent rock through layers of soil or fractured rock

Monumentation:

Reinforced concrete pillar

Interference:

Minimum sky obstruction

Minimise multipath sources

Long-term site tenure

Power:

Ensure continuous operation of GNSS receiver

Communication:

Support remote control and data access
Reliable and continuous, with a latency of less than 2 seconds from CORS to end user (when used for real-time positioning applications)

Receiver:

Dual frequency code and carrier phase tracking
Continuous logging of raw GNSS data inside the receiver
Ability to store at least 60 days of raw data

Antenna:

Choke ring antenna
Individually calibrated absolute antenna phase centre
IGS calibrated absolute antenna phase centre

Weather Station:

Pressure measurement accuracy better than ± 0.5 hPa
Temperature measurement accuracy better than ± 1 degree C
Relative Humidity measurement to better than $\pm 2\%$

Coordinates:

Coordinates in national geodetic datum, derived by national processing centre

Site Monitoring:

Continuous monitoring with IGS sites
Periodic high precision, local monitoring survey

Data format:

Raw Proprietary format for archiving
RINEX for post-processing

Reliability:

Require complete, continuous time series dataset for post-processing
Short communication outages tolerated

Metadata:

Complete and current IGS site log including DOMES number
Readily available site metadata

Antennas:

- 1 Aeroantenna,
- 4 Trimble Choke Ring,
- 3 Leica AR25,
- 10 Trimble Zephyr Geodetic,

Receivers:

- 1 Novatel
- 6 NETRS
- 5 NETR5
- 1 NETR9
- 3 LEICA
- 2 SEPTENTRIO

Single Reference Station RTK

- The rover transmits their location to the system using NMEA-GGA output.
- The user selects the input format available in IceCORS NtripTable through **213.167.147.216:2101**
 - ✓ RTCM23 (RTCM 2.3)
 - ✓ RTCM30 (RTCM 3.0)

| Caster | Mountpoint | Identifier / Description | Format | Format Details (Rate) |
|----------------------|------------|--------------------------|----------|--|
| 2101 | FKP2 | FKP23 | RTCM 2.3 | 1, 3(10), 14(60), 16(300), 20, 21, 22(10) 23(10), 24(10) |
| 2101 | VRS3 | VRS30 | RTCM 3.0 | 1004(1), 1006(10), 1007(30), 1012, 1030(30), 1031(30), 1032(10), 1033(60) |
| 2101 | MAC | MAC | RTCM 3.1 | 1004, 1006(10), 1007(10), 1012, 1014(10), 1017(10), 1030(30), 1031(30), 1033(60), 1039(10) |
| 2101 | RTCM30 | RTCM30 | RTCM 3.0 | 1004(1), 1006(10), 1012, 1033(10) |
| 2101 | FKP3 | FKP31 | RTCM 3.1 | 1004, 1006(10), 1007(30), 1012, 1030(30), 1031(30), 1033(10), 1034(10), 1035(10) |
| 2101 | RTCM23 | RTCM23 | RTCM 2.3 | 1, 3(17), 14(61), 16(300), 20(1), 21(1), 22(17), 23(17), 24(17) |
| 2101 | VRS2 | VRS23 | RTCM 2.3 | 1, 3(10), 14(60), 16(300), 20, 21, 22(10), 23(10), 24(10) |

Single Reference Station RTK

| | | | | |
|----------------------|--------|--------|-------------|-----------------------------------|
| 2101 | RTCM30 | RTCM30 | RTCM 3.0 | 1004(1), 1006(10), 1012, 1033(10) |
|----------------------|--------|--------|-------------|-----------------------------------|

1004 – GPS L1+L2 observations, Signal to Noise (CNO) and full milliseconds for code observations

1006 – ARP station coordinates, ECEF XYZ and antenna height

1012 – GLONASS L1+L2 observations , Signal to Noise (CNO) and full milliseconds for code observations

1033 – Receiver and antenna description

| | | | | |
|----------------------|--------|--------|-------------|---|
| 2101 | RTCM23 | RTCM23 | RTCM 2.3 | 1, 3(17), 14(61), 16(300), 20(1), 21(1), 22(17), 23(17), 24(17) |
|----------------------|--------|--------|-------------|---|

1 – Differential GPS corrections

3 – Reference station coordinates ECEF XYZ

14 – GPS time (GPS week and full hours within week, leap seconds between UTC and GPS time)

16 – Special message

20 – RTK carrier phase corrections

21 – RTK pseudorange corrections

22 – Antenna height

23 – Antenna description, antenna serial number

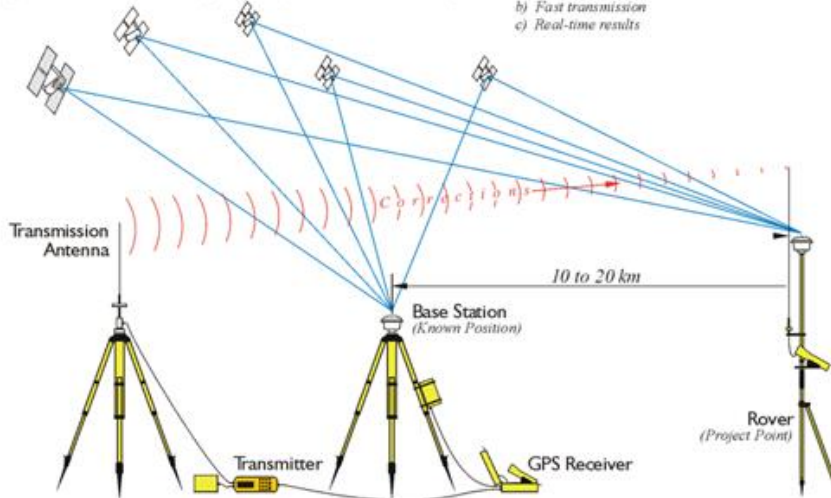
24 – Coordinates of antenna reference point ARP of reference station ECEF XYZ, antenna height

RTK and Differential GPS

Real-Time-Kinematic

Positional Accuracy +/- 2 cm or so

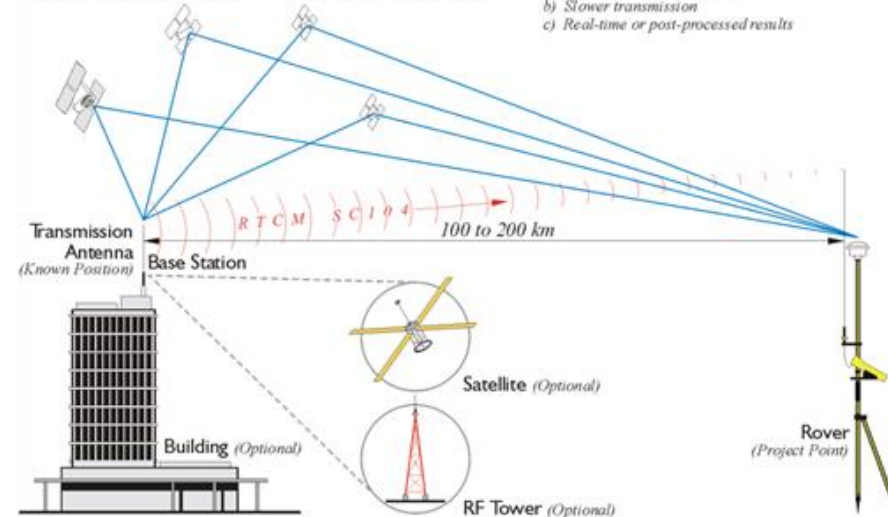
- Same Satellite Constellation (Base Station - Rover/or Rovers)
- Carrier Phase (Track 5 Satellites Minimum)
- Radio Link
 - a) More information
 - b) Fast transmission
 - c) Real-time results



Differential GPS/DGPS

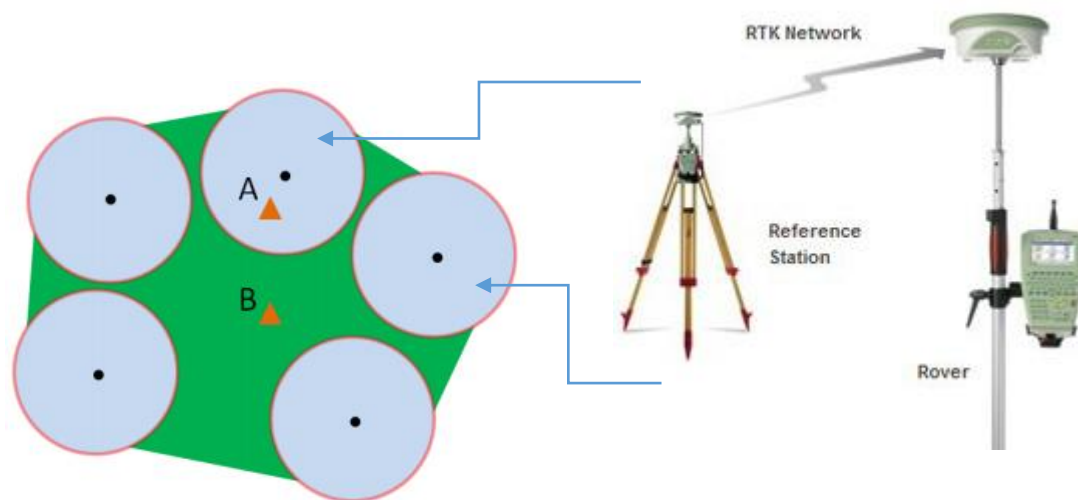
Positional Accuracy +/- 1 meter or so

- Same Satellite Constellation (Base Station - Rover/or Rovers)
- Code Phase/Pseudorange (Track 4 Satellites Minimum)
- Radio Link
 - a) Less information than RTK
 - b) Slower transmission
 - c) Real-time or post-processed results



Single Reference Station RTK

- RTCM23 (GPS only)
- RTCM30 (GPS+GLONASS)



- The rover and the base station must be able to see the same constellation of satellites (minimum of 5) for accurate correction data and to achieve RTK quality.
- The reference sends all its position and satellite observations to the rover.
- The rover combines these reference station observations with its own observations to compute an RTK position relative to the base with RTCM3.0 but with RTCM 2.3 the rover applies the corrections from the reference station to his observations to calculate rovers RTK position.
- **Disadvantage:** This method is limited to baselines of approximately 10 – 20km due to the effect that distance related errors (atmosphere and satellite orbits) have on the ambiguity resolution (initialization) and solution precision. As the distance increases between the reference and the rover the accuracy of the rovers computed position decreases.

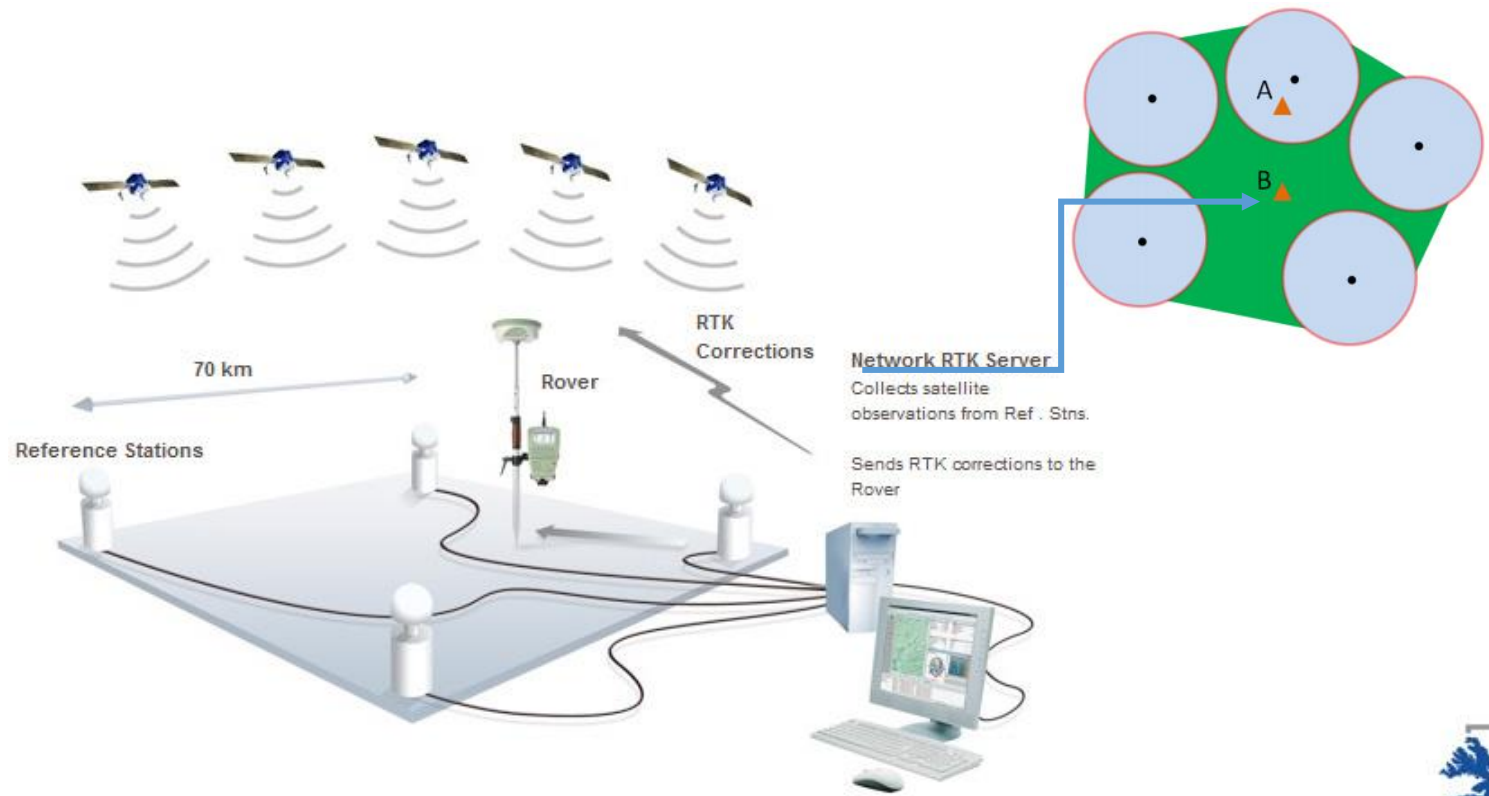
Network RTK

- The rover transmits their location to the system using NMEA –GGA output.
- The user selects the input format available in IceCORS NtripTable through **213.167.147.216:2101**
 - ✓ VRS3 (RTCM 3.0) and VRS2 (RTCM 2.3)
 - ✓ MAC (RTCM 3.1)
 - ✓ FKP2 (RTCM 2.3) and FKP3 (RTCM 3.1)

| Caster | Mountpoint | Identifier / Description | Format | Format Details (Rate) |
|-------------|------------|--------------------------|----------|--|
| <u>2101</u> | FKP2 | FKP23 | RTCM 2.3 | 1, 3(10), 14(60), 16(300), 20, 21, 22(10) 23(10), 24(10) |
| <u>2101</u> | VRS3 | VRS30 | RTCM 3.0 | 1004(1), 1006(10), 1007(30), 1012, 1030(30), 1031(30), 1032(10), 1033(60) |
| <u>2101</u> | MAC | MAC | RTCM 3.1 | 1004, 1006(10), 1007(10), 1012, 1014(10), 1017(10), 1030(30), 1031(30), 1033(60), 1039(10) |
| <u>2101</u> | FKP3 | FKP31 | RTCM 3.1 | 1004, 1006(10), 1007(30), 1012, 1030(30), 1031(30), 1033(10), 1034(10), 1035(10) |
| <u>2101</u> | VRS2 | VRS23 | RTCM 2.3 | 1, 3(10), 14(60), 16(300), 20, 21, 22(10), 23(10), 24(10) |

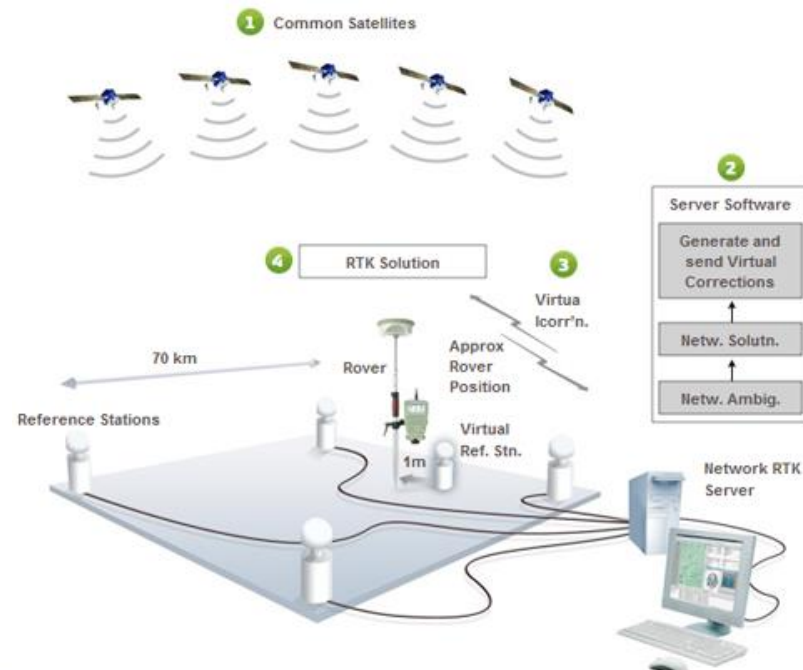
Network RTK

- The network RTK is to minimize the influence of the distance dependent errors (atmosphere and satellite orbits) on the computed position of a rover within the bounds of the network
- If observations from one reference station are not available, a solution is still possible since the observations are gathered and processed in a common network adjustment.



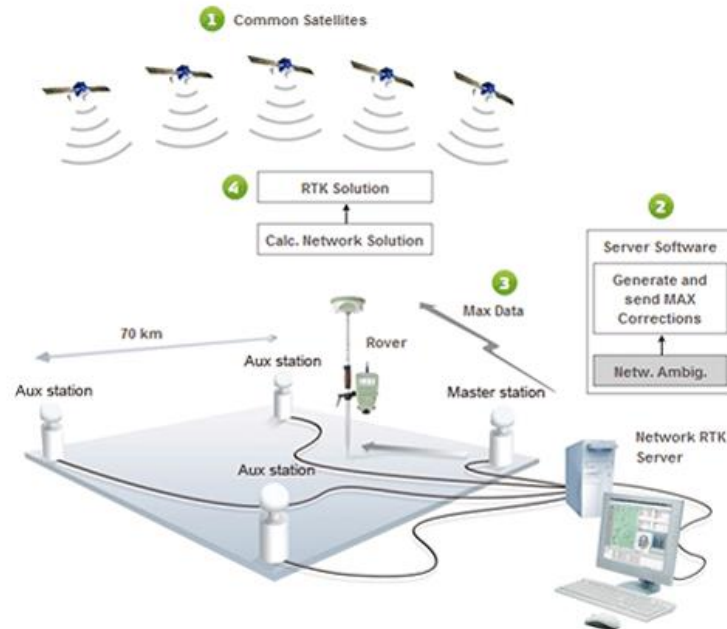
NRTK(RTN) – Virtual reference Station

- VRS3 (RTCM 3.0) and VRS2 (RTCM 2.3)
 - The rover sends approximate position through NMEA-GGA format.
 - The VRS location is typically selected at the initial approximate position of the rover.
 - Using an appropriate algorithm, the network server resolves the ambiguities of the network and reduces the satellite data to this common ambiguity. **(Network ambiguity)**
 - The reference stations continuously track the satellites signals in order to determine the dispersive (ionosphere) and non-dispersive (troposphere and ephemeris) biases. **(Network solution)**
 - Those bias can be interpolated for a virtual reference station and send to the rover. **(Virtual corrections)**
 - The rover applies the corrections to his observations from a VRS and update his position. In RTCM 3.0 the constructed VRS observations are computed and sent to the rover.
 - With the Virtual Reference Station method the rover does not receive any observations related to a real reference station. This means that the baseline between the virtual reference station and the measured point cannot be directly re-measured.



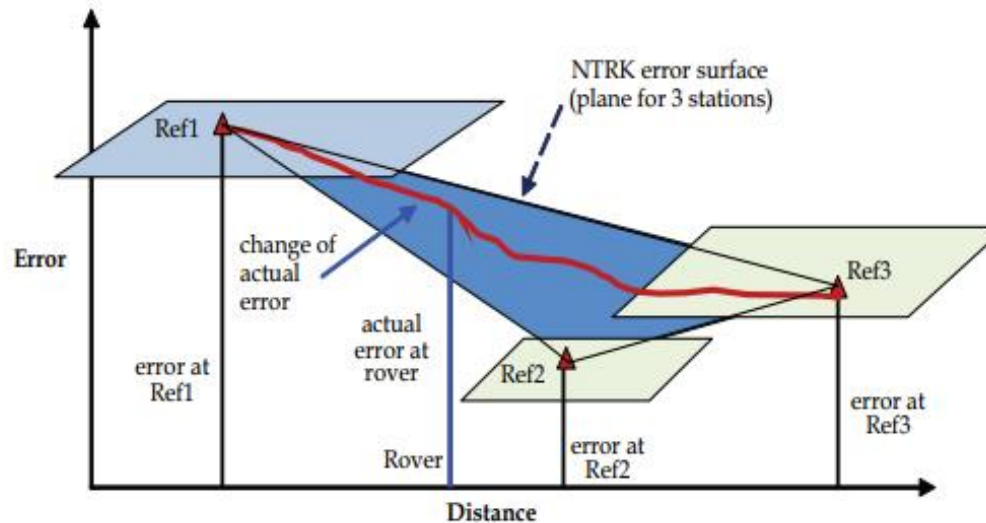
NRTK(RTN) – MAC (MAX corrections)

- MAC (RTCM 3.1)
 - The rover sends its approximate position via NMEA-GGA
 - The nearest station is selected as a Master station.
 - The phase ranges from all reference stations are reduced to a common ambiguity level. (**Network ambiguity resolution**)
 - Full raw observation and coordinate information for the Master station are sent to the rover.
 - The Master – auxiliary correction differences are formed using the phase observations of the selected reference stations, corrected only by the estimated network ambiguities, the common part of the receiver clock and known values (geometric range and satellite clock). Between – station single differences are then used to create the correction differences that are transmitted for the auxiliary stations. (**Mac/MAX corrections**)
 - The rover uses the information provided by the network to determine the dispersive and non-dispersive errors at its location.
 - The rover resolves its ambiguities and determines its position using full information of the reference network.



NRTK(RTN) – FKP

- FKP2 (RTCM 2.3) and FKP3 (RTCM 3.1)
 - The rover sends his approximate coordinates in NMEA-GGA output.
 - Using an appropriate algorithm, the network server resolves the ambiguities of the network . (**Network ambiguity**)
 - The reference stations continuously track the satellites signals in order to determine the dispersive (ionosphere) and non-dispersive (troposphere and ephemeris) biases. (**Network solution**)
 - The FKP's provide information about the distance dependent error components. For the representation of the position dependent errors a linear area polynomial is used.
 - FKP is transmitted to the rover.
 - The interpretation of the FKP and the individualization of the corrections are done at the rover.
 - The correction of a real reference station are used in combination with the FKP to compute the individualized corrections for the rover position.
 - MAC and FKP is similar. They both use output for the master station and add information about spatial variations of the corrections. FKP sends these spatial variations as ppm values in N,E directions and MAC sends the spatial variations for discrete points (auxiliary stations)



Near future- Dynamic frame

- The fix coordinates of the IceCORS network keep in the range of 2cm accuracy.
 - The coordinates will be updated every 6 month, that to keep the accuracy in the range of 2cm. The values of max velocities from the current 18 CORS stations looks like this:
 - KALF dE=7.17mm/year, dN=9.58mm/year, dU=24.18mm/year
 - SELF dE=0.80mm/year, dN=18.4mm/year, dU=1.10mm/year
 - FJOC dE=-7.31mm/year, dN=27.21mm/year, dU=23.06mm/year
 - Or the coordinates can be changed regarding big event as earthquake.
 - Deformation model is also updated at the same time the coordinates are updated.
- The first implementation of the reference coordinates ISN2016, epoch 2016.5 (IGS14) will be in 1.9.2017
 - Rover by connecting to all streams will stay in ISN2016 frame:

| Caster | Mountpoint | Identifier / Description | Format | Format Details (Rate) |
|----------------------|------------|--------------------------|----------|--|
| 2101 | FKP2 | FKP23 | RTCM 2.3 | 1, 3(10), 14(60), 16(300), 20, 21, 22(10) 23(10), 24(10) |
| 2101 | VRS3 | VRS30 | RTCM 3.0 | 1004(1), 1006(10), 1007(30), 1012, 1030(30), 1031(30), 1032(10), 1033(60) |
| 2101 | MAC | MAC | RTCM 3.1 | 1004, 1006(10), 1007(10), 1012, 1014(10), 1017(10), 1030(30), 1031(30), 1033(60), 1039(10) |
| 2101 | RTCM30 | RTCM30 | RTCM 3.0 | 1004(1), 1006(10), 1012, 1033(10) |
| 2101 | FKP3 | FKP31 | RTCM 3.1 | 1004, 1006(10), 1007(30), 1012, 1030(30), 1031(30), 1033(10), 1034(10), 1035(10) |
| 2101 | RTCM23 | RTCM23 | RTCM 2.3 | 1, 3(17), 14(61), 16(300), 20(1), 21(1), 22(17), 23(17), 24(17) |
| 2101 | VRS2 | VRS23 | RTCM 2.3 | 1, 3(10), 14(60), 16(300), 20, 21, 22(10), 23(10), 24(10) |

Near future- Dynamic frame

- The second expected implementation of the reference coordinates would be epoch 2018,2 (IGS14) in 1.3.2018
 - New Mount points in the IceCORS NtripCaster table. These Mount points will be dedicated for ISN2016 frame:

| Caster | Mountpoint | Identifier / Description | Format | Format Details (Rate) |
|----------------------|------------|--------------------------|----------|--|
| 2101 | VRS3_16 | VRS30 | RTCM 3.0 | 1004(1), 1006(10), 1007(30), 1012, 1030(30), 1031(30), 1032(10), 1033(60) |
| 2101 | MAC_16 | MAC | RTCM 3.1 | 1004, 1006(10), 1007(10), 1012, 1014(10), 1017(10), 1030(30), 1031(30), 1033(60), 1039(10) |
| 2101 | RTCM30_16 | RTCM30 | RTCM 3.0 | 1004(1), 1006(10), 1012, 1033(10) |
| 2101 | FKP3_16 | FKP31 | RTCM 3.1 | 1004, 1006(10), 1007(30), 1012, 1030(30), 1031(30), 1033(10), 1034(10), 1035(10) |

- Residual grid is used to make transformation between current reference frame to ISN2016 frame.
- The current Mount points rover will stay in the dynamic IGS14, epoch 2018,2 frame.

| Caster | Mountpoint | Identifier / Description | Format | Format Details (Rate) |
|----------------------|------------|--------------------------|----------|--|
| 2101 | FKP2 | FKP23 | RTCM 2.3 | 1, 3(10), 14(60), 16(300), 20, 21, 22(10) 23(10), 24(10) |
| 2101 | VRS3 | VRS30 | RTCM 3.0 | 1004(1), 1006(10), 1007(30), 1012, 1030(30), 1031(30), 1032(10), 1033(60) |
| 2101 | MAC | MAC | RTCM 3.1 | 1004, 1006(10), 1007(10), 1012, 1014(10), 1017(10), 1030(30), 1031(30), 1033(60), 1039(10) |
| 2101 | RTCM30 | RTCM30 | RTCM 3.0 | 1004(1), 1006(10), 1012, 1033(10) |
| 2101 | FKP3 | FKP31 | RTCM 3.1 | 1004, 1006(10), 1007(30), 1012, 1030(30), 1031(30), 1033(10), 1034(10), 1035(10) |
| 2101 | RTCM23 | RTCM23 | RTCM 2.3 | 1, 3(17), 14(61), 16(300), 20(1), 21(1), 22(17), 23(17), 24(17) |
| 2101 | VRS2 | VRS23 | RTCM 2.3 | 1, 3(10), 14(60), 16(300), 20, 21, 22(10), 23(10), 24(10) |

Virtual RINEX

- The current Virtual RINEX represents ISN2016 frame.
- After implementing dynamic frame. In the header of Virtual RINEX the coordinates ARP (X,Y,Z) allways changes
- User must be aware in what epoch of ITRF he is getting Virtual RINEX

Regular RINEX

- The coordinates of marker (X,Y,Z) always changes
- User must be aware in what epoch of ITRF he is getting RINEX

Thank you

References

1. <https://sites.aces.edu>
2. <http://uk.smartnet-eu.com>
3. <https://www.e-education.psu.edu>
4. <http://www.geopp.com>