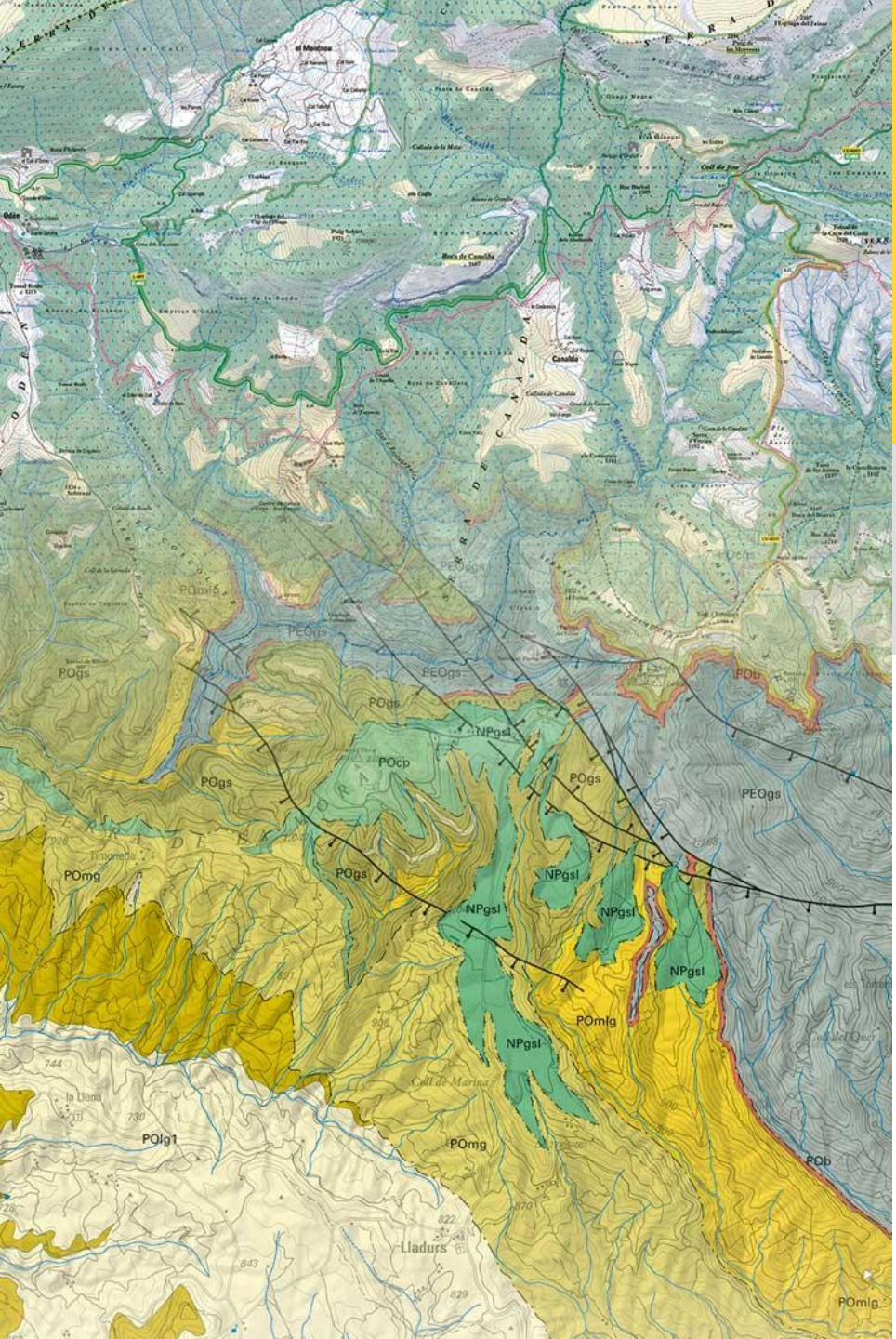


P-VRS: The Permanent – Virtual Reference Station new concept

Joel Grau Bellet

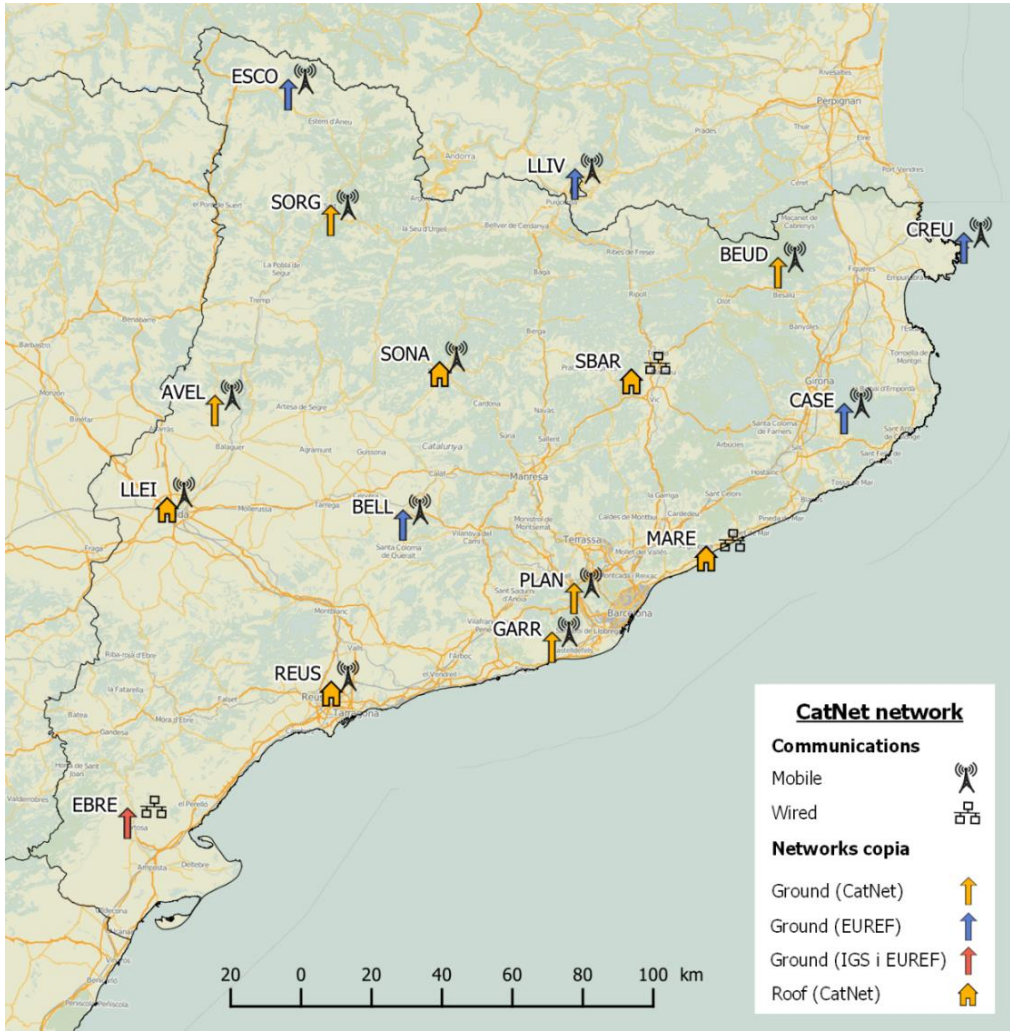
Head of Geodesy Unit

ICGC
Institut Cartogràfic i Geològic de Catalunya

Generalitat de Catalunya

CatNet network current status

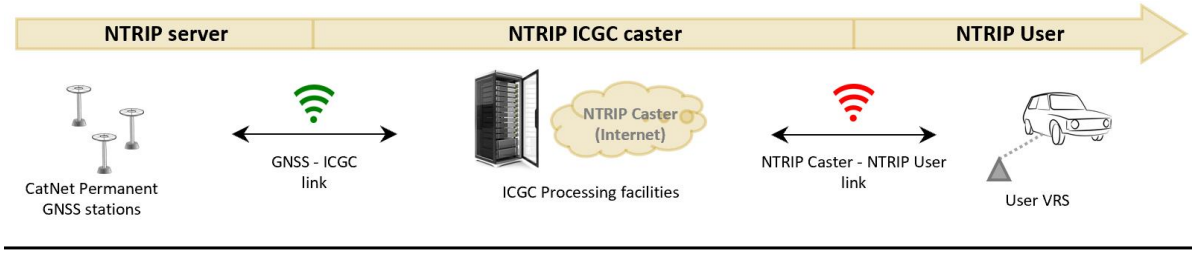
- GPS, GLO, GAL & BDS receivers
- Geodetic and individually calibrated antennas
- 4G and LAN connectivity
- Services
  - NTRIP
  - GeoFons
  - RINEX shop

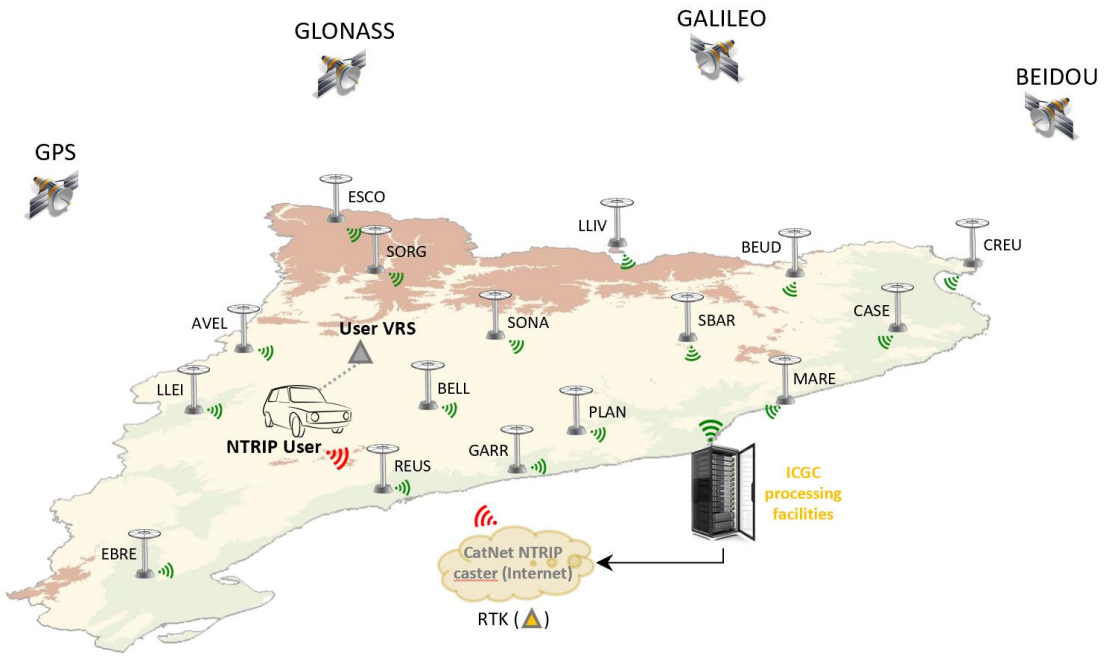


VRS – Virtual Reference Station

- The servers at ICGC create a VRS for each user in its coordinates
  - The user needs to send the approximate coordinates
  - This limits de potential scalability of the solution*

- UNION proposes the new Permanent VRS (P-VRS) network concept
  - No scalability limitations
  - Includes Galileo – HAS
  - Allows interterritorial navigation





* Current status of the real time services at ICGC and scalability for the future

P-VRS – Permanent Virtual Reference Station

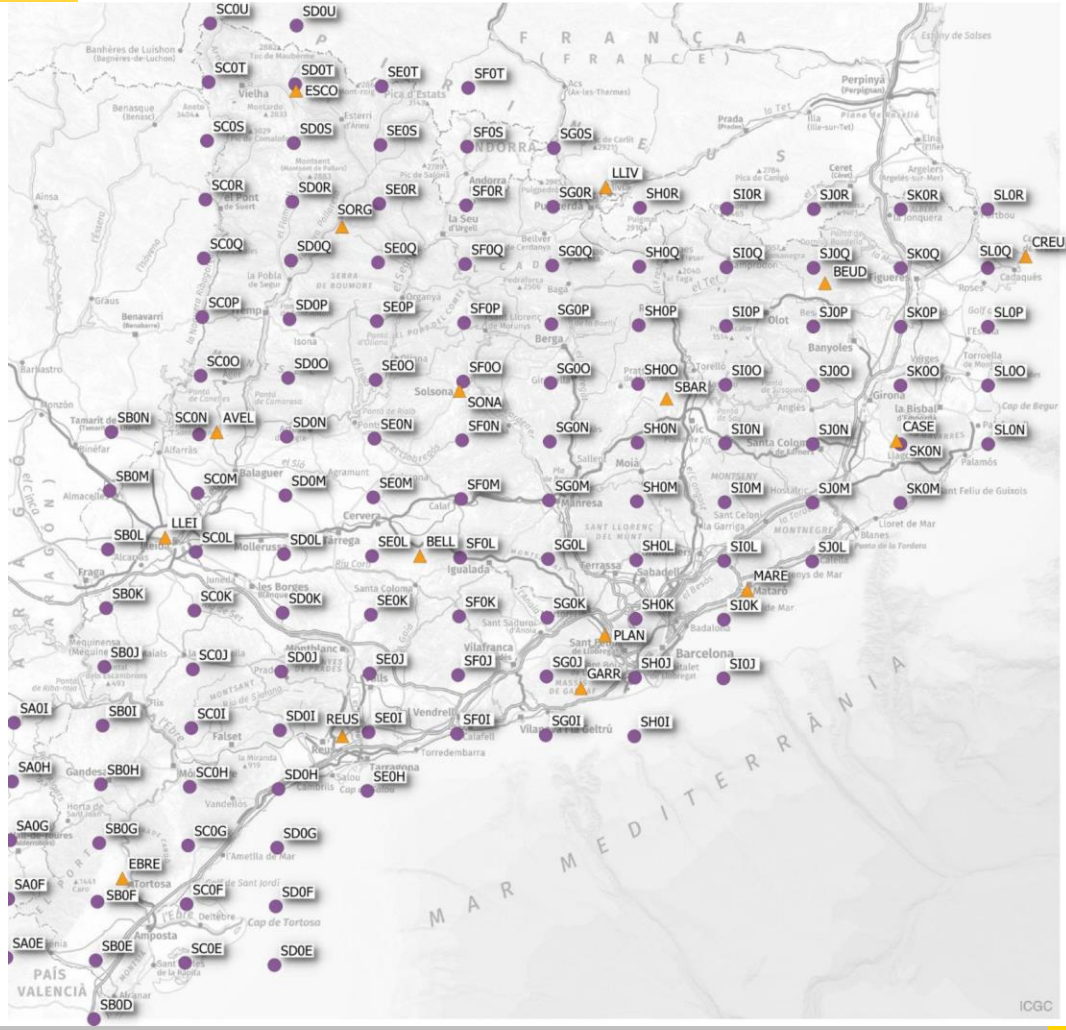
- Consists in the creation of a regular grid of VRS stations
  - With a grid spacing of 20 x 20 km should be enough to fulfil VRS like accuracy
  - These stations are called P-VRS (Permanent Virtual Reference Station)

- This P-VRS are published in the UNION NTRIP caster
  - Any user will have at least 3 stations closer than 20 km
    - TTFF (Time-To-First-Fix) should be similar to the one from the standard VRS concept
  - Users can (have to) “choose” and connect to the closest station
  - There is no need to send coordinates as:
    - All the P-VRS required stations are already available and accessible to all users
    - The users are capable of choosing the closest station according its position
    - The server does not need to create a new VRS for each user accessing the service

Proposed network of P-VRS stations

Worldwide naming: UNION_ααββ

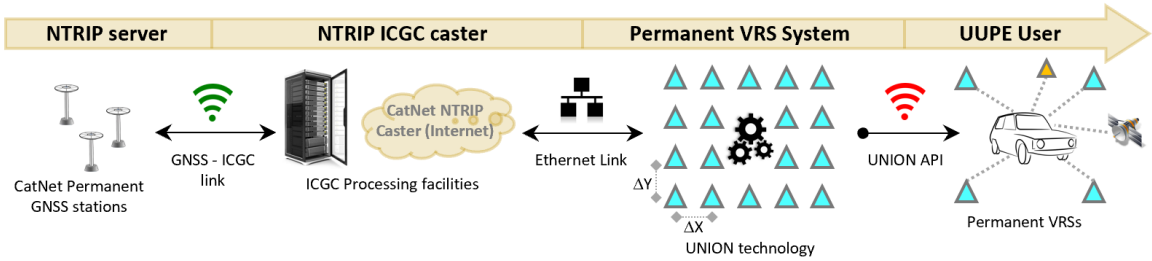
- α and β take values from:
  - A,B,C,D…Z,1,2,3,4…9
  - 36 x 36 = 1296 nodes
- NTRIP naming
  - UNION - Constant
  - AA – Longitude (26 + 10)
  - BB – Latitude (26 + 10)
- IGS std. RINEX naming
  - AA – Longitude (26 + 10)
  - BB – Latitude (26 + 10)

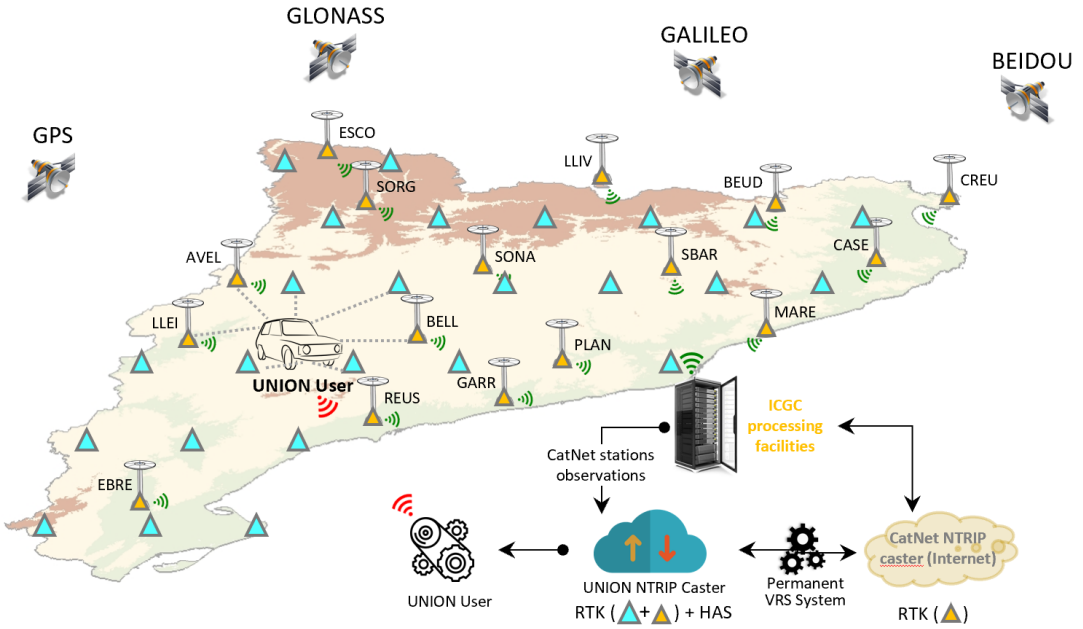


Permanent VRS System

Unidirectional connection

- Designed to provide access to a network of “synthetical” stations
  - Nowadays, the CatNet network is the one providing corrections
  - The tool should work with any other similar network anywhere in the world
- Physical stations are also used in combination with P-VRS





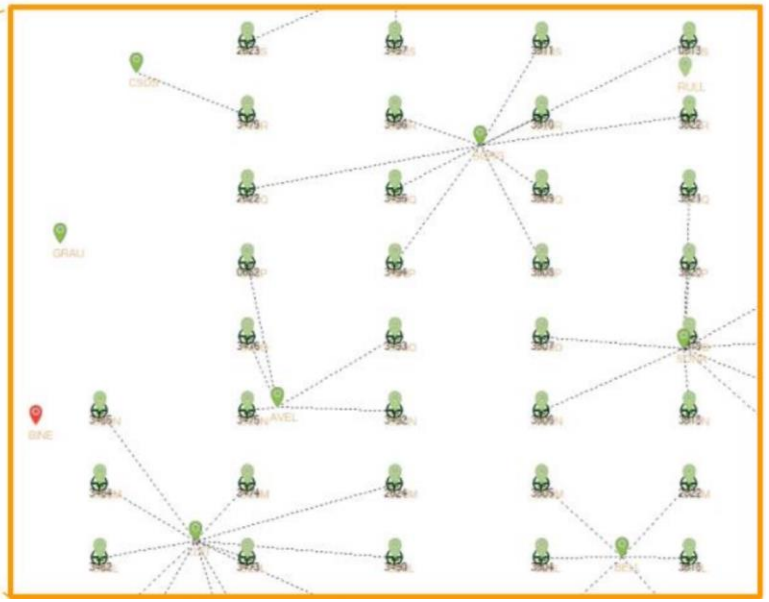
Permanent VRS System

Permanence of stations

- P-VRS are created in exactly the same way as if they were users working in the field

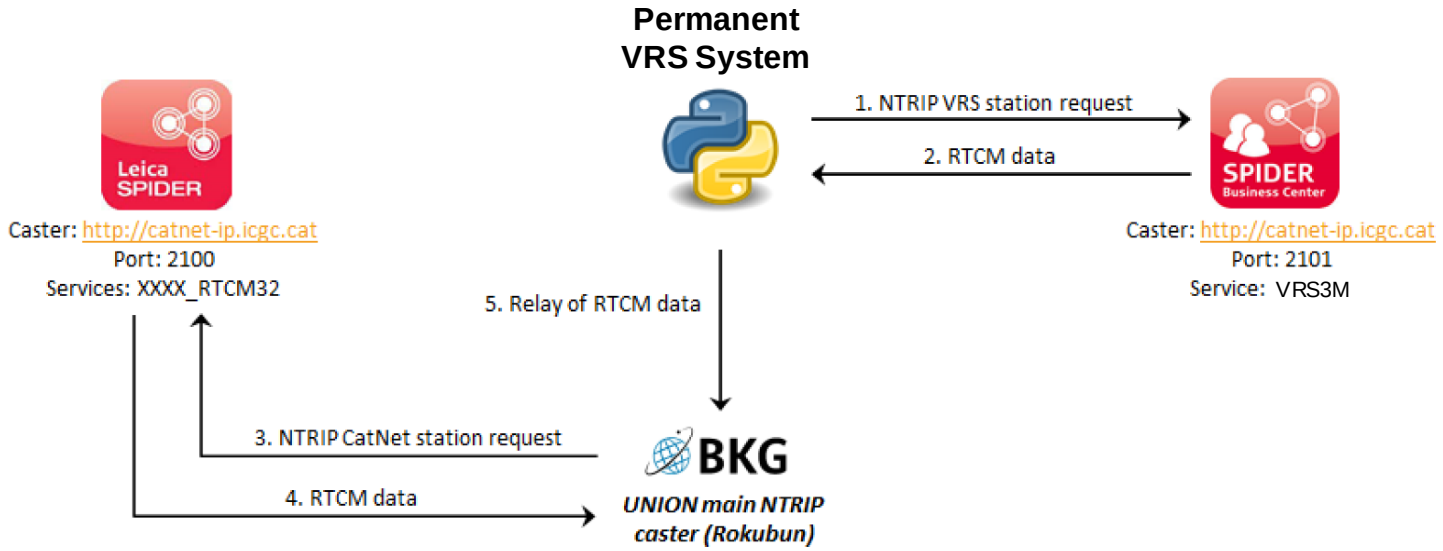
PVRS all over Catalonia (124)

VRS baselines details



Permanent VRS System

- P-VRS are created in exactly the same way as if they were users working in the field
- Real CatNet stations are also included in the UNION NTRIP caster, so acting as additional mountpoints



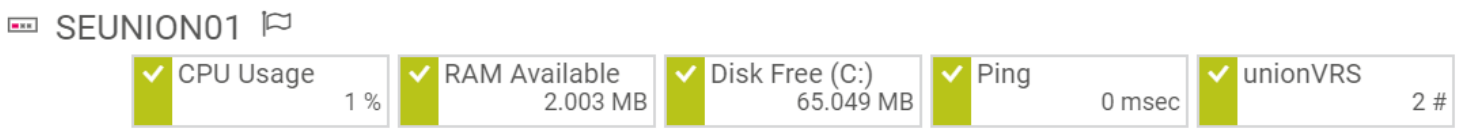
Data flow

- ICGC provides GPS, GLO, GAL, BDS data to the UNION caster:
  - UNION P-VRS are getting data from the ‘VRS3M’ service
  - CatNet stations are providing also MSM5 RTCM 3.2 in 1075(1),1085(1),1095(1),1125(1)

Site Name	Age [s]	Comm Activity	Data Rate	Da...	GPS	GLO	GAL	BDS
UNION_SC0U	0.23	receive data	1.000 sec	99.7	9	7	7	3
UNION_SD0E	0.20	receive data	1.000 sec	99.9	9	7	7	3
UNION_SD0F	0.28	receive data	1.000 sec	99.9	9	7	7	3
UNION_SD0G	0.28	receive data	1.000 sec	99.8	9	7	7	3
UNION_SD0H	0.28	receive data	1.000 sec	99.8	9	7	7	3
UNION_SD0I	0.28	receive data	1.000 sec	99.8	9	7	7	3
UNION_SD0J	0.28	receive data	1.000 sec	99.8	9	7	7	3
UNION_SD0K	0.53	receive data	1.000 sec	99.8	9	6	7	3
UNION_SD0L	0.53	receive data	1.000 sec	99.8	9	6	7	3
UNION_SD0M	0.53	receive data	1.000 sec	99.9	9	6	7	3
UNION_SD0N	0.25	receive data	1.000 sec	99.9	9	5	7	3
UNION_SD0O	0.31	receive data	1.000 sec	99.9	9	5	7	3
UNION_SD0P	0.38	receive data	1.000 sec	99.8	9	7	7	3
UNION_SD0Q	0.38	receive data	1.000 sec	99.7	9	7	7	3
UNION_SD0R	0.38	receive data	1.000 sec	99.7	9	7	7	3
UNION_SD0S	0.23	receive data	1.000 sec	99.7	9	7	7	3
UNION_SD0T	0.23	receive data	1.000 sec	99.8	9	7	7	3
UNION_SD0U	0.23	receive data	1.000 sec	99.8	9	7	7	3
UNION_SE0H	0.28	receive data	1.000 sec	99.8	9	7	7	3
UNION_SE0I	0.28	receive data	1.000 sec	99.8	9	7	7	3
UNION_SE0J	0.28	receive data	1.000 sec	99.8	9	7	7	3
UNION_SE0K	0.27	receive data	1.000 sec	99.9	9	6	6	3
UNION_SE0L	0.14	receive data	1.000 sec	99.9	9	6	6	3
UNION_SE0M	0.27	receive data	1.000 sec	99.8	9	6	6	3
UNION_SE0N	0.31	receive data	1.000 sec	99.9	9	7	7	3
UNION_SE0O	0.31	receive data	1.000 sec	99.9	9	7	7	3
UNION_SE0P	0.38	receive data	1.000 sec	99.8	9	7	7	3
UNION_SE0Q	0.38	receive data	1.000 sec	99.8	9	7	7	3
UNION_SE0R	0.38	receive data	1.000 sec	99.9	9	7	7	3
UNION_SE0S	0.39	receive data	1.000 sec	99.9	9	7	7	3
UNION_SE0T	0.31	receive data	1.000 sec	99.9	9	7	7	3
UNION_SF0I	0.28	receive data	1.000 sec	99.8	9	7	7	3
UNION_SF0J	0.28	receive data	1.000 sec	99.9	9	7	7	3

UNION server at ICGC

- The P-VRS software is solely based on Python
- It is running on an Ubuntu Linux (64-bit server)
  - CPU: 2 CPUs
  - Memory: 4 GB
  - Hard disk: 80 GB
- It is performing 24x7 and monitored using PRTG:



Accuracy validation

- Accuracy has been evaluated against the official ETRS89 RF

					Against Bernese coordinates		
Measure	X_UTM (m)	Y_UTM (m)	EH (m)	DD with...	DX_UTM	DY_UTM	D_EH
1	429425.940	4580163.768	114.153	VRS_GAL	0.002	0.003	0.077
2	429425.958	4580163.767	114.125	VRS_GAL	0.020	0.002	0.049
3	429425.934	4580163.775	114.095	VRS_GAL	-0.004	0.010	0.019
Mean:	429425.944	4580163.770	114.047				
101	429425.930	4580163.739	113.990	SH0J	-0.008	-0.026	-0.009
102	429425.944	4580163.743	113.971	SH0J	0.006	-0.022	-0.028
103	429425.942	4580163.741	113.997	SH0J	0.004	-0.024	-0.002
202	429425.940	4580163.759	113.988	SH0K	0.002	-0.006	-0.011
203	429425.939	4580163.763	114.028	SH0K	0.001	-0.002	0.029
301	429425.933	4580163.754	113.997	SI0K	-0.005	-0.011	-0.002
303	429425.904	4580163.771	113.996	SI0K	-0.034	0.006	-0.003

Mean:	-0.005	-0.012	-0.004
Min:	-0.034	-0.026	-0.028
Max:	0.006	0.006	0.029

Conclusions

- From the user point of view:
  - It is essentially the same trusted VRS concept
  - It is capable of providing the same accuracy as current services
  - It allows the combination with PPP positioning whenever required
  - It allows using extra services as HAS and could be continuous worldwide
- From the provider point of view:
  - Allows scalability with the same resources that are currently used
  - It takes benefit from the wide extended NTRIP concept
  - It allows providing extra services
  - It allows covering the whole territory, either with VRS or with PPP

Mass-market is feasible

This project has received funding from the European Union Agency for the Space Programme under grant agreement No GSA/GRANT/06/2019-UNION

Institut Cartogràfic i Geològic de Catalunya

Parc de Montjuïc,
E-08038 Barcelona

41º22’12” N, 2º09’20” E (ETRS89)

www.icgc.cat
icgc@icgc.cat
twitter.com/ICGCat
facebook.com/ICGCat

Tel. (+34) 93 567 15 00
Fax (+34) 93 567 15 67