Vlaanderen
is verbonden

Integratie van Galileo in Flepos

Laatste stand van zake

INFORMATIE
VLAANDEREN

www.vlaanderen.be/informatievlaanderen

Overview

> Flepos – supporting all GNSS systems and signals

> Will Galileo/Modernized GPS obsolete Network RTK?

> Where and how do we find Galileo? – General information

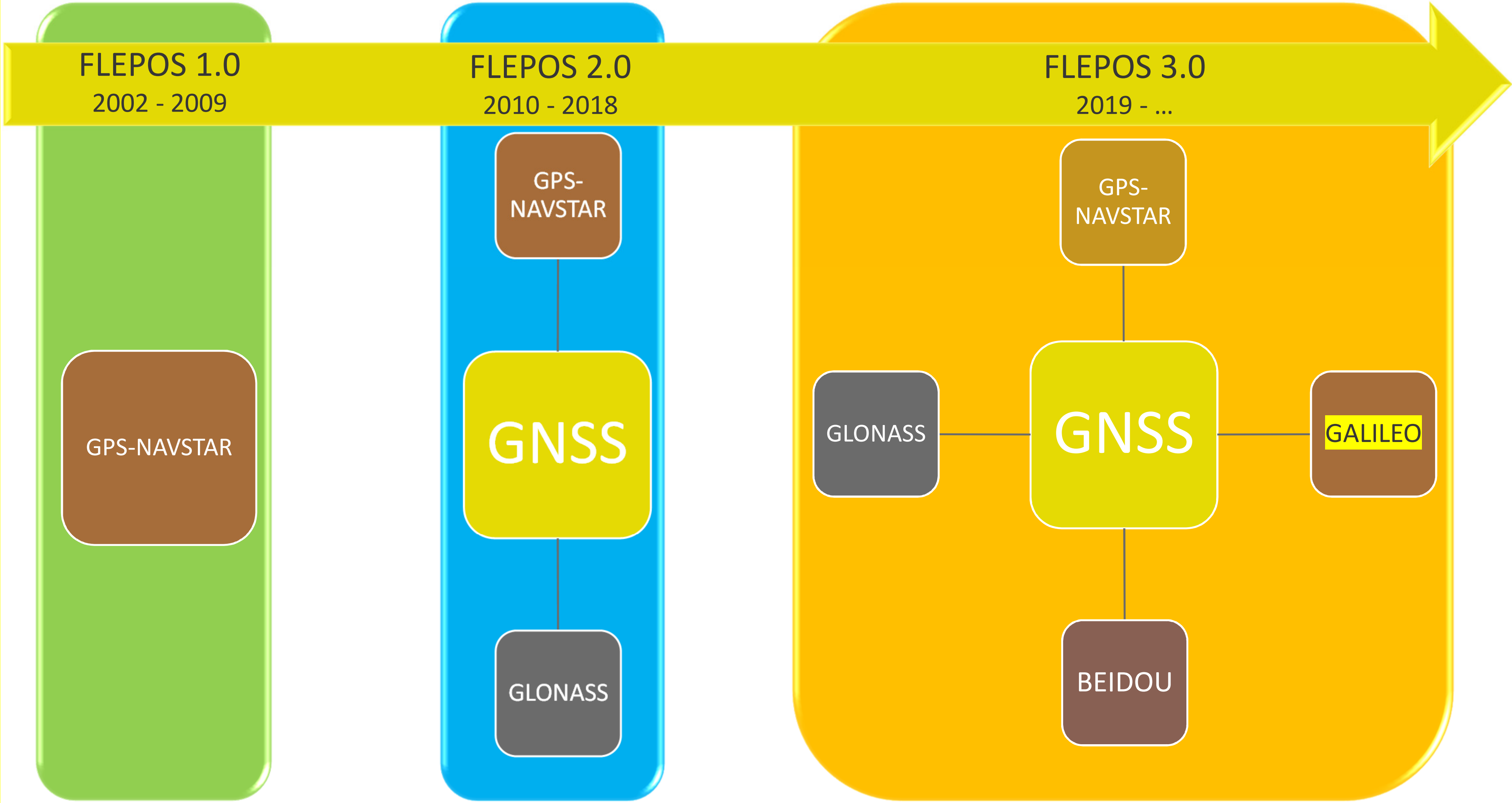
> Galileo in Flepos

> What do I need to start using Galileo?

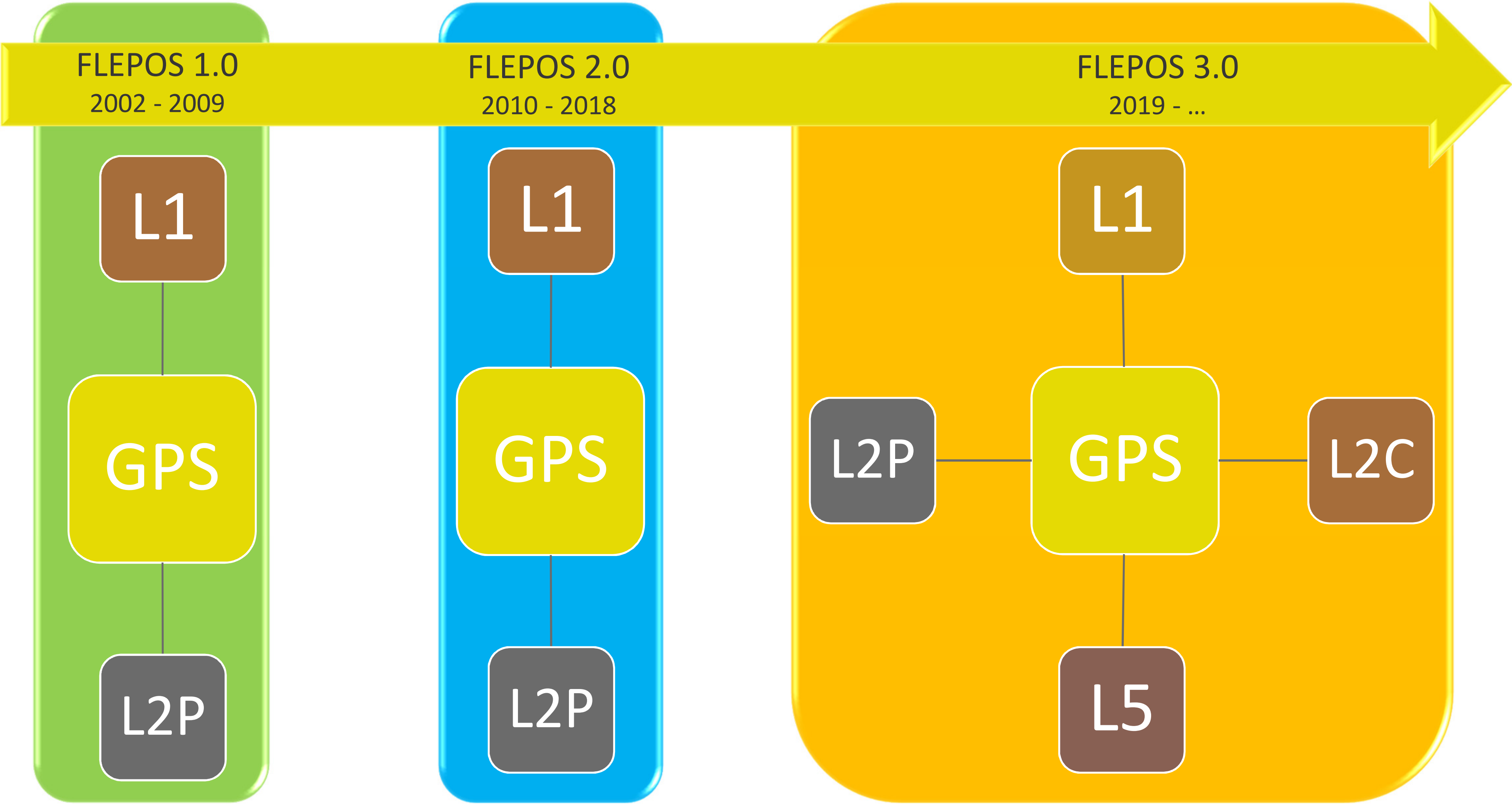
FLEPOS in 1 slide

- RTK network in Flanders
- Service of Informatie Vlaanderen
- 2 main products:
  - RTK data
  - Post-processing data
- Others tasks: general GNSS-advice, GNSS spectrum monitoring...
- Users >3.500
  - Surveyors
  - Precision farming
  - (Road) construction
  - Maritime operations

General idea

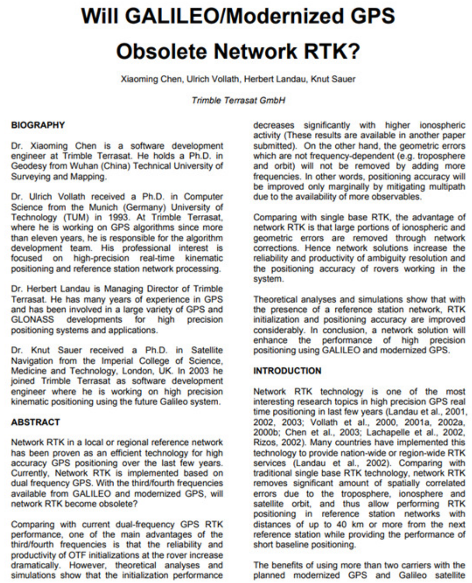


Supporting all signals



Will Galileo/Modernized GPS obsolete Network RTK?

- NO, a network solution will still enhance the performance of high precision positioning using Galileo and modernized GPS
- Advantage: CORS spacing
  - Two frequencies GPS/GLO: baseline up to 40km or more
  - Three frequencies GPS/GLO/GAL: baseline up to 80km or more



Will GALILEO/Modernized GPS Obsolete Network RTK?

Xiaoming Chen, Ulrich Vollath, Herbert Landau, Knut Sauer

Trimble Terrasat GmbH

BIOGRAPHY

Dr. Xiaoming Chen is a software development engineer at Trimble Terrasat. He holds a Ph.D. in Geodesy from Wuhan (China) Technical University of Surveying and Mapping.

Dr. Ulrich Vollath received a Ph.D. in Computer Science from the Munich (Germany) University of Technology (TUM) in 1993. At Trimble Terrasat, where he is working on GPS algorithms since more than eleven years, he is responsible for the algorithm development team. His professional interest is focused on high-precision real-time kinematic positioning and reference station network processing.

Dr. Herbert Landau is Managing Director of Trimble Terrasat. He has many years of experience in GPS and has been involved in a large variety of GPS and GLONASS developments for high precision positioning systems and applications.

Dr. Knut Sauer received a Ph.D. in Satellite Navigation from the Imperial College of Science, Medicine and Technology, London, UK. In 2003 he joined Trimble Terrasat as software development engineer where he is working on high precision kinematic positioning using the future Galileo system.

ABSTRACT

Network RTK in a local or regional reference network has been proven as an efficient technology for high accuracy GPS positioning over the last few years. Currently, Network RTK is implemented based on dual frequency GPS. With the third/fourth frequencies available from GALILEO and modernized GPS, will network RTK become obsolete?

Comparing with current dual-frequency GPS RTK performance, one of the main advantages of the third/fourth frequencies is that the reliability and productivity of OTF initializations at the rover increase dramatically. However, theoretical analyses and simulations show that the initialization performance decreases significantly with higher ionospheric activity (These results are available in another paper submitted). On the other hand, the geometric errors which are not frequency-dependent (e.g. troposphere and orbit) will not be removed by adding more frequencies. In other words, positioning accuracy will be improved only marginally by mitigating multipath due to the availability of more observables.

Comparing with single base RTK, the advantage of network RTK is that large portions of ionospheric and geometric errors are removed through network corrections. Hence network solutions increase the reliability and productivity of ambiguity resolution and the positioning accuracy of rovers working in the system.

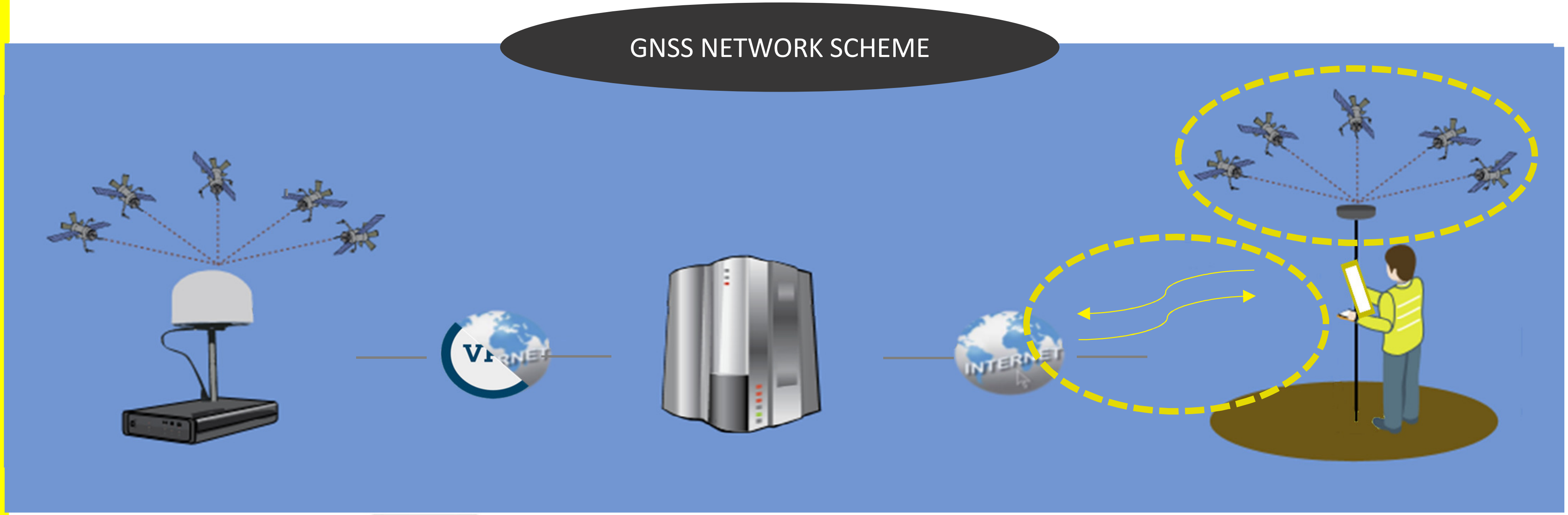
Theoretical analyses and simulations show that with the presence of a reference station network, RTK initialization and positioning accuracy are improved considerably. In conclusion, a network solution will enhance the performance of high precision positioning using GALILEO and modernized GPS.

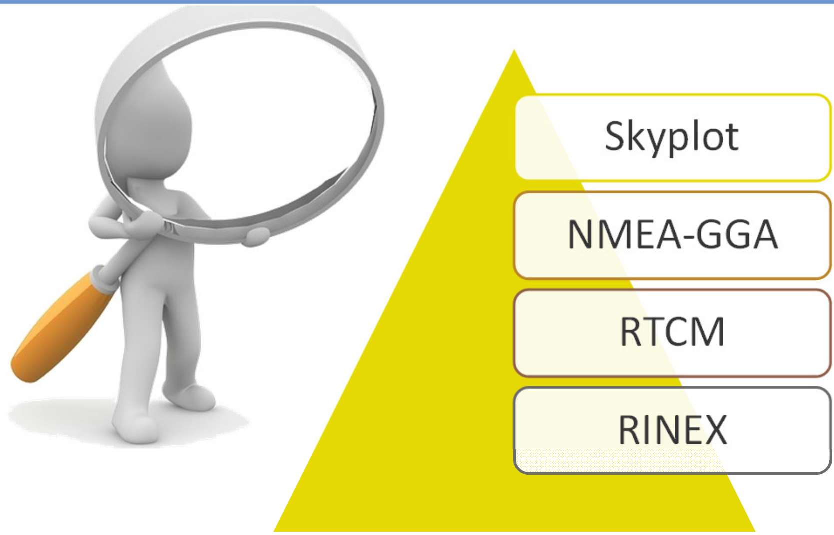
INTRODUCTION

Network RTK technology is one of the most interesting research topics in high precision GPS real time positioning in last few years (Landau et al., 2001, 2002, 2003; Vollath et al., 2000, 2001a, 2002a, 2000b; Chen et al., 2003; Lachapelle et al., 2002, Rizos, 2002). Many countries have implemented this technology to provide nation-wide or region-wide RTK services (Landau et al., 2002). Comparing with traditional single base RTK technology, network RTK removes significant amount of spatially correlated errors due to the troposphere, ionosphere and satellite orbit, and thus allow performing RTK positioning in reference station networks with distances of up to 40 km or more from the next reference station while providing the performance of short baseline positioning.

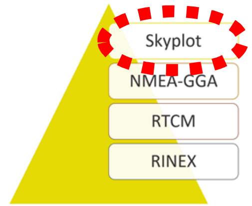
The benefits of using more than two carriers with the planned modernized GPS and Galileo satellite

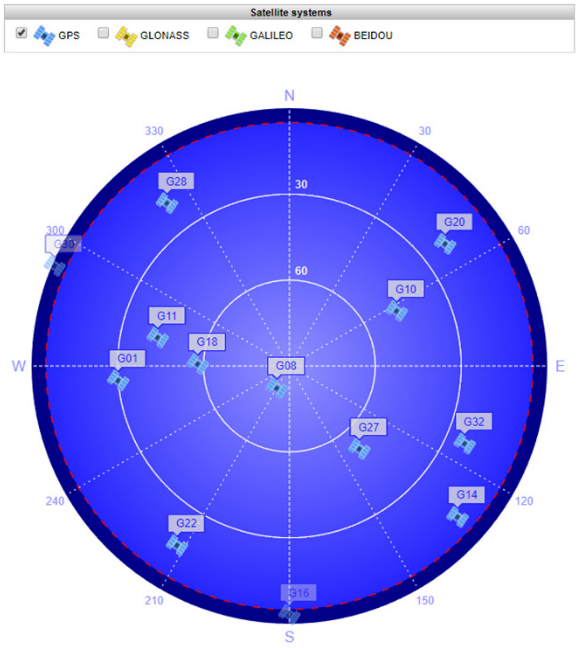
Where and how do we find Galileo?





Skyplot: more satellites are visible



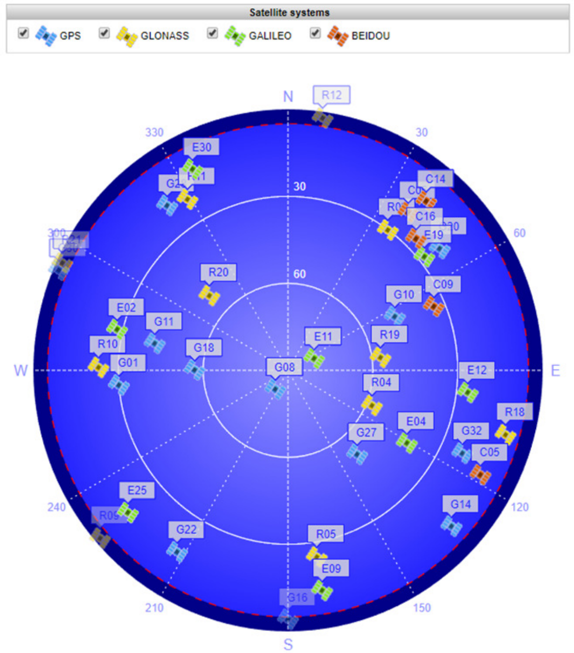


10 sats

GPS (10)

18 sats

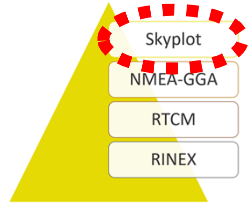
GPS (10)
GLONASS (8)



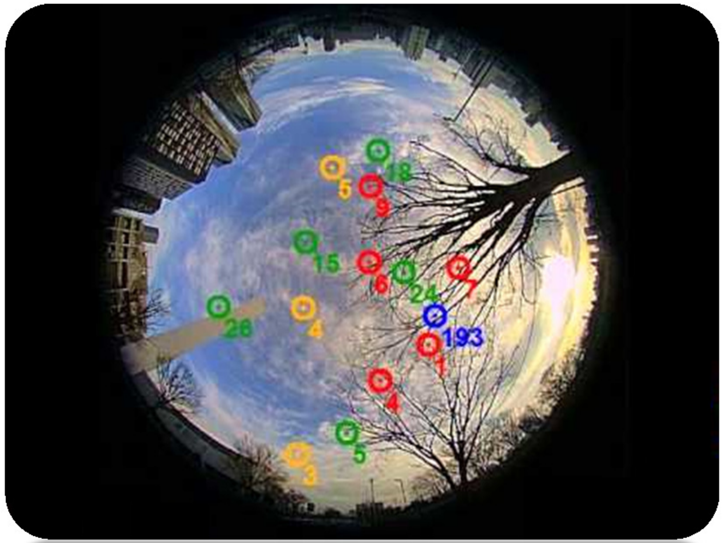
29 sats

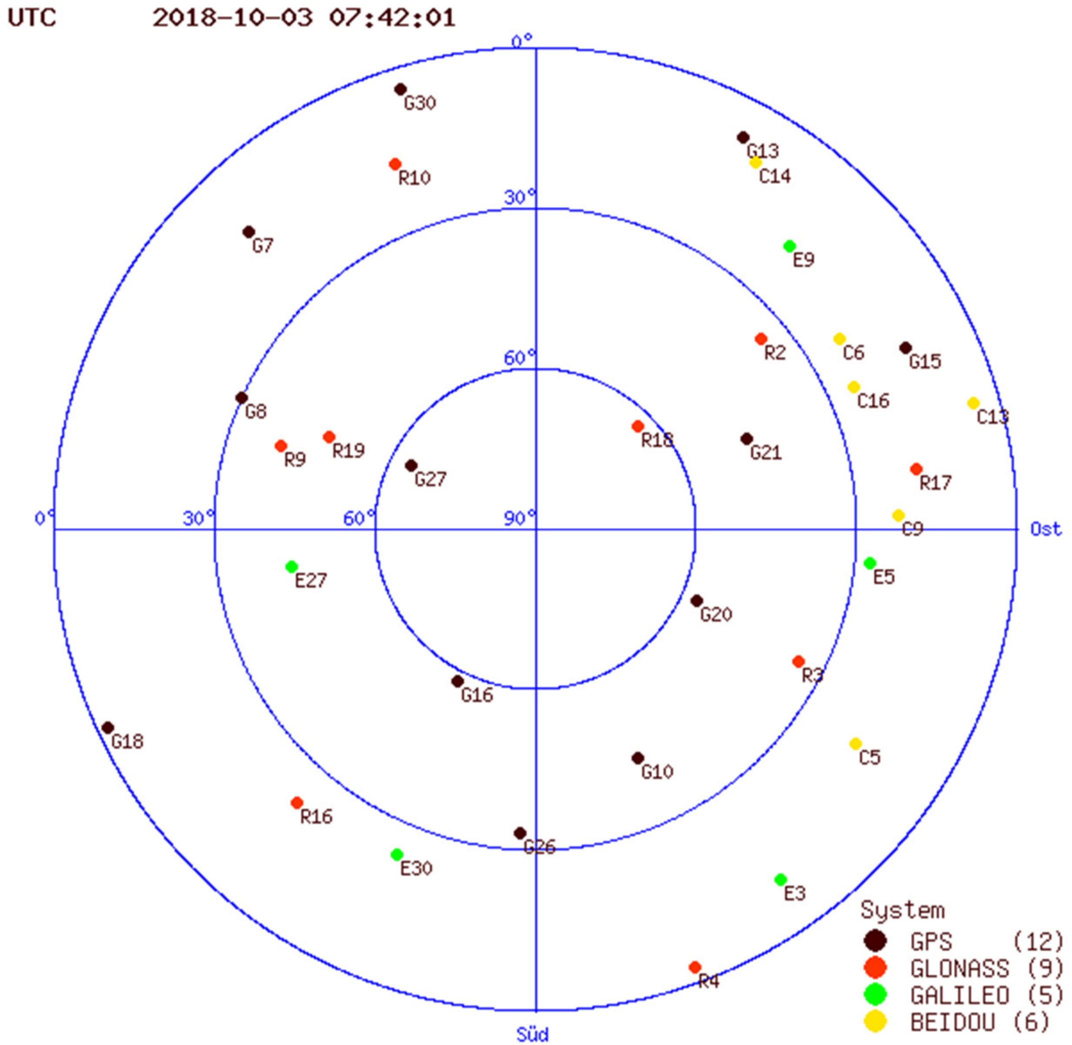
GPS (10)
GLONASS (8)
Galileo (7)
Beidou (4)

Which ones are Galileo sats?

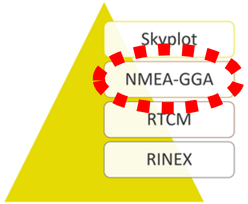


- G: GPS-NAVSTAR
- R: GLONASS
- E: GALILEO
- C: BEIDOU
- J: QZSS



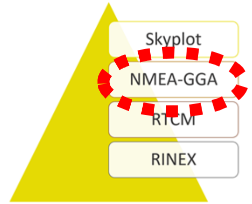


NMEA-GGA: structuur



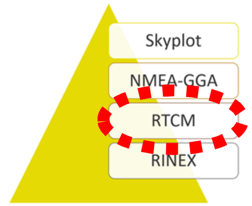
- $GPGGA,hhmmss.ss,llll.ll,a,yyyyy.yy,a,x,xx,x.x,x.x,M,x.x,M,x.x,xxxx*hh
- 1 = UTC of Position
- 2 = Latitude
- 3 = N or S
- 4 = Longitude
- 5 = E or W
- 6 = GPS quality indicator
  (0=invalid; 1=GPS fix; 2=DGPS fix; 3=PPS fix; 4=RTK; 5=float RTK; 6=…)
- 7 = Number of satellites in use [not those in view]
- 8 = Horizontal dilution of position
- 9 = Antenna altitude above/below mean sea level (geoid)
- 10 = Meters (Antenna height unit)
- 11 = Geoidal separation (Diff. between WGS-84 earth ellipsoid and
- mean sea level. -=geoid is below WGS-84 ellipsoid)
- 12 = Meters (Units of geoidal separation)
- 13 = Age in seconds since last update from diff. reference station
- 14 = Diff. reference station ID#
- 15 = Checksum

NMEA – GGA: voorbeelden



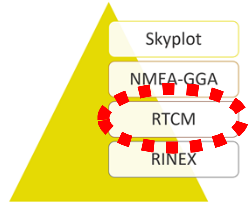
- $GPGGA,100948.80,5109.967822,N,00542.001645,E,4,06,1.7,31.306,M,47.445,M,,*5
  - 6 GPS satellieten in gebruik (≠ zichtbaar)
- $GNGGA,074221.00,5105.1970397,N,00421.7304760,E,1,14,0.7,52.422,M,,,,*17
  - 14 GPS/GLO satellieten in gebruik (≠ zichtbaar)
- $GNGGA,095101.00,5106.220478,N,00452.034662,E,1,22,0.9,49.645,M,,,,*12
  - 22 GPS/GLO/GAL/BEI satellieten in gebruik (≠ zichtbaar)

RTCM



- Radio Technical Commision for Maritime Services (RTCM)
- Special committe (SC) 104 on Differential Global Navigation Satellite Systems (DGNSS)
- Formats:
  - 2.1: RTK standard
  - 2.3: RTK network standard
  - 3.0: NTRIP
  - 3.2: MSM

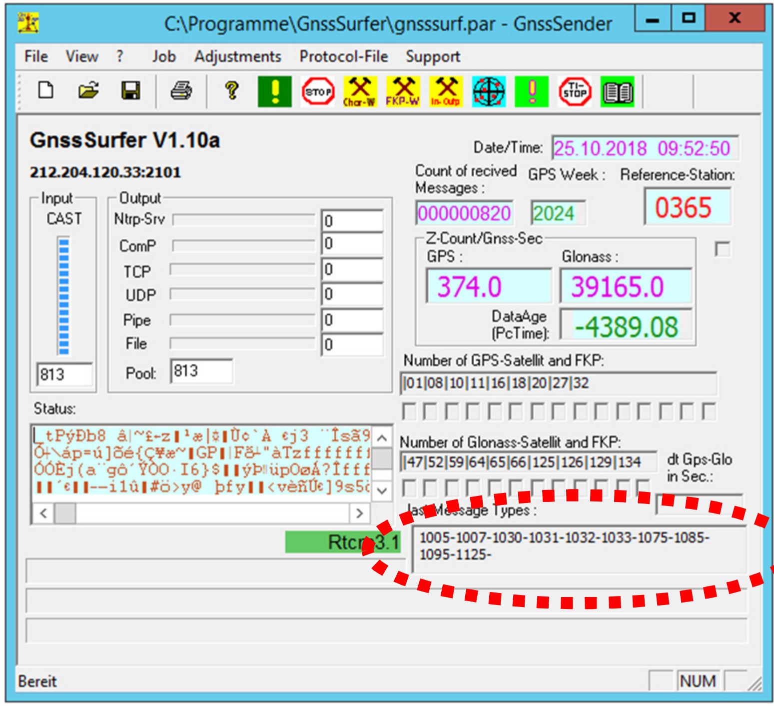
RTCM 3.2 MSM

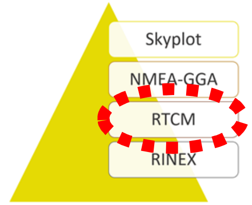


Message	Description
MSM1	Provides the code measurements.
MSM2	Provides the phase measurements.
MSM3	Provides the data from MSM1 (code) and MSM2 (phase) in a single message.
MSM4	Provides all the data from MSM3 (code and phase) and adds the CNR measurements.
MSM5	Provides all the data from MSM4 (code, phase and CNR) and adds the doppler measurements.
MSM6	Provides the same information as MSM4, but has extended resolution on the measurements.
MSM7	Provides the same information as MSM5, but has extended resolution on the measurements.

RTCM 3.2 MSM 5

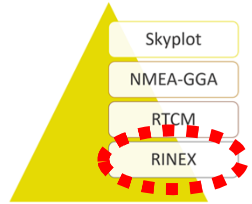
> Message type:





Message	GPS	GLONASS	Galileo	QZSS	BeiDou
MSM1	RTCM1071	RTCM1081	RTCM1091	RTCM1111	RTCM1121
MSM2	RTCM1072	RTCM1082	RTCM1092	RTCM1112	RTCM1122
MSM3	RTCM1073	RTCM1083	RTCM1093	RTCM1113	RTCM1123
MSM4	RTCM1074	RTCM1084	RTCM1094	RTCM1114	RTCM1124
MSM5	RTCM1075	RTCM1085	RTCM1095	RTCM1115	RTCM1125
MSM6	RTCM1076	RTCM1086	RTCM1096	RTCM1116	RTCM1126
MSM7	RTCM1077	RTCM1087	RTCM1097	RTCM1117	RTCM1127

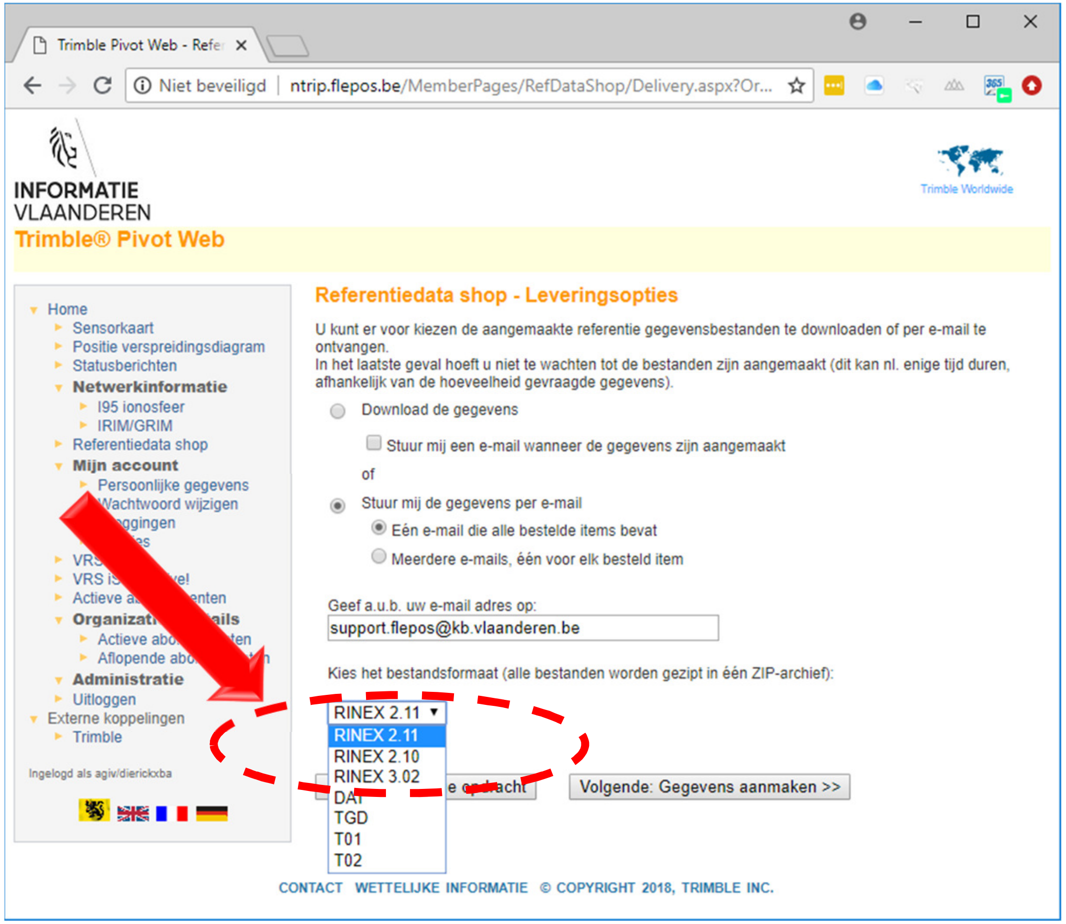
RINEX data via Referentie Datashop



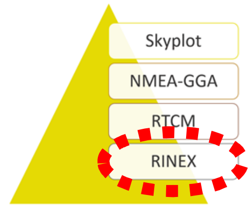
- CORS: BREC
- Time: 15'
- Interval 1"

- Rinex 2.11: 390 Kb
- Rinex 3.02: 815 Kb

x2



RINEX: naming files



- ssssdddhmm.yyx
  - ssss: 4-character ID CORS
  - ddd: day of the year
  - h: character for n-th hour (a=1st hour, b= 2nd hour,…)
  - mm: starting minute within the hour
  - yy: 2-digit year
  - X: type
    - .yyO: Observation files
    - .yyN: GPS Navigation files
    - .yyG: GLONASS Navigation files
    - .yyL: Galileo Navigation files
    - .yyC: Beidou Navigation files
    - (.yyJ: QZSS Navigation files)

RINEX 2.11

9 + 8 = 17 satellites

```
  18 10 03  7  0  0.0000000  0 17G07G08G10G16G20G21G26G27G29R01R02R03 0.000000000
                                 R09R16R17R18R19
  24642802.930                129498791.26716        1859.432          43.800
  24642800.223  24642800.500  100908143.39316        1448.914          22.600

  23947672.227                125845865.23715        3164.518          40.900
  23947672.875  23947672.992   98061705.44016        2465.853          25.400
  23947672.773  93975805.98019      2363.118           47.300
  23482422.961                123400985.93515        3435.320          41.700
  23482423.879  23482424.129   96156612.23617        2676.875          30.400
  23482424.160  92150080.87119      2565.333           48.600
  20400466.383                107205180.21717        -479.852          47.800
                20400463.406   83536485.83319        -373.911          41.300

  21798050.570                114549547.81316        2217.185          46.600
                21798048.398   89259371.56418        1727.676          34.800

  21620068.758                113614219.99317       -1611.168          48.600
                21620065.891   88530566.90618       -1255.453          40.200

  21250926.602                111674381.73617       -2306.390          51.300
  21250927.422  21250927.863   87018993.19419       -1797.186          42.000
  21250926.586  83393197.02119     -1722.303           53.900
  21174227.492                111271320.17717        2134.237          50.900
  21174227.457  21174227.504   86704929.51519        1663.042          41.500
  21174227.156  83092228.06619      1593.741           53.800
  25037344.031                131572108.70015       -3330.352          40.400
  25037344.441  25037344.293  102523715.47216       -2595.086          19.900

  23414498.836  23414497.273  125163918.82916       -2559.872          41.300
  23414496.141  23414496.492   97349709.39918       -1991.012          36.000

  21748268.906  21748267.855  116052945.75717        1525.834          49.000
  21748265.352  21748265.891   90263404.01519        1186.757          44.000

  23351409.586  23351409.324  125001921.65216        4059.433          41.800
  23351407.191  23351407.262   97223719.99918        3157.337          39.300

  21012169.195  21012167.789  112203802.14317        1968.264          48.300
  21012164.109  21012164.539   87269620.45419        1530.873          46.500

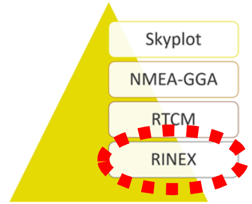
  20556056.234  20556056.160  109806736.28417       -2757.417          45.500
  20556051.875  20556052.469   85405228.97019       -2144.656          41.200

  21597614.133  21597612.945  115573203.16317       -3131.613          47.600
  21597609.758  21597610.328   89890270.02319       -2435.699          43.500

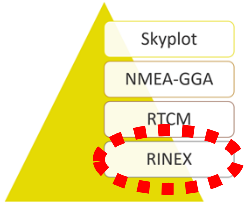
  19359936.719  19359936.121  103344634.65118        -364.115          50.300
```

9 GPS

8 GLONASS



RINEX 3.03

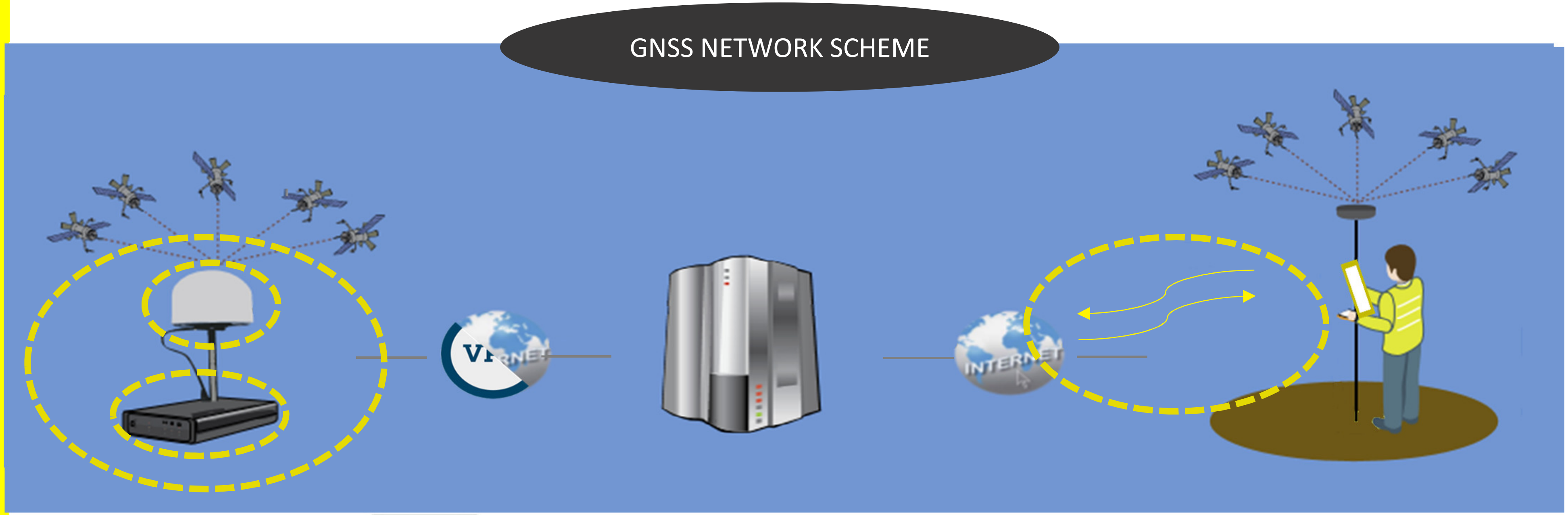


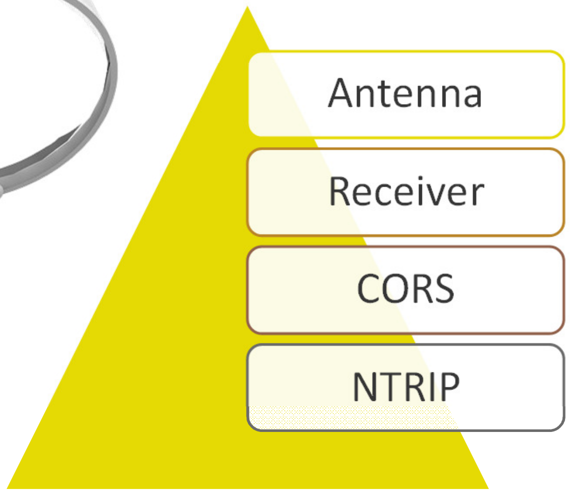
17 + 4 + 6 = 27 satellites

```
> 2018 10 03  7  0  0.0000000  0 27      0.000000000000
G07  24642802.930                    129498791.26717                   1859.432                              43.800                                          24
G08  23947672.227                    125845865.23716                   3164.518                              40.900                                          23
G10  23482422.961                    123400985.93516                   3435.320                              41.700                                          23
G16  20400466.383                    107205180.21717                   -479.852                              47.800                                          20
G20  21798050.570                    114549547.81317                   2217.185                              46.600                                          21
G21  21620068.758                    113614219.99318                  -1611.168                              48.600                                          21
G26  21250926.602                    111674381.73618                  -2306.390                              51.300                                          21
G27  21174227.492                    111271320.17718                   2134.237                              50.900                                          21
G29  25037344.031                    131572108.70016                  -3330.352                              40.400                                          25
R01  23414498.836    23414497.273    125163918.82916 125163911.84416  -2559.872       -2559.896              41.300          38.400    23414496.141    23
R02  21748268.906    21748267.855    116052945.75718 116052939.77417   1525.834        1525.821              49.000          47.400    21748265.352    21
R03  23351409.586    23351409.324    125001921.65216 125001924.65916   4059.433        4059.444              41.800          40.700    23351407.191    23
R09  21012169.195    21012167.789    112203802.14318 112203802.14517   1968.264        1968.256              48.300          46.600    21012164.109    21
R16  20556056.234    20556056.160    109806736.28417 109806755.29017  -2757.417       -2757.424              45.500          44.200    20556051.875    20
R17  21597614.133    21597612.945    115573203.16317 115573203.16717  -3131.613       -3131.611              47.600          45.500    21597609.758    21
R18  19359936.719    19359936.121    103344634.65118 103344672.64618   -364.115        -364.116              50.300          49.000    19359932.262    19
R19  21255136.617    21255135.281    113700650.39117 113700645.38717   2771.182        2771.183              43.400          42.400    21255133.074    21
E05  27603517.219                                    145057461.58616                                       2533.095
E09  25242358.977                                    132649497.10216                                        651.523
E27  24130741.266                                    126807891.24918                                        204.372
E30  23313307.930                                    122512254.06118                                      -2489.325
C05  40202090.504  170108193.28816       -13.508          38.100    40202109.648  209343039.07715       -16.622          35.500    40202097.027   161
C06  40372952.570  170831193.42516      1065.962          37.600    40372974.836  210232683.98016      1311.818          39.200    40372959.633   162
C09  40852663.129  172860997.27316      1593.662          36.800    40852683.086  212730641.14716      1961.238          36.900    40852671.410   164
C13  41011367.102  173532518.24716      -862.609          36.300    41011381.508  213557033.30516     -1061.574          37.000    41011374.680   165
C14  25251885.395  106849008.36217     -1014.027          43.700    25251905.664  131493312.05916     -1247.906          40.100    25251892.648   101
C16                                                                 40245197.422  209567307.75816      1573.104          41.500    40245188.020   162
> 2018 10 03  7  0  1.0000000  0 27      0.000000000000
G07  24642449.832                    129496932.332 7                   1858.935                              43.400                                          24
G08  23947070.633                    125842700.771 6                   3164.466                              40.600                                          23
```

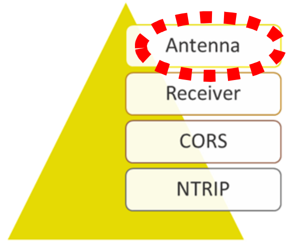
9 GPS
8 GLONASS
4 Galileo
6 Beidou

GALILEO in Flepos





GNSS Antenna



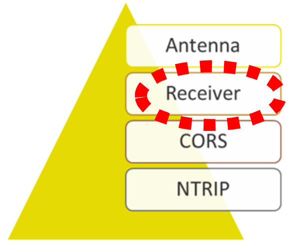
Leica AR25.R3

- Signals;
  - GPS: L1, l2? L2c, L5
  - GLO: L1, L2, L3
  - GAL: E2-L1-E1, E5a, E5b, E6, AltBOC
  - BEI: E1, E2, E5b, E6
- Phase center repeatability:
  - < 1mm
- Weight: 7.6 kg

Trimble Zephyr 3

- Signals
  - L1/L2/L5/G1/G2/G3/E1/E5ab/E6/B1/B2/B3
- Phase center repeatability:
  - < 1mm
- Weight: 1.36 kg

GNSS - receivers



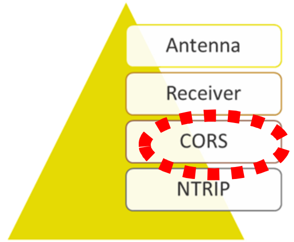
- Types ontvangers:
  - Leica GRX1200+ GNSS

  - Trimble NetR9

  - Leica GR50

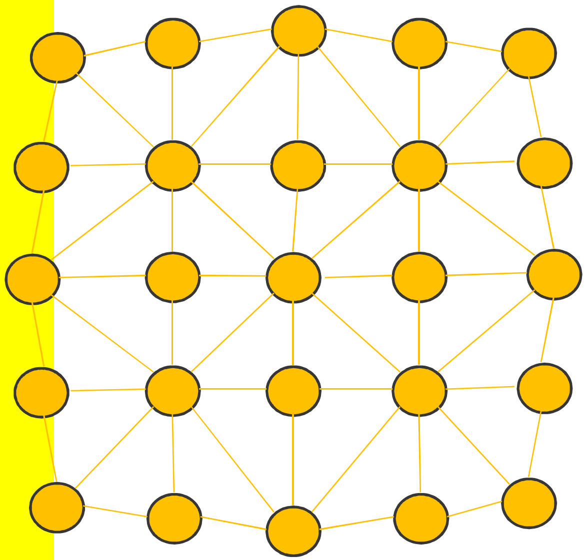
  - Septentrio PolaRx4

CORS - layout



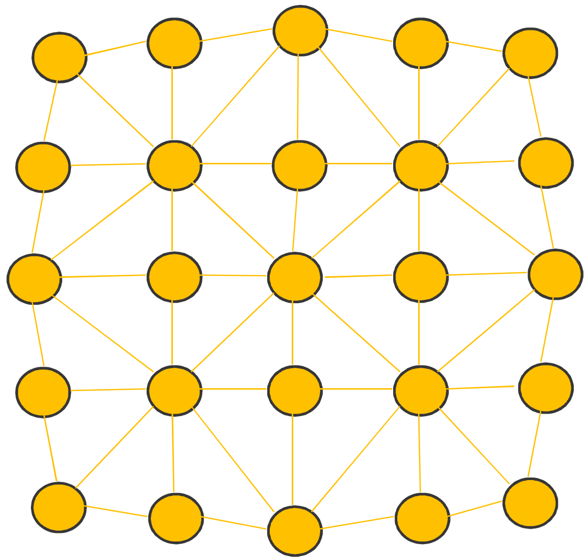
- Answer obsolete question:
  - Three frequencies GPS/GLO/GAL: baseline up to 80km or more

FLEPOS 1.0



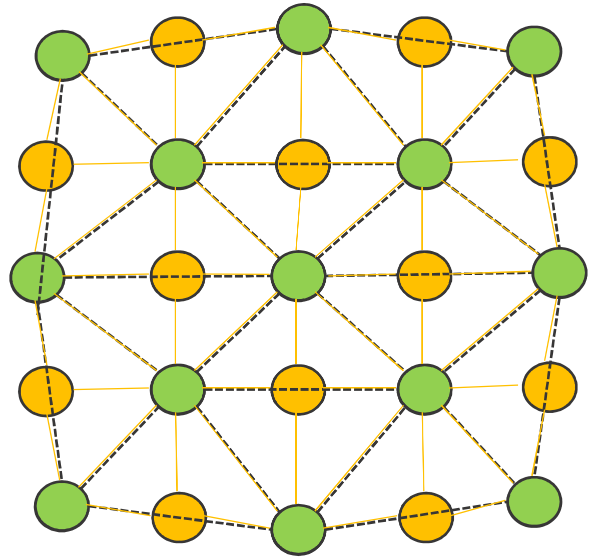
GPS
46 CORS
30-40 km

FLEPOS 2.0



GPS/GLO
46 CORS
30-40 km

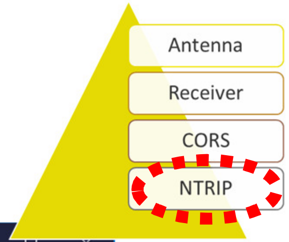
FLEPOS 3.0

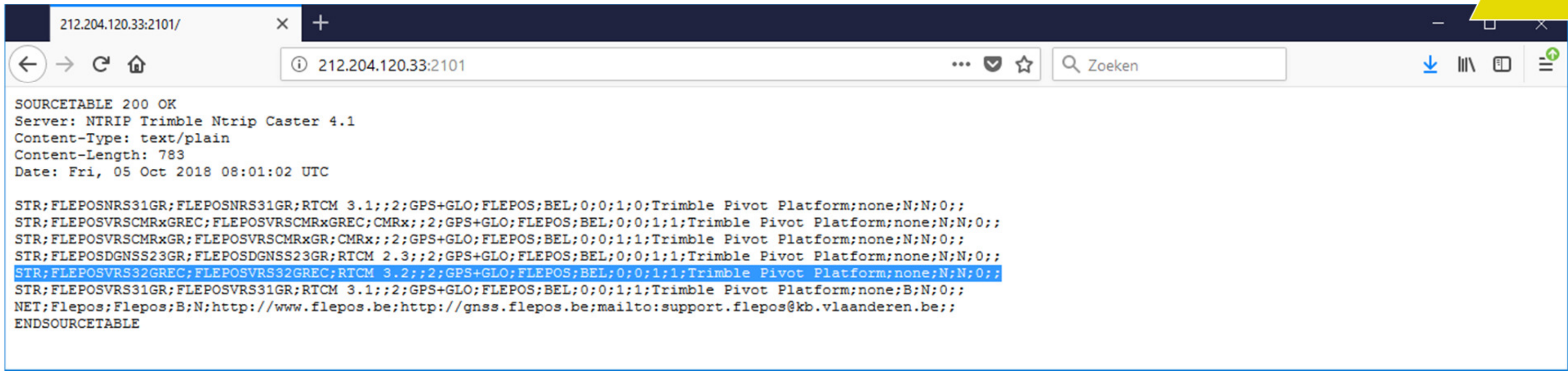


GPS/GLO
46 CORS
30-40 km

GPS/GLO/GAL/BEI
22/46 CORS
60-70 km

Ntrip mountpoints



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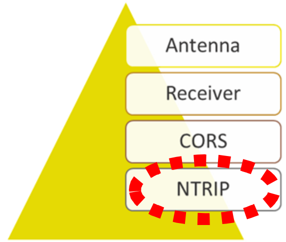
SOURCETABLE 200 OK
Server: NTRIP Trimble Ntrip Caster 4.1
Content-Type: text/plain
Content-Length: 783
Date: Fri, 05 Oct 2018 08:01:02 UTC

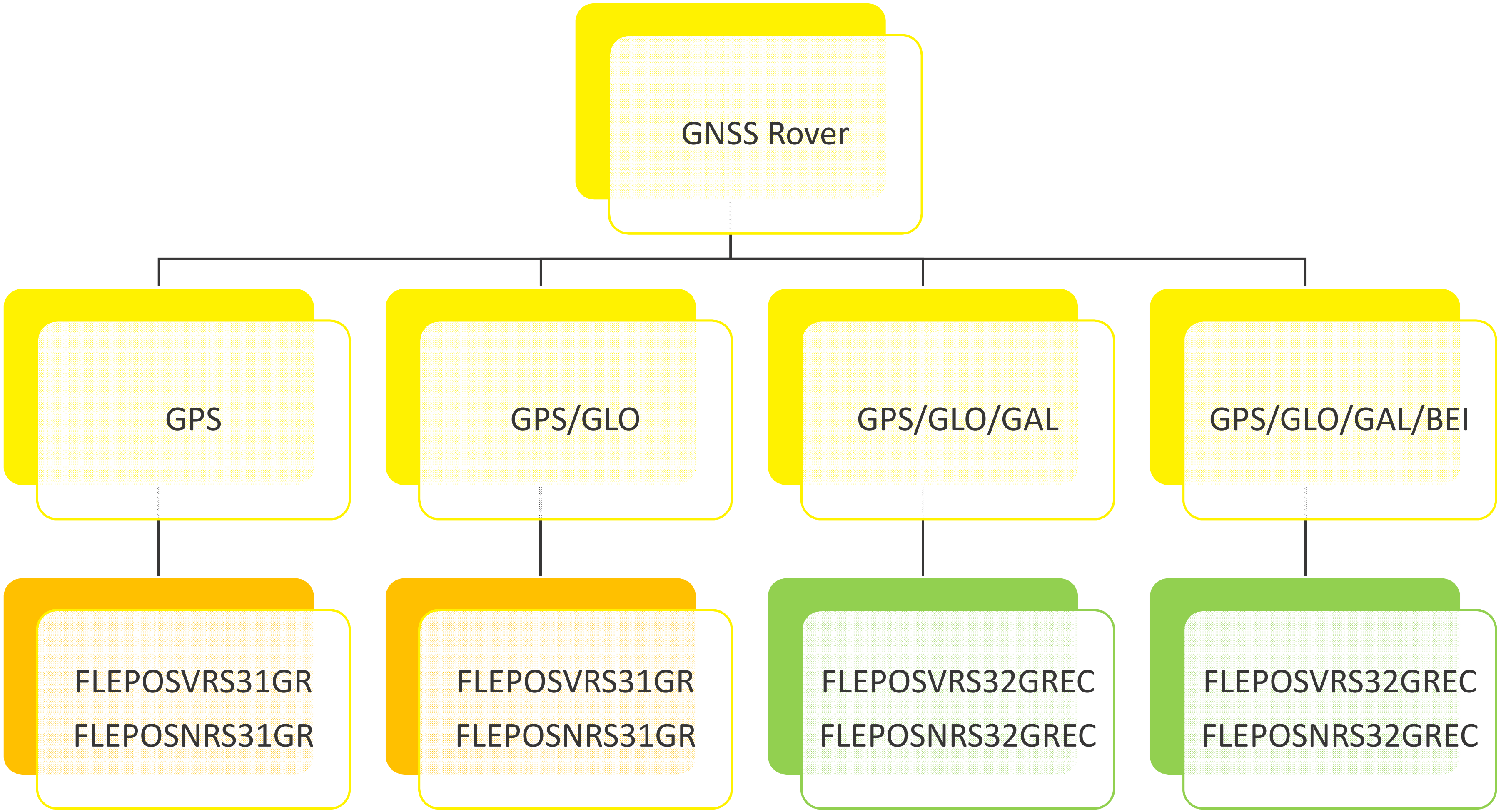
STR;FLEPOSNRS31GR;FLEPOSNRS31GR;RTCM 3.1;;2;GPS+GLO;FLEPOS;BEL;0;0;1;0;Trimble Pivot Platform;none;N;N;0;;
STR;FLEPOSVRSCMRxGREC;FLEPOSVRSCMRxGREC;CMRx;;2;GPS+GLO;FLEPOS;BEL;0;0;1;1;Trimble Pivot Platform;none;N;N;0;;
STR;FLEPOSVRSCMRxGR;FLEPOSVRSCMRxGR;CMRx;;2;GPS+GLO;FLEPOS;BEL;0;0;1;1;Trimble Pivot Platform;none;N;N;0;;
STR;FLEPOSDGNSS23GR;FLEPOSDGNSS23GR;RTCM 2.3;;2;GPS+GLO;FLEPOS;BEL;0;0;1;1;Trimble Pivot Platform;none;N;N;0;;
STR;FLEPOSVRS32GREC;FLEPOSVRS32GREC;RTCM 3.2;;2;GPS+GLO;FLEPOS;BEL;0;0;1;1;Trimble Pivot Platform;none;N;N;0;;
STR;FLEPOSVRS31GR;FLEPOSVRS31GR;RTCM 3.1;;2;GPS+GLO;FLEPOS;BEL;0;0;1;1;Trimble Pivot Platform;none;B;N;0;;
NET;Flepos;Flepos;B;N;http://www.flepos.be;http://gnss.flepos.be;mailto:support.flepos@kb.vlaanderen.be;;
ENDSOURCETABLE
```

- G: GPS-NAVSTAR
- R: GLONASS
- E: GALILEO
- C: BEIDOU

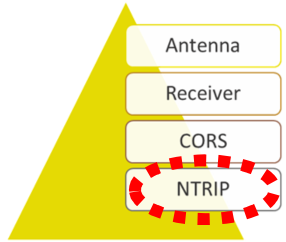
	NETWERK	OPLOSSING	FORMAAT	Gps (G)	Glonass (R)	Galileo (E)	Beidou (C)
	FLEPOS	VRS of NRS	RTCM 3.1 RTCM 3.2	G	R	E	C
FLEPOSVRS31GR	FLEPOS	VRS	RTCM 3.1	Gps	Glonass	-	-
FLEPOSVRS32GREC	FLEPOS	VRS	RTCM 3.2	Gps	Glonass	Galileo	Beidou
FLEPOSNRS31GR	FLEPOS	NRS	RTCM 3.1	Gps	Glonass	-	-

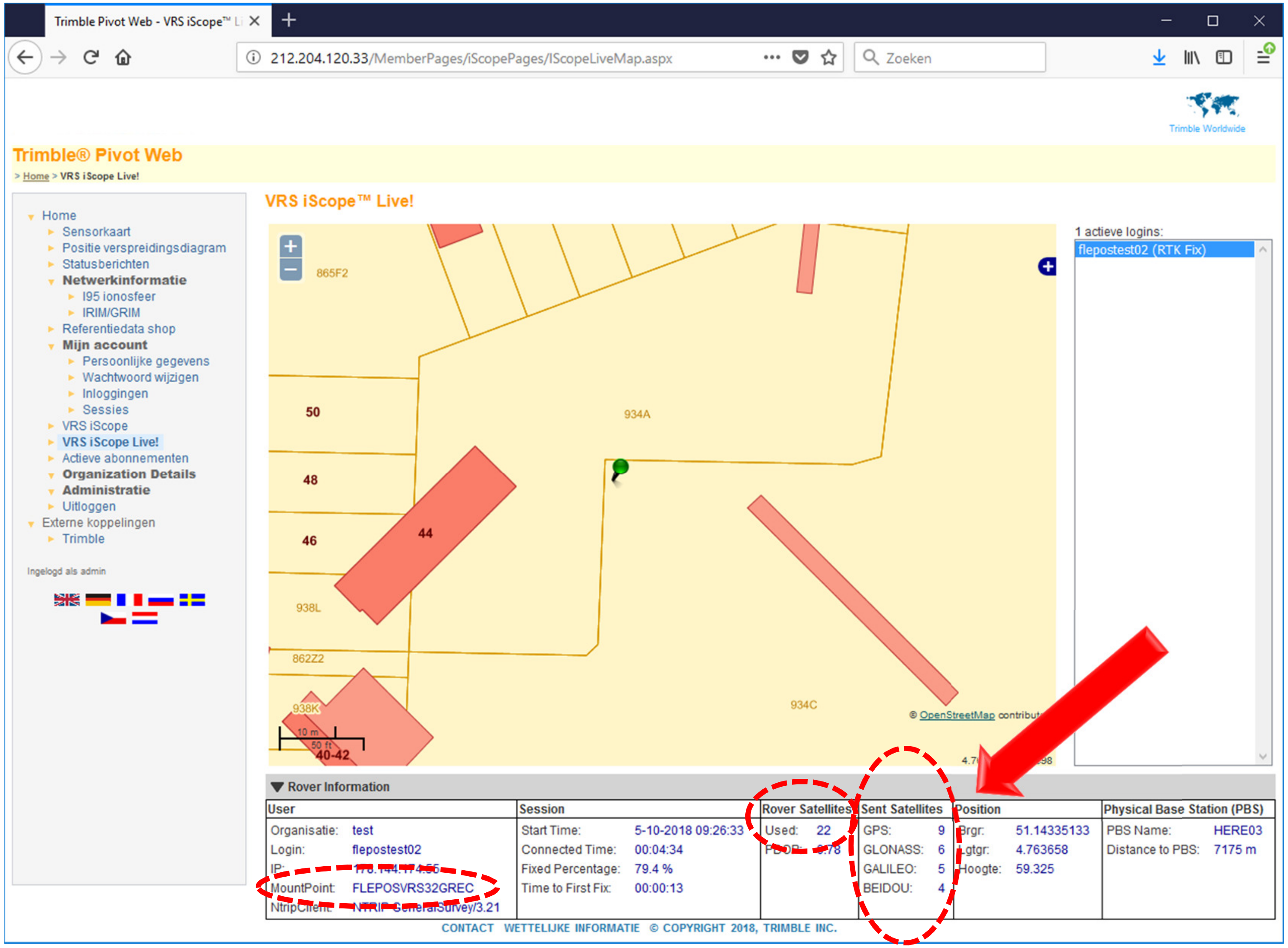
Overview NTRIP mountpoints



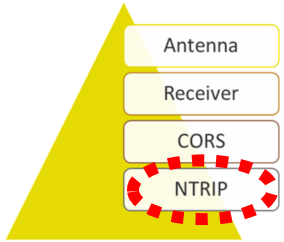


RTK measurement

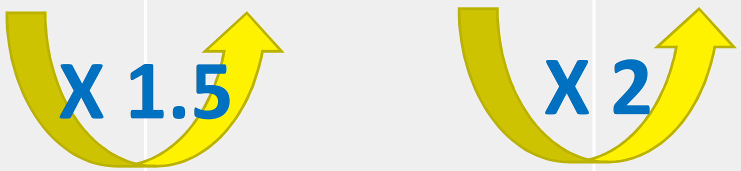




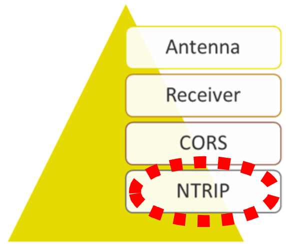
Size NTRIP data



	FLEPOSVRS31	FLEPOSVRS31GLO	FLEPOS32GREC
System	FLEPOS 1.0	FLEPOS 2.0	FLEPOS 3.0
GNSS	GPS	GPS/GLO	GPS/GLO/Gal/Bei
Message types	1004 (1) 1005 (5) 1007 (5) 1030 (10) 1032 (10) 4094 (10)	1004 (1) 1007 (5) 1012 (1) 1032 (10) 1033 (10) 4094 (10)	1007 (5) 1032 (10) 1033 (10) 1075 (1) 1085 (1) 1095 (1) 1125 (1)
Size	0,8 Mb/h	1,2 Mb/h	2,5 Mb/h



Testphase



- Testphase is still running
  - 5 mountpoints
    - FLEPOS 2.0 (FLEPOSVRS31GLO, FLEPOSNRS31GLO)
    - FLEPOS 3.0 (FLEPOSVRS31GR, FLEPOS32GREC, FLEPOSNRS32GREC)
  - 2 sessions
  - 5 measurements per sessions
  - 20 measurements per point (NGI or other known point)

Customer

- GNSS-Antenna
  - Which signals and constellation can be received? => check datasheet
  - Remark: interference risk due to bigger bandwith

- GNSS-Receiver
  - Check datasheet
  - License activation or not?
  - Change mountpoint

Conclusion

- Flepos will be ready to support Galileo in 2019
- Are you ready?

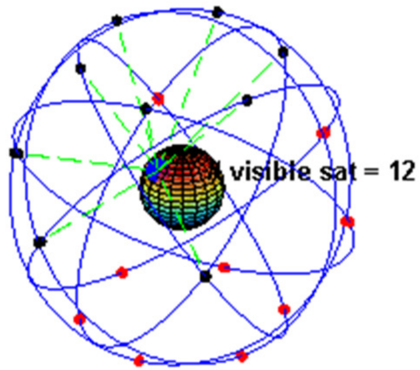
Noteer alvast **29/11/2018** in je agenda en Kom naar de

Trefdag Digitaal Vlaanderen

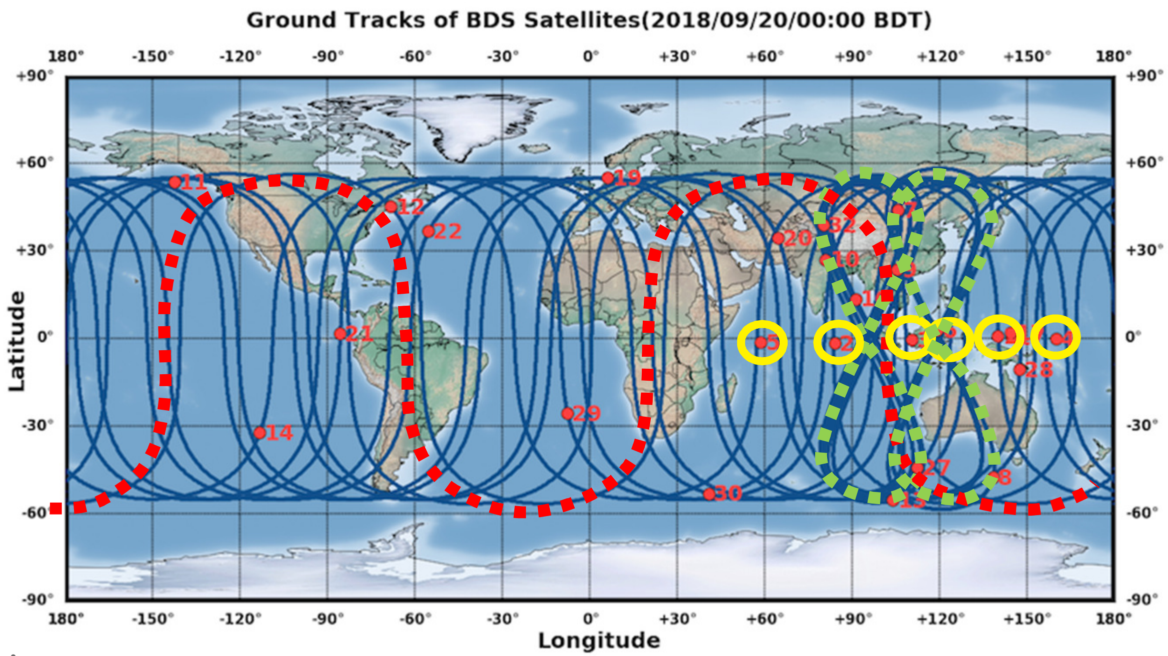
ICC Gent

#TDV18 - meer info op onze website

Beidou



- 3 types of satellite orbits (Aug 2018):
  - 6x GEO (geostationairy) = not usable in Flanders
  - 6x 55° IGSO (inclined geosynchronous orbits)
  - 3x MEO (medium earth orbits)



Dillution of position (elevation cuttof 40°)

- GPS
- + GLONASS
- + GALILEO
- + BEIDOU

Signal to noise ratio

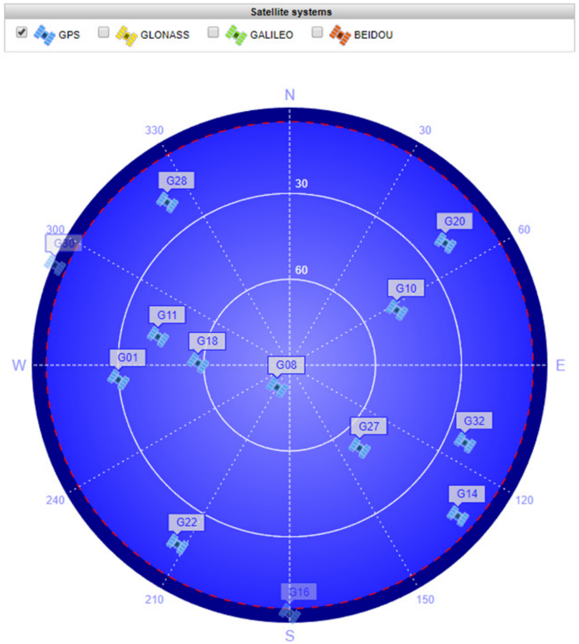
General | GPS | GLONASS | GALILEO | BEIDOU | QZSS | SBAS

Sat	Elevation	Azimuth	S/N L1	S/N L2P(Y)	S/N L2C	S/N L5	URA	IODE
G08	79 ▾	193	55	51	53	56	2.0	4
G18	61 ▴	273	53	48	--	--	2.0	13
G27	48 ▾	142	54	50	51	54	2.0	69
G11	46 ▴	283	52	45	--	--	2.0	29
G10	45 ▾	61	53	48	50	53	2.0	28
G01	33 ▴	267	50	46	47	51	2.8	93
G32	25 ▴	112	50	43	45	48	2.0	85
G28	21 ▴	321	47	39	--	--	2.8	99
G22	19 ▴	212	48	42	--	--	2.0	43
G20	18 ▾	52	44	41	--	--	2.0	3
G14	14 ▴	131	44	39	--	--	2.0	108
G16	0 ▾	179	--	--	--	--	--	--
G30	0 ▾	291	--	--	--	--	--	--
G03	-2 ▴	215	--	--	--	--	--	--
G24	-4 ▴	35	--	--	--	--	--	--
G15	-5 ▾	13	--	--	--	--	--	--
G21	-6 ▾	86	--	--	--	--	--	--
G07	-8 ▾	264	--	--	--	--	--	--
G17	-17 ▴	310	--	--	--	--	--	--
G13	-18 ▾	343	--	--	--	--	--	--
G26	-19 ▾	166	--	--	--	--	--	--

Elevation	L1 / E1	L2P	L2C	L5 / E5
25°	50	43	45	48
45°	53	48	50	53
75°	55	51	53	56

Galileo => more satellites are visible

FLEPOS 1.0
2002 - 2009



FLEPOS 2.0
2010 - 2018

FLEPOS 3.0
2019 - …