SSR-Technologie für skalierbare GNSS Dienste

Prinzipien, Anwendungen, Standardisierung

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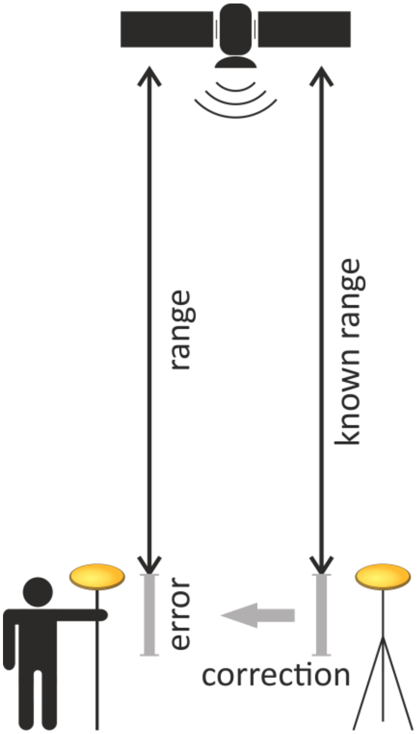
GNSS Augmentation in the OSR Domain

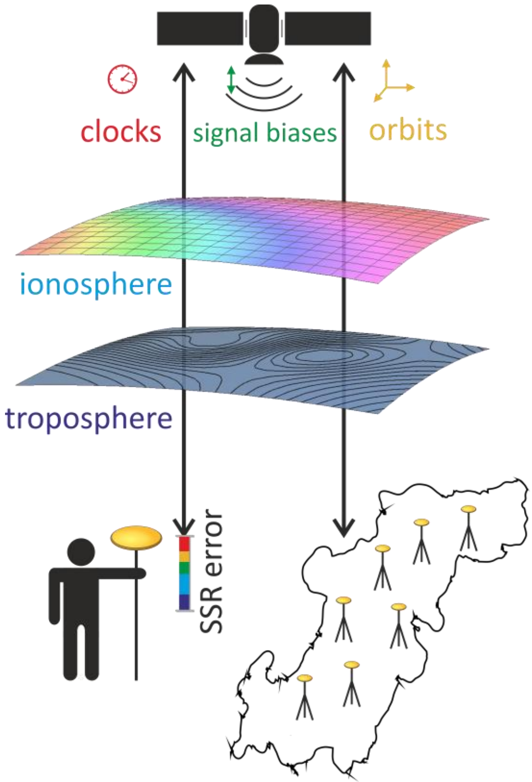


The range measurements of a rover are improved by applying a range correction as measured by a nearby reference station.

Since the observations of the reference stations are used directly, this approach is classified as an **observation space representation (OSR)** technique.

Examples include (network)-RTK and DGPS.

GNSS Augmentation in the SSR Domain



A network of reference stations is used to **decorrelate** the different GNSS error **components:**

- satellite clocks
- satellite orbits
- satellite signal biases
- ionospheric delay/advance
- tropospheric delay

With this, users can generate the corrections valid for their position.

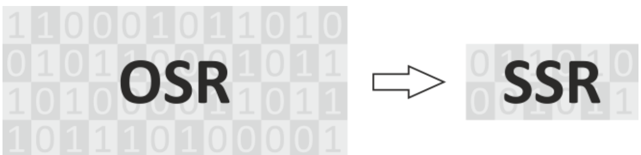
Additionally, statistical accuracy information can be transmitted to support the rover algorithm.

Since the state of the GNSS error components is determined, this approach is a
state space representation (SSR) technique.

Examples include SBAS, PPP and PPP-RTK.

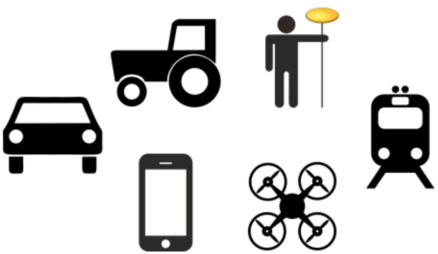
Major Benefits of SSR Augmentation

Broadcasting corrections



Minimizing bandwidth

Scalable services



Broadcasting – Working Principle of Pseudo-/Virtual Reference Stations (OSR)

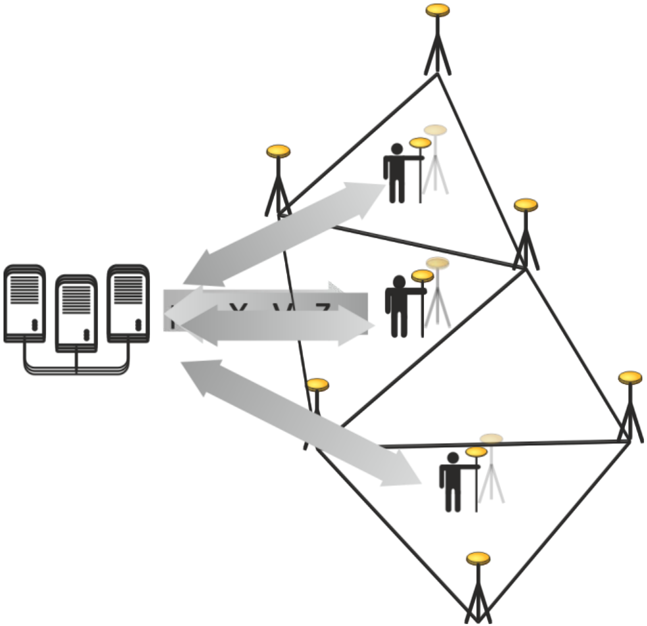
Often, OSR is realized with so called pseudo (PRS) or virtual reference stations (VRS).

1. The rover transmits his coarse position to the service provider.

2. Pseudo reference station observations are generated by interpolation of real station data.

3. Pseudo observations are transmitted to the rover and are used equivalently to a real nearby reference station.

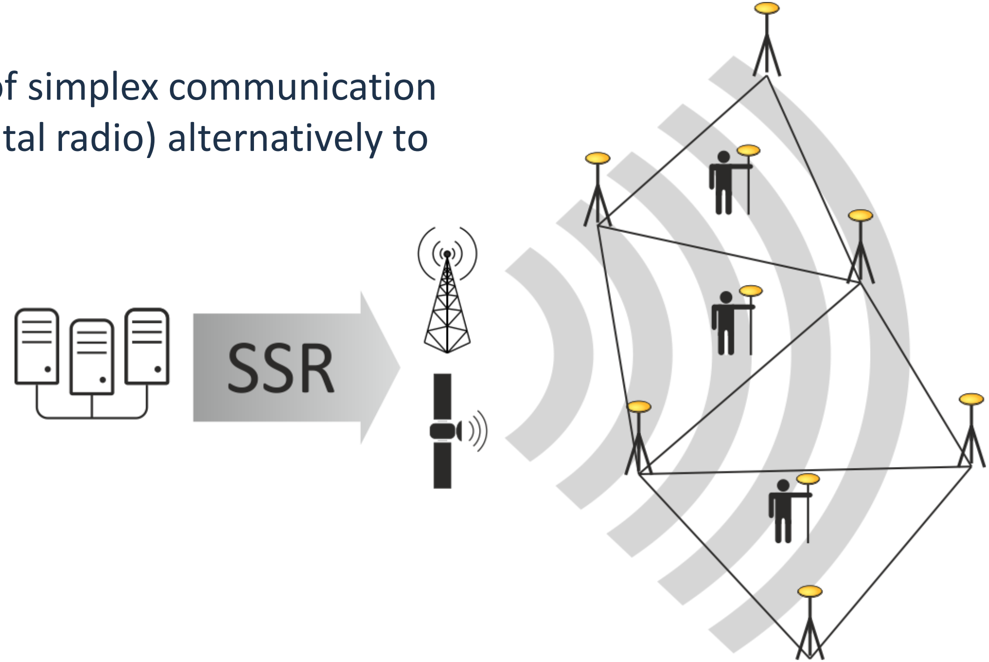
This requires one duplex data channel per user.



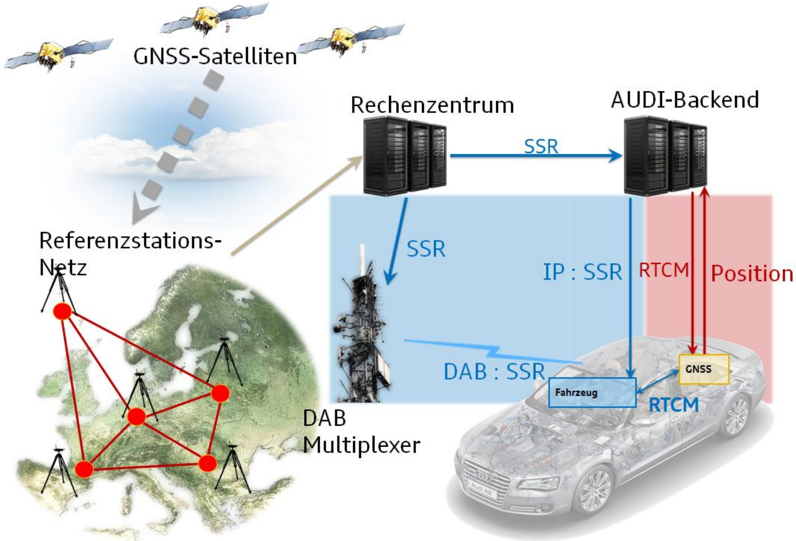
Broadcasting – SSR is Well Suited

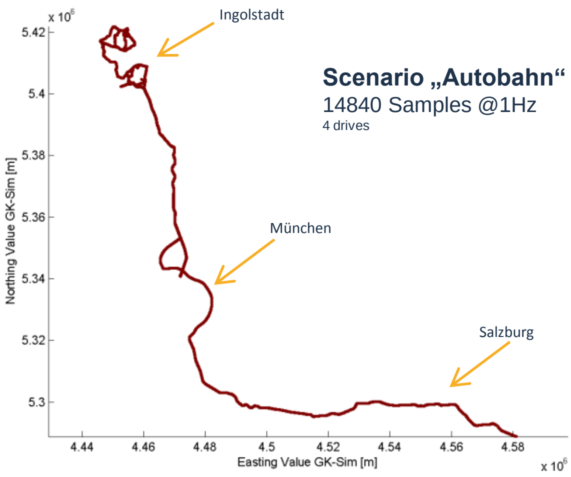
With SSR based network-RTK, **only one** data stream is transmitted to **all users**.

This enables the use of simplex communication media (satellites / digital radio) alternatively to the internet.



Broadcasting – An Example with DAB





SSR

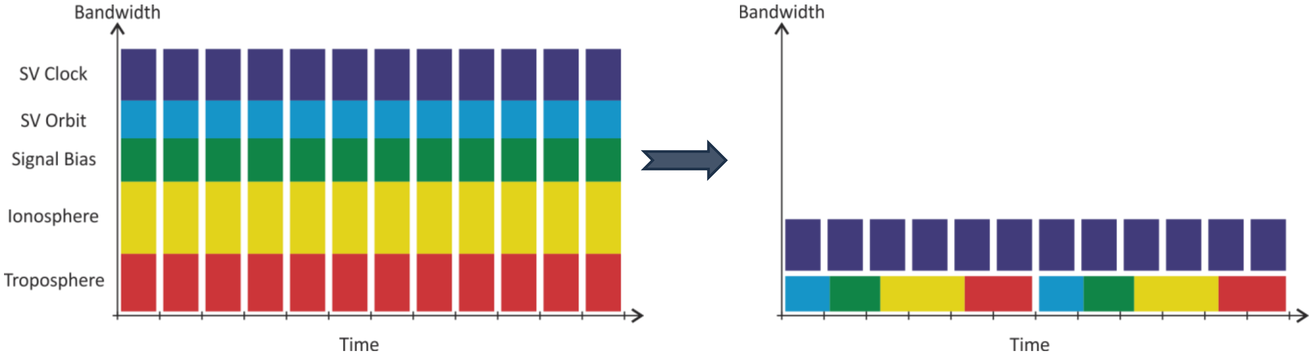
OSR

Figure from **Florian Mickler**:
“Lane-level vehicle localization through GPS with correction data distributed over digital radio broadcasting (DAB)”, ELIV 2015

Minimizing Bandwidth – Scaling SSR in Time Domain

Due to short-term fluctuations of satellite clocks, cm level positioning requires correction data updates approximately every 10 seconds.

Adjusting the update rate of individual SSR components can drastically reduce the bandwidth requirement while keeping the quality the same.



Minimizing Bandwidth – SSR via Satellite

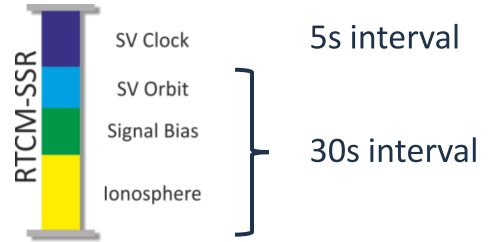
TERIASAT broadcasts SSR corrections via Satellite to provide RTK services in areas with insufficient mobile internet.

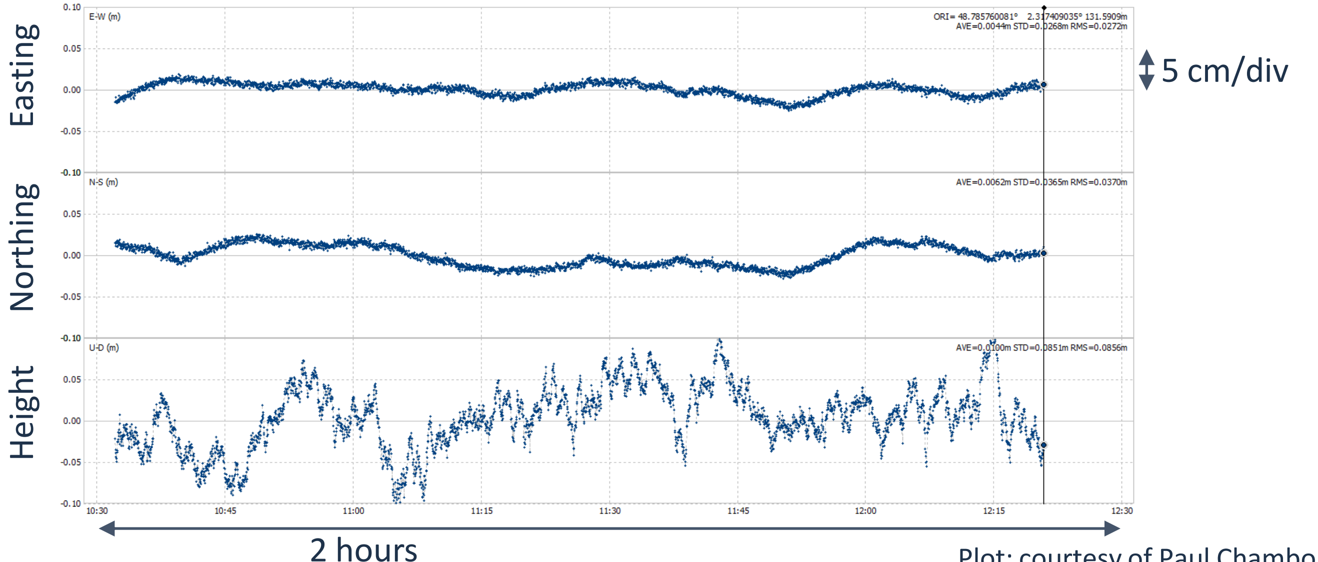
To reduce bandwidth, different states are updated with different rates.

Figure from: http://www.reseau-teria.com

TERIASAT: SSR via Satellite

The TERIASAT service broadcasts SSR using standardised and proposed RTCM-SSR messages as well as additional messages for biases and ionosphere.

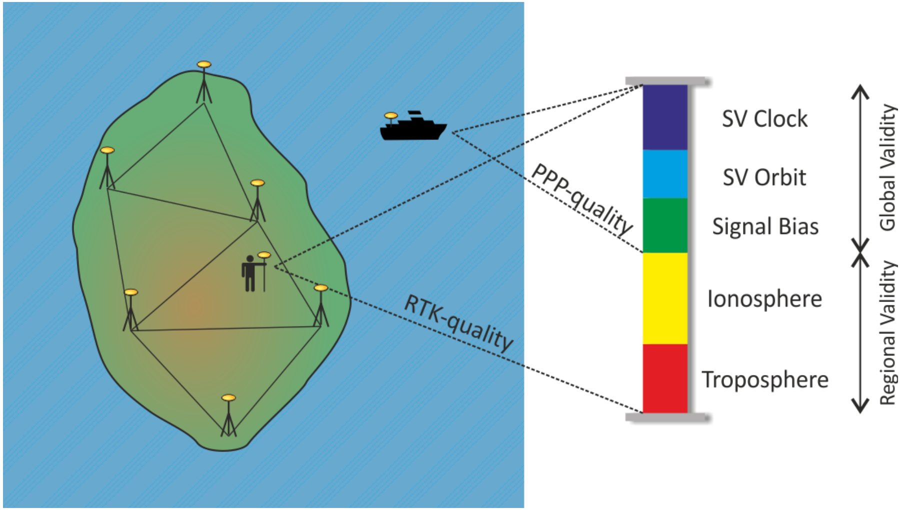




Plot: courtesy of Paul Chambon

Scalable Services – Scaling Service Areas

With SSR, **various quality levels for different regions** can be represented with a **single data stream**.
For example, a service could supply a region with high reference station density with an RTK quality service, while all neighbouring regions are provided with PPP quality.

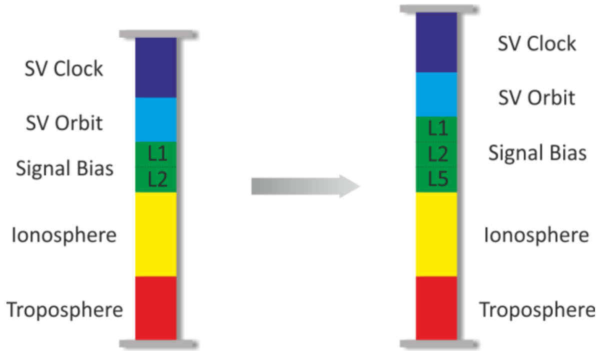


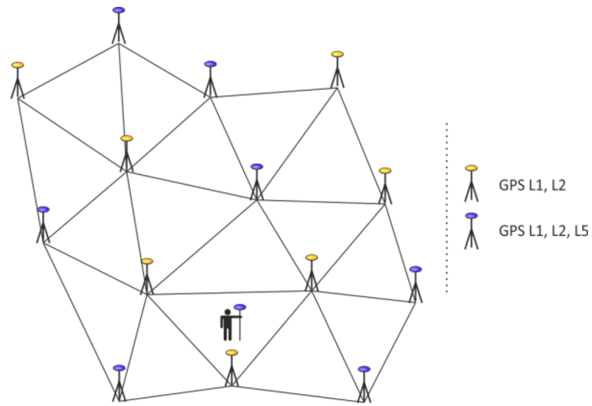
Scalable Services – Scaling Signals

SSR is intrinsically GNSS and frequency agnostic. Additional GNSS or signals can be added to existing services seamlessly.

Not all reference stations need to support all GNSS and signals.

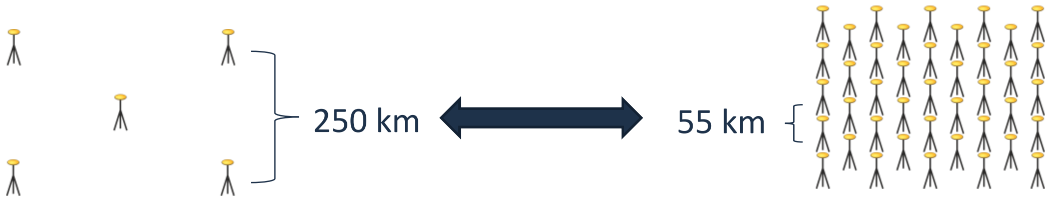
Mass market single frequency users and highest precision multi-GNSS multi-frequency users can use the same SSR service.



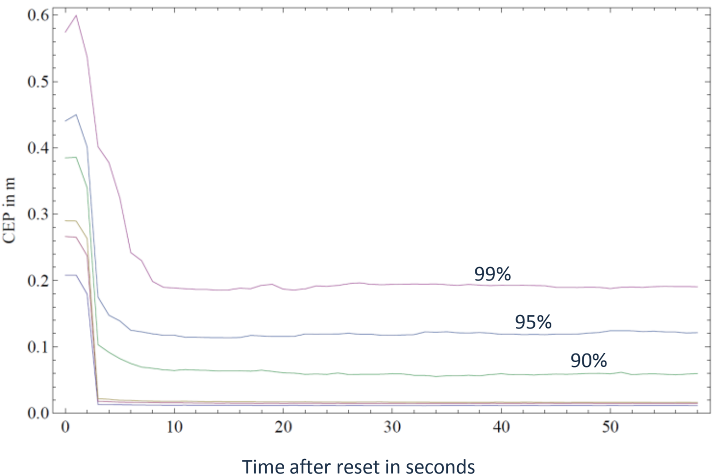


Scalable Services - Network Density

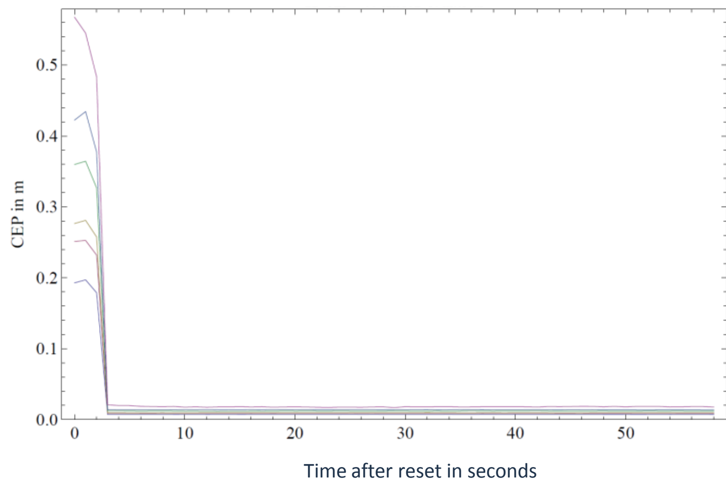
The network density can be scaled to meet different performance requirements.



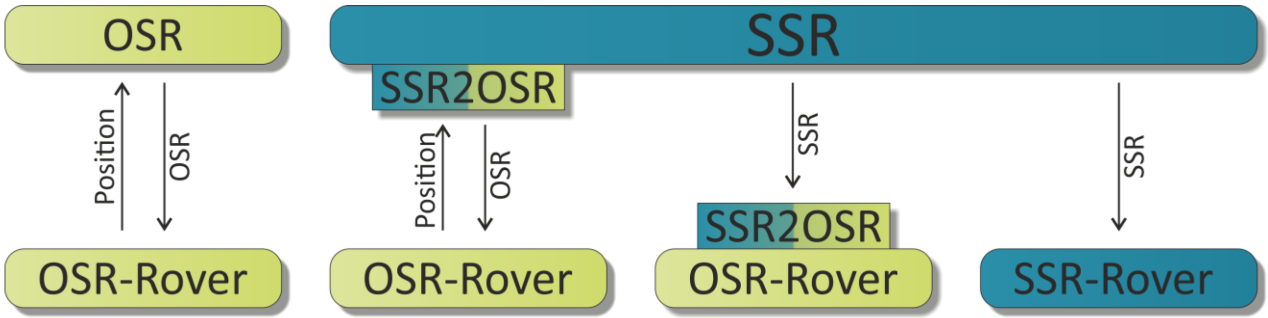
2D CEP in 250 km Network



2D CEP in 55 km Network



Scalable Services – Backward Compatibility



Legacy rovers can be supported via SSR2OSR conversion either on the server or rover side. Optimal performance will be reached once the SSR corrections with accompanying accuracy information are directly incorporated in the positioning engine.

SSR Standardization by the RTCM

Since 2007 the SSR working group of the Radio Technical Commission for Maritime Services (RTCM) Special Committee 104 is developing a standard message format for SSR messages.

Standardized (2011)	Proposed (2013)	In Preparation
Orbits*	Phase Biases	Slant TEC (STEC)
Clocks*	Vertical TEC (VTEC)	Troposphere
Code Biases*		Compressed Messages
User Range Accuracy		

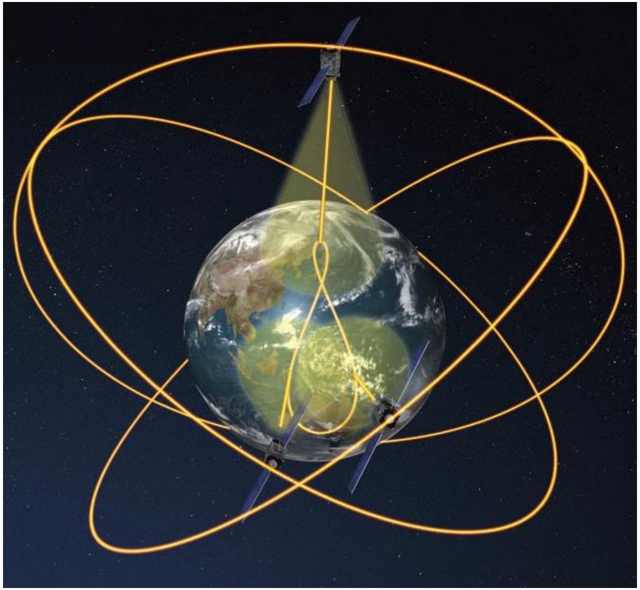
*: for GPS and GLONASS only, messages are proposed for Galileo, QZSS, BDS & SBAS

Quasi-Zenith Satellite System

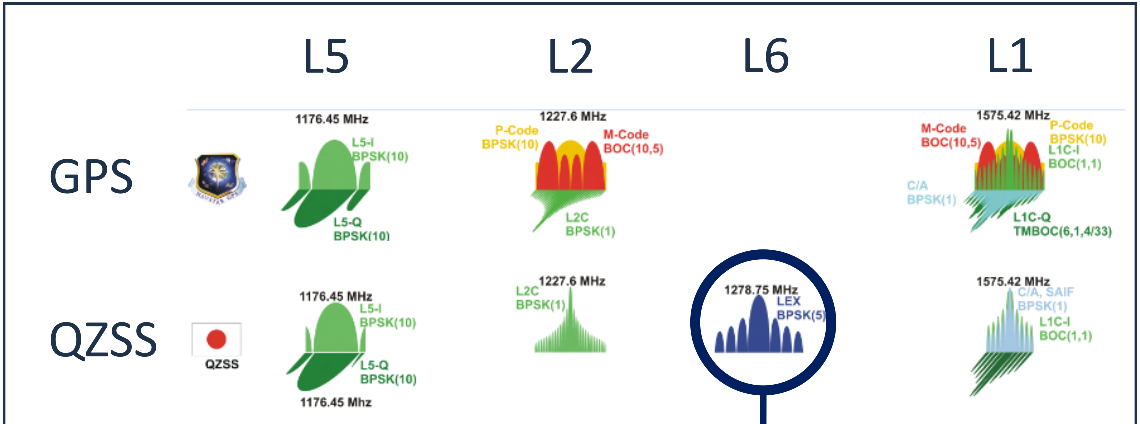
QZSS
- Regional GNSS
- SBAS System
- Disaster alert
- **Centimetre Level Augmentation Service (CLAS)**

Evaluation phase since 2010:
- 1 geosynchronous satellite „MICHIBIKI“

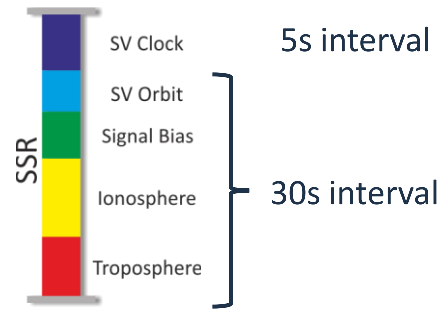
Operational phase from 2018:
- 3 geosynchronous satellites
- 1 geostationary satellite



Centimeter Level Augmentation Service (CLAS)

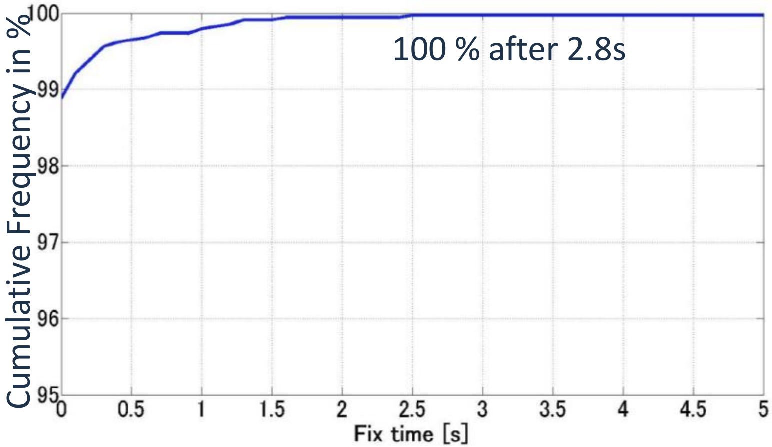


Each QZSS satellite broadcasts the complete SSR state vector for the area of Japan with a bandwidth of 1.7 kbps on L6



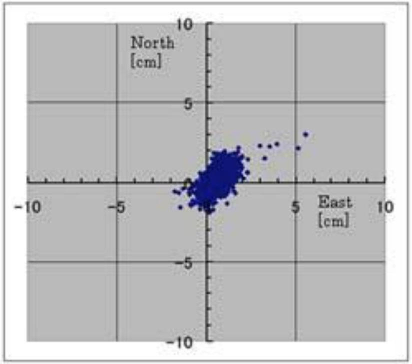
CLAS Performance

Rover Fixing Performance



- Fixing Time at hot start is < 3 s
- Fixing Time at cold start is limited to 33 s due to the longest update interval of 30 s

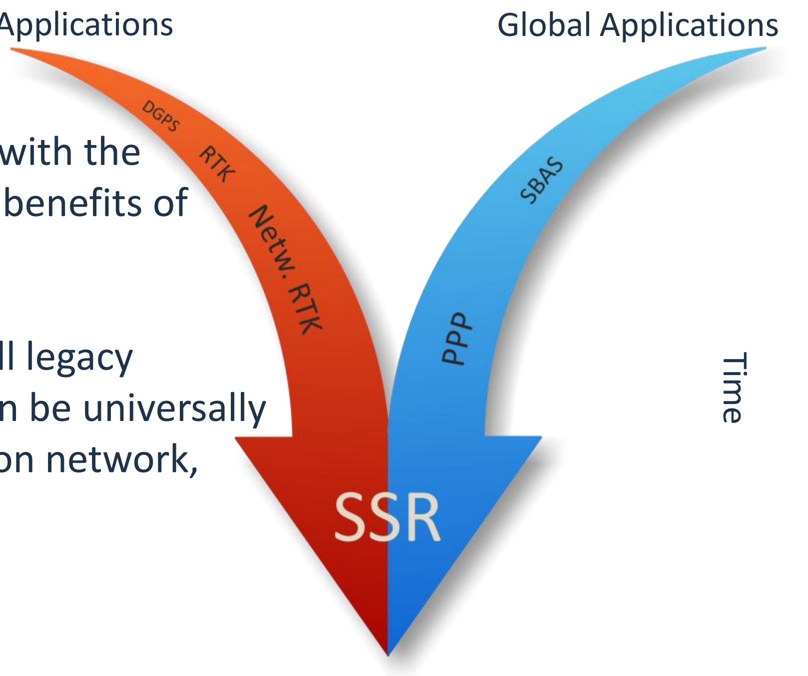
Kinematic Positioning Performance



Horizontal	
Average error	0.6cm
Standard deviation (σ)	1.2cm
Vertical	
Average error	1.4cm
Standard deviation (σ)	1.9cm

Plots & Data: Yuki Sato et al. at PPP-RTK & Open Standards Symposium 2012, Frankfurt
“Centimeter-class Positioning Augmentation Utilizing Quasi-Zenith Satellite System “

SSR – Fusion of GNSS Augmentations



GNSS augmentation with SSR combines the **accuracy** of RTK with the **broadcast** and low **bandwidth** benefits of PPP.

It is **backward compatible** to all legacy augmentation methods and can be universally adopted to any reference station network, no matter if

- global or regional
- high density or low density
- single, double or triple frequency.

SSR – Try it Yourself!

Visit us!
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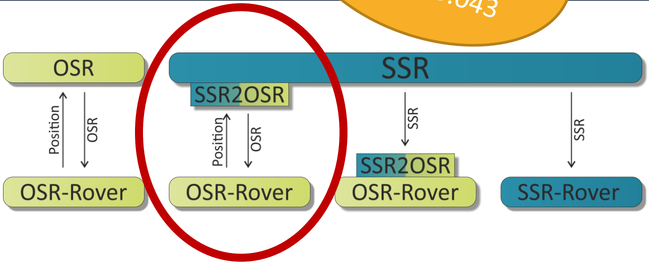
RTCM 3.1 Mountpoint:

Server:	141.91.161.192
Port:	2101
Mountpoint:	VRS_3_2G_SSR-Test
User:	SSR-Test
Password:	Intergeo



Many thanks to ***SAPOS*** GeoNord

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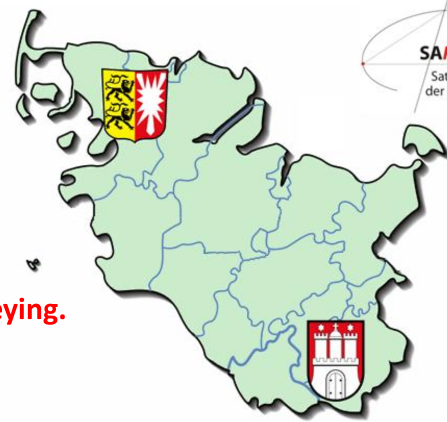

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