The 8th Meeting of International Committee on GNSS

--Working Group A

Analyzing the Viewpoints on Interoperability

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Contents

Background

Multi-GNSS make **interoperability possible**.

The user/industry's viewpoint is a very important input for providers to implement GNSS interoperability.

Background

Some User/Industry's Viewpoints on GNSS Interoperability:

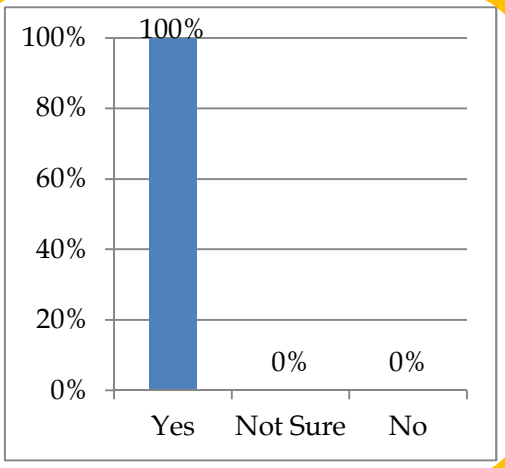
- April, GNSS **user/industry's** viewpoints (investigated during ***ION-PNT 2013***);
- May, GLONASS **user/industry's** viewpoints (published in ***WG-A Interim Meeting 2013***);
- May, Beidou **user/industry's** viewpoints (investigated during ***CSNC-2013***).

Comparing the answers about the same questions from these three ways, we can obtain some common viewpoints of the users and industries.

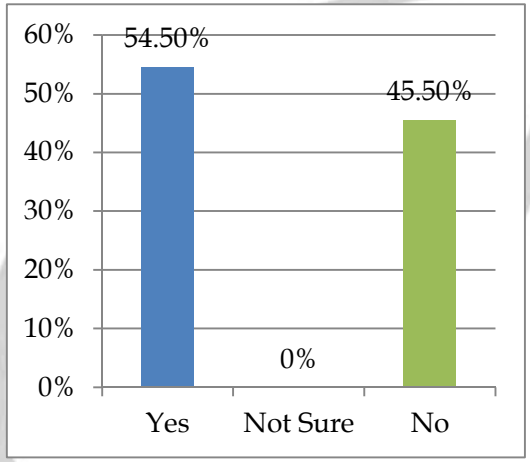
Viewpoints Analyzing

Does a wider satellite transmitter bandwidth help with multipath mitigation?

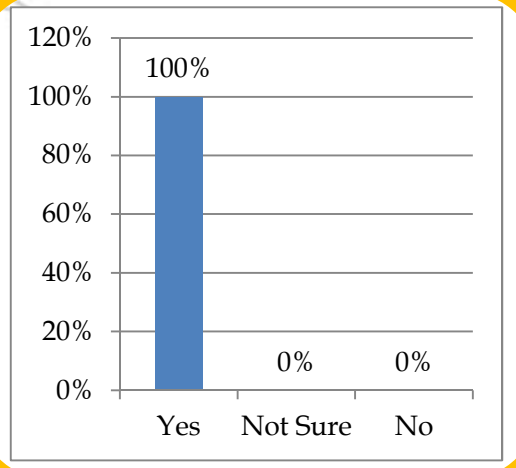
ION-PNT 2013



Russia Investigation



CSNC-2013

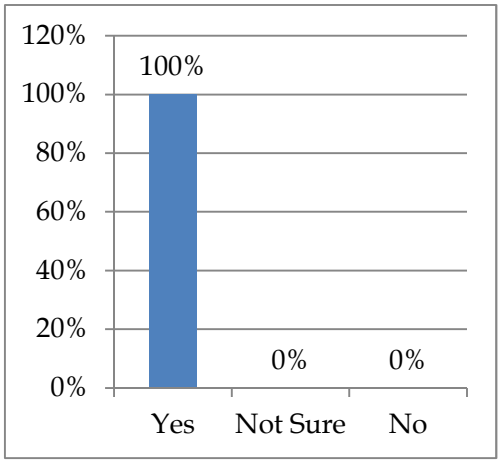


In PNT & CSNC, most respondents held the similar opinion.

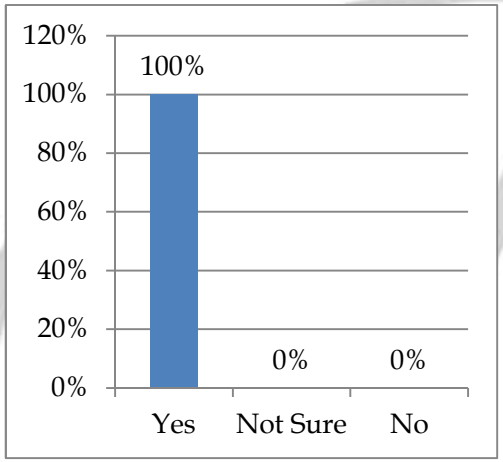
Viewpoints Analyzing

Should the international community strive to protect all GNSS signal bands from terrestrial signal interference?

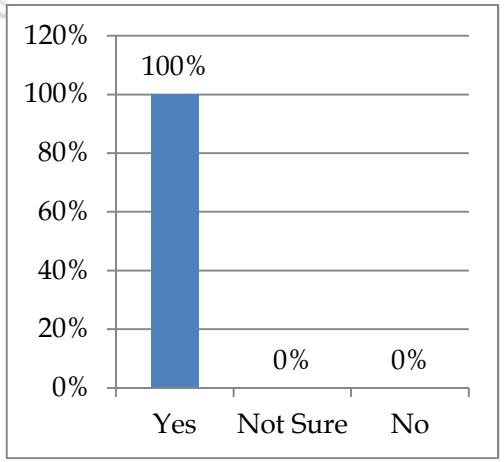
ION-PNT 2013



Russia Investigation



CSNC-2013

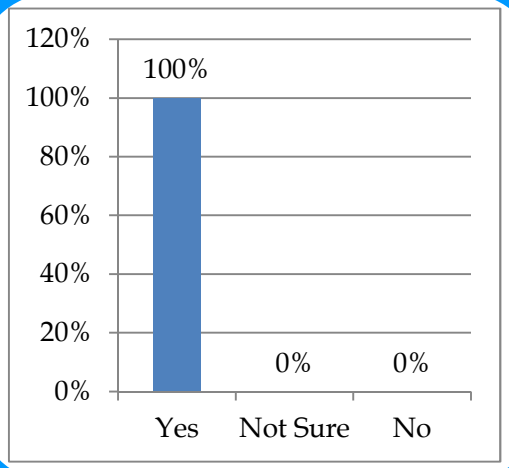


The same opinion.

Viewpoints Analyzing

To assure only "good" signals, should GNSS providers agree on minimum international signal quality standards and agree to provide only signals meeting the standard?

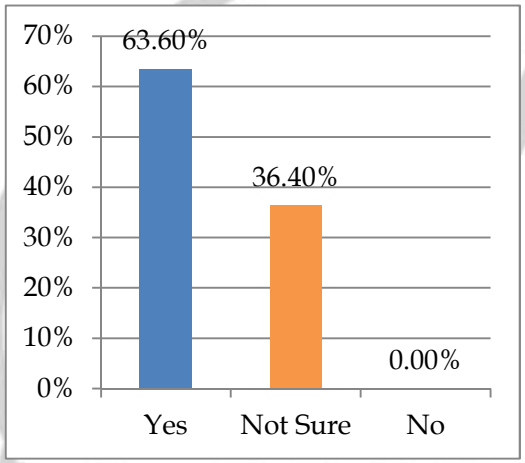
ION-PNT 2013



- Obey the exactly index, not "error less than 100m"

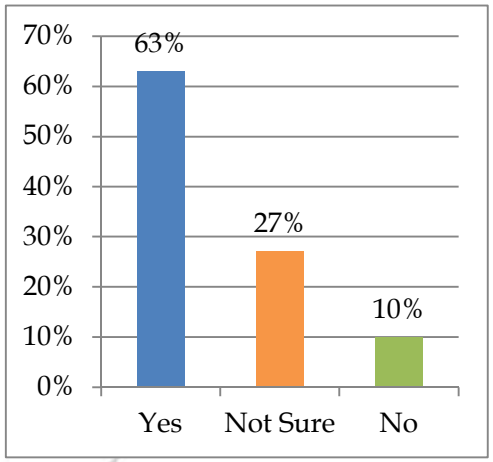
All the same.

Russia Investigation



- All providers should agree;
- Unify the parameters calculation method;
- Also provide performance parameters.

CSNC-2013

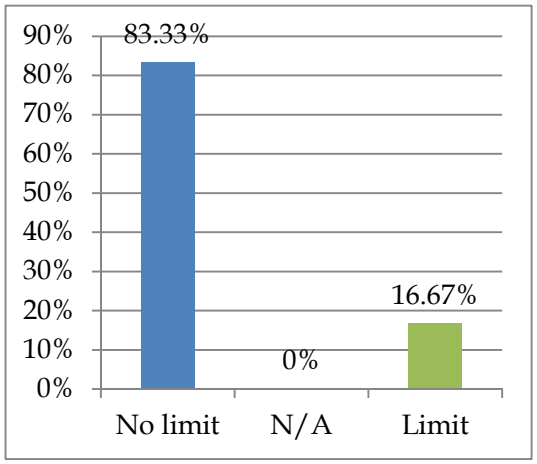


- Consider service standard;
- Standards should be separated into types by user.

Viewpoints Analyzing

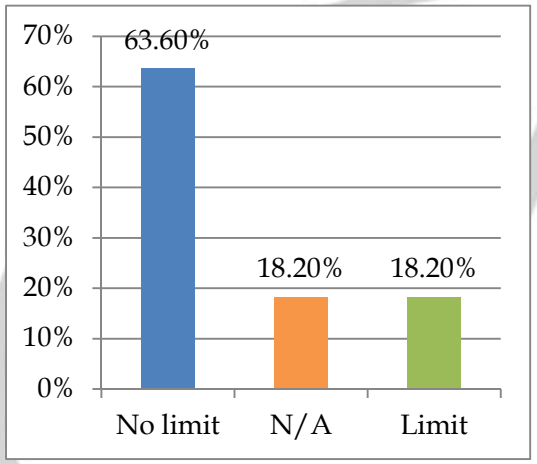
Is having more signals inherently better or do you think there should be a limit?

ION-PNT 2013

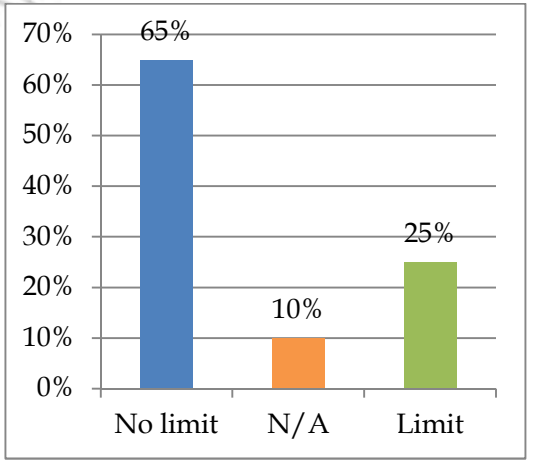


- No need to limit the "good" signal;
- No limit while do not obviously rise up the noise floor;
- 50-60 satellites are enough.

Russia Investigation



CSNC-2013



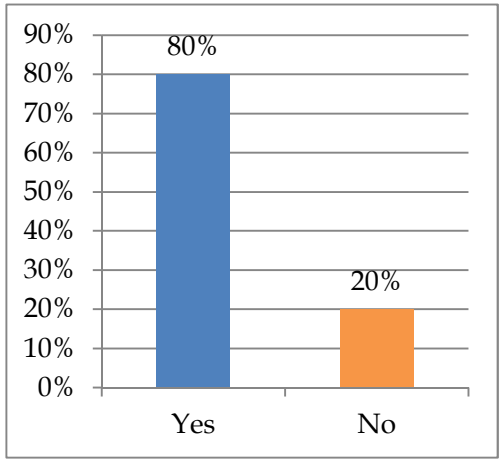
- Depend on different situations, "good" signals are welcome;
- Should be limit if rise up the noise floor.

Most user/industry have the similar opinion.

Viewpoints Analyzing

Will the marketplace "force" you to make use of every available signal?

ION-PNT 2013

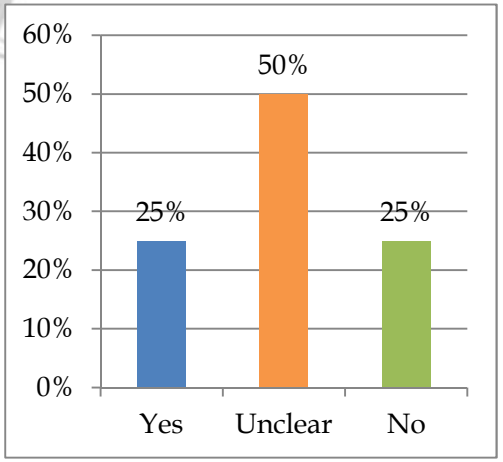


- Minute noise floor arising, help to eliminate time delay.

Russia Investigation

N/A

CSNC-2013



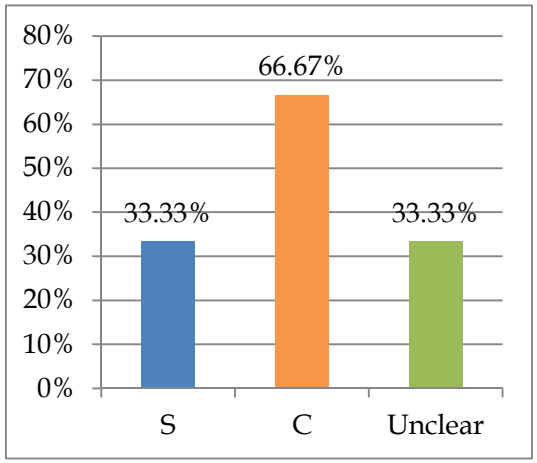
- "Unclear": depend on user;
- "No": from mass consumption/car user.

Different opinions.

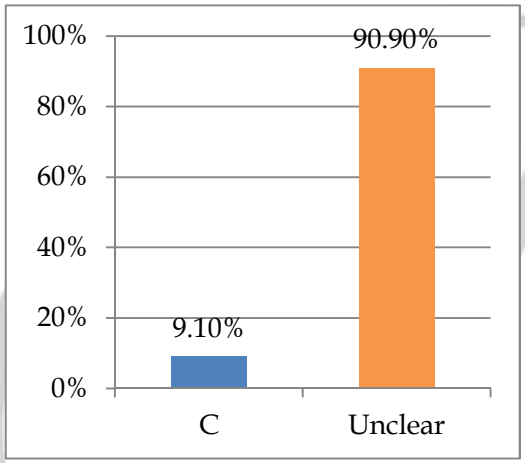
Viewpoints Analyzing

Would you prefer a common open signal in S Band? In C Band? Why?

ION-PNT 2013



Russia Investigation



- Did not mention the "S" band.

CSNC-2013

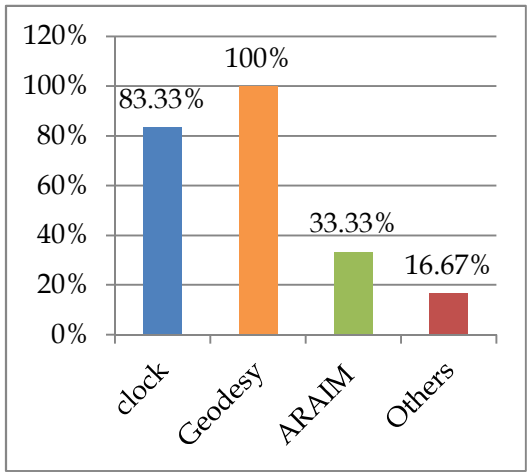
N/A

Different opinion.

Viewpoints Analyzing

Would you recommend GNSS or SBAS services provide interoperability parameters:
System clock offsets, Geodesy offset, ARAIM parameters, Others

ION-PNT 2013

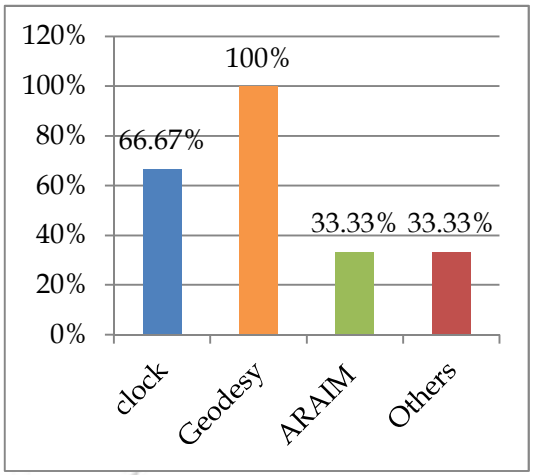


- Data refresh rate is important.

Russia Investigation

N/A

CSNC-2013



- Perhaps using SBAS to provide the parameters.

The same opinion.

Viewpoints Analyzing

Compare the outcomes from these three investigations:

Kinds of Viewpoint	Data	Ratio
Same/Similar	4	36.4%
Different	7	63.6%
Total	11	100%

Kinds of different opinions	Data	Ratio 1 (÷7)	Ratio 2 (÷11)
Two are the same	4	57.1%	36.4%
Totally different	3	42.9%	27.2%
Total	7	100%	63.6%

- 36.4% of the User/Industry viewpoint questions have the same/similar opinions;
- 63.6% (including **36.3% two are the same** & **27.3% totally different**) of the questions still have disagreements;
- The related works need go further.

Positioning Equation

Ten Parameters

Signal Parameters

- User Received Signal Level
- Modulation
- Correlation Characteristics
- Phase Coherence
- GNSS Coordinate Bias
- GNSS Time Bias
- Clock Offset

Message Parameters

- Orbit
- TGD
- Ionosphere

Positioning Equation

Positioning equation of multi-GNSS (Interoperability):

$$\rho_i = c(t_u - (t_i + \delta t_{j,\mathrm{UTC}})) + \sqrt{\sum \left(\Lambda_u - (\Lambda_{i,\mathrm{ITRF}} + \delta\Lambda_{j,\mathrm{ITRF}} + V_\Lambda \times (\delta t_i + \Delta t_{j,\mathrm{UTC}})\right)^2}$$

Variable	Implication	Reference
ρ_i	Pseudo-range from user to the ith satellite	Time & Orbit
c	speed of light	
t_u	user time	Time
t_i	time of the ith satellite (in different time scale)	Time
$\delta t_{j,\mathrm{UTC}}$	bias between the jth time reference to UTC	Time
Λ	x or y or z	Orbit
Λ_u	user coordinate (in ITRF)	Orbit
$\Lambda_{i,\mathrm{UTRF}}$	coordinate of the ith satellite in ITRF	Orbit
V_Λ	components of velocity in the different directions	Time & Orbit
$\Delta t_{j,\mathrm{UTC}}$	ephemeris start time bias with UTC	Time

Positioning Equation

Positioning equation of multi-GNSS (Interoperability):

$$\rho_i = c(t_u - (t_i + \delta t_{j,\mathrm{UTC}})) + \sqrt{\sum \left(\Lambda_u - (\Lambda_{i,\mathrm{ITRF}} + \delta\Lambda_{j,\mathrm{ITRF}} + V_\Lambda \times (\delta t_i + \Delta t_{j,\mathrm{UTC}})\right)^2}$$

Variable	Implication	Reference
ρ		Orbit
δt		
$\Lambda_{i,U}$		
V_Λ	components of velocity in the different directions	Time & Orbit
$\Delta t_{j,\mathrm{UTC}}$	ephemeris start time bias with UTC	Time

How to calculate these parameters?
How important are they to interoperability?
Are these parameters enough?
……

Too many unsolved questions.

Conclusion

We need more inputs on GNSS interoperability. It will include not only the issues of TOM's questionnaire but also the following actions:

1. Interoperable signals

- *Monitoring the performance of GNSS interoperable signals*
- *Joint observe the signal in space*
- *Detect the difference of the diverse signals*
- *Provide the formula of GNSS interoperable service*
- ……

2. GNSS differential system interoperability

- *Implementation of SBAS interoperability*
- *Implementation of DGNSS interoperability*
- ……

3. Time system interoperability;

- *Time and frequency transfer among the time keeping laboratories*
- *Model of broadcast time difference parameters*
- ……

4. The third way to implement interoperability

- *Utilizing the data from IGS, iGMAS, MGA.*
- ……

Recommendation

Prepared by: **Joint with China and The United State**
Issue Title: **Proposed the 2nd Interoperability**
Recommendation of ICG WG-A Action:

In the 2nd interoperability workshop which will be held in conjunction with the "CSNC 2014", the following interoperability subjects may be addressed:

1. Interoperable signals
–*Monitoring the performance of GNSS interoperable signals*
–*Joint observe the signal in space*
–*Detect the difference of the diverse signals*
–*Provide the formula of GNSS interoperable service*
–……
2. GNSS differential system interoperability
–*Implementation of SBAS interoperability*
–*Implementation of DGNSS interoperability*
–……
3. Time system interoperability;
–*Time and frequency transfer among the time keeping laboratories*
–*Model of broadcast time difference parameters*
–……
4. The third way to implement interoperability
–*Utilizing the data from IGS, iGMAS, MGA.*
–……

Thank You for Your Attention!

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