ICG-6 Working Group A

Relationship between Visible Satellite and Receiver Noise Floor

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Background

- Multi-GNSS world is coming and it will provide more visible satellites and more signals.
- Interoperability is an effective way to provide better services to users.
- On the one hand, increasing satellite number will improve PDOP value. On the other hand it will raise receiver noise floor.

Background

- The noise floor is not only caused by intra-system signals, but also caused by inter-system signals .
- Increased noise floor will impact the service.
- Analyze the relationship between visible satellite and noise floor is benefit for interoperability.

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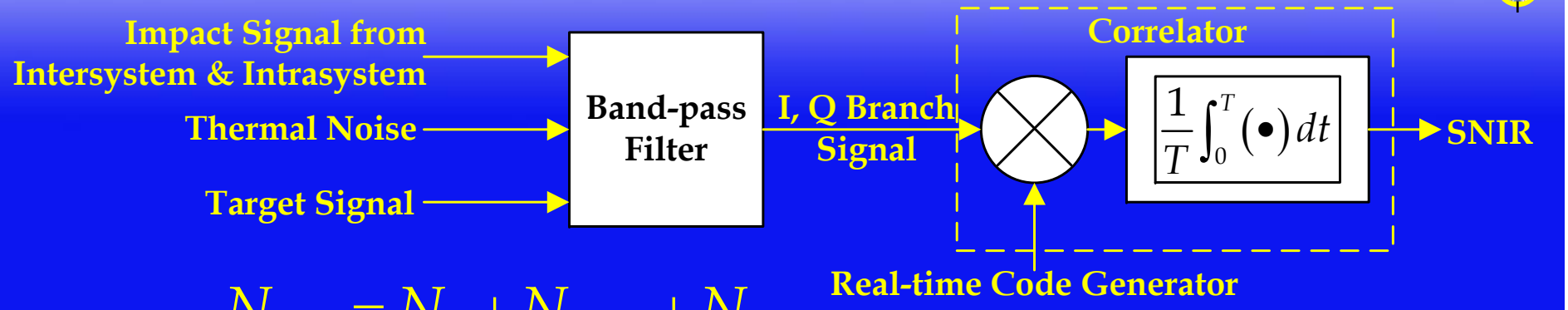
Analyzing Principle



$$N_{total} = N_0 + N_{inter} + N_{intra}$$

$$= N_0 + \sum_{q=1}^{Q-1}\sum_{k=1}^{K_q}\sum_{j=1}^{J_q} P_{q,k}^{(j)} k_{q,k}^{(j)} (\Delta f_{q,k}^{(j)})$$

$$+ \sum_{i=1}^{I-1} P_M^{(i)} K_M^{(i)} (\Delta f_M^i) + \sum_{u=1}^{U-1}\sum_{i=1}^{I} P_u^{(i)} k_u^{(i)} (\Delta f_u^{(i)})$$

N_{total}: Total complex noise floor.

N_0: Thermal noise (-201.5dBW/Hz).

N_{intra}: Equivalent noise power density of impact signal from satellites belonging to the same system.

N_{inter}: Equivalent noise power density of impact signal from satellites belonging to the other system.

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Simulation Condition

Consider the following signals:

Signal		Minimal receive power (dBW)	Maximal receive power (dBW)
BeiDou	MBOC(6,1)	-158	-155
	BOC(14,2)	-158	-155
GPS	BPSK(1)	-158.5	-153
	BPSK(10)	-160	-155.5
	BOC(10,5)	-157	-150
	MBOC(6,1)	-157	-154
Galileo	BOC_COS(15,2.5)	-155	-150
	CBOC(6,1)	-157	-154

N_0: Thermal noise (-201.5dBW/Hz)

Front receive band-width: 30MHz;

Receiver location: Lintong, (34.27°N, 109.22°E, 450m).

Simulation

Three Constellation conditions we simulated:

1、Current Constellation

(GPS 33+BeiDou 9+Galileo 2)

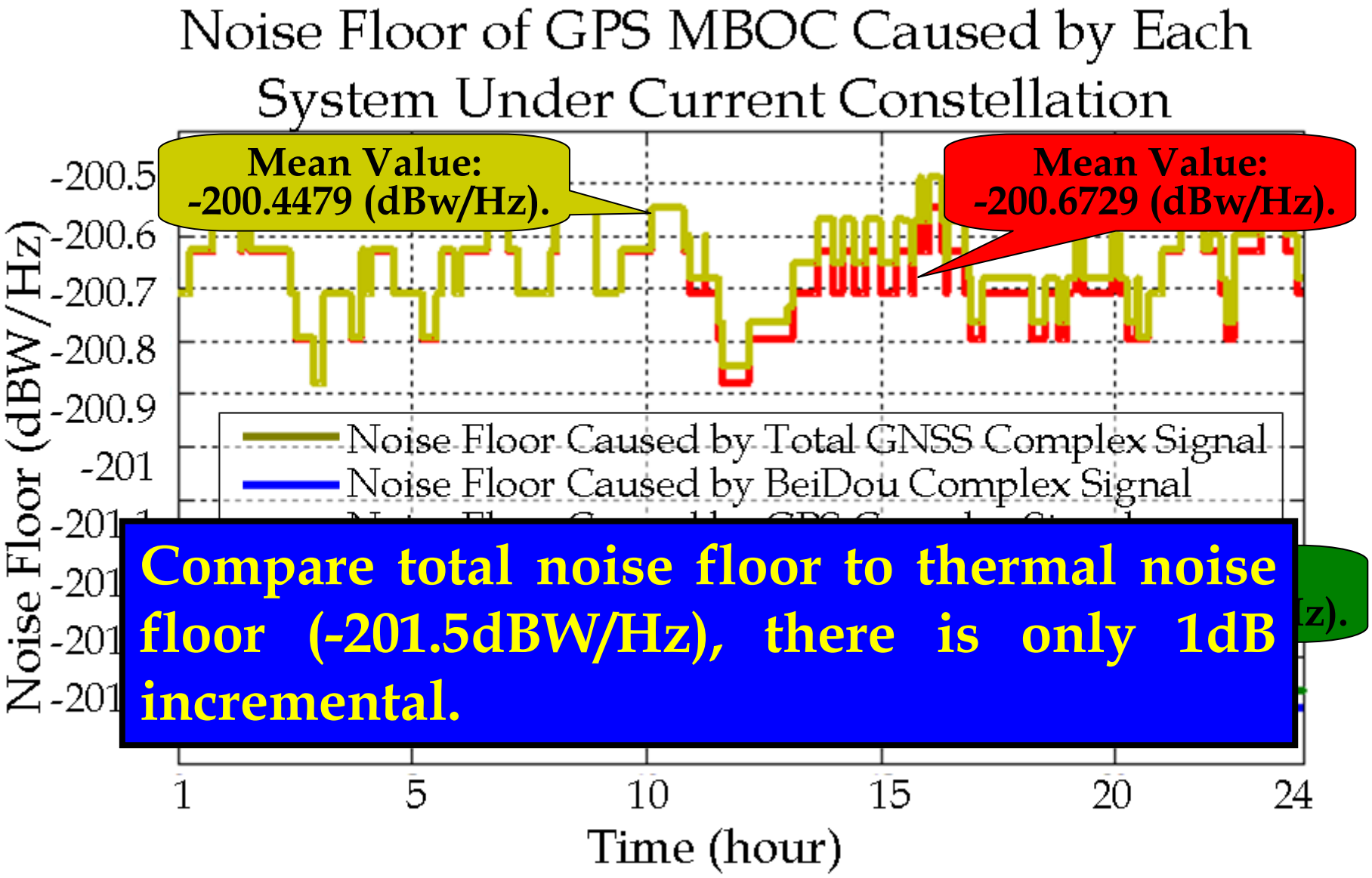
2、Designed Constellation

(GPS 33+BeiDou 35+Galileo 30)

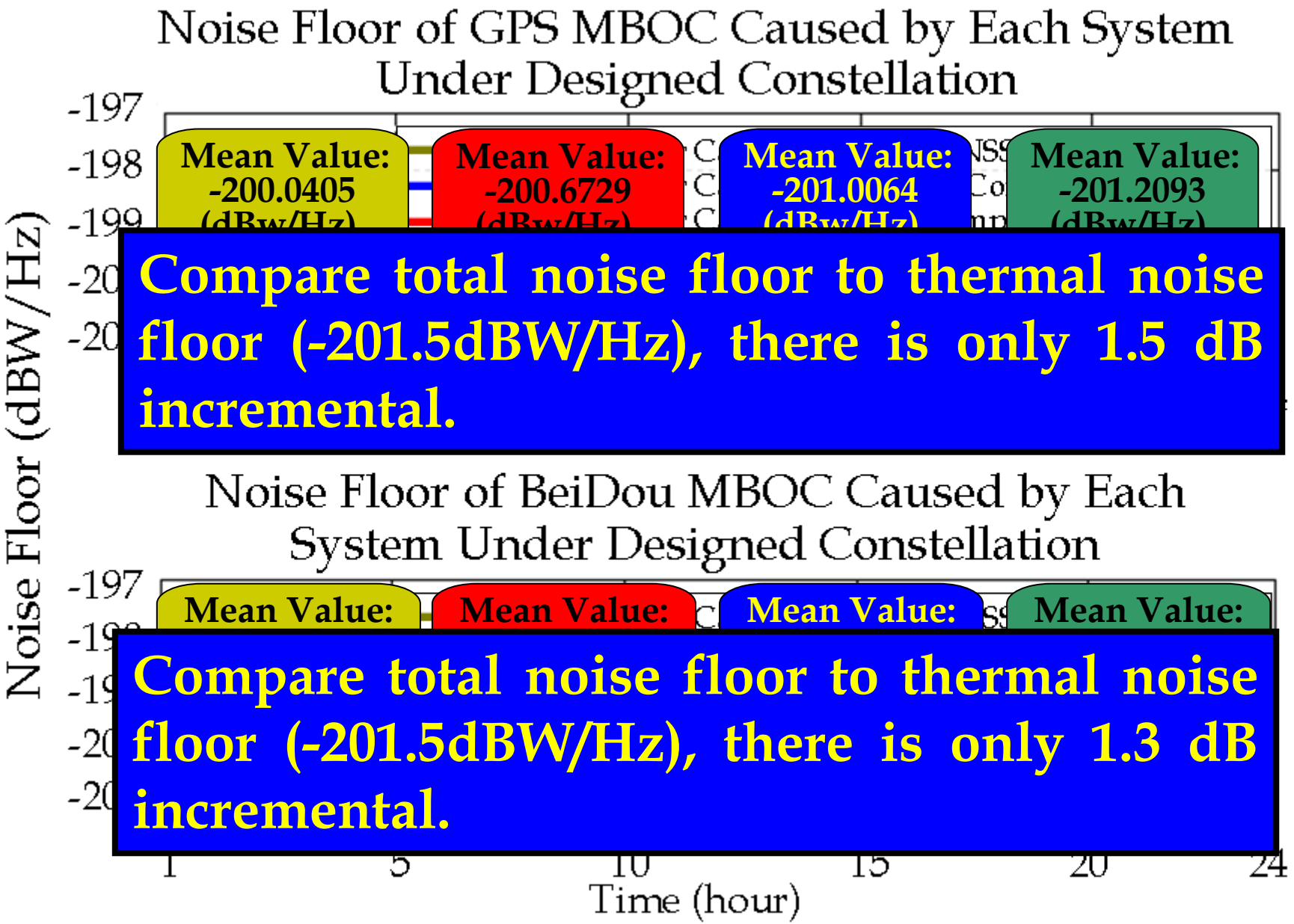
3、 Adding Visible Satellite Numbers

(GPS 533+BeiDou 535+Galileo 530)

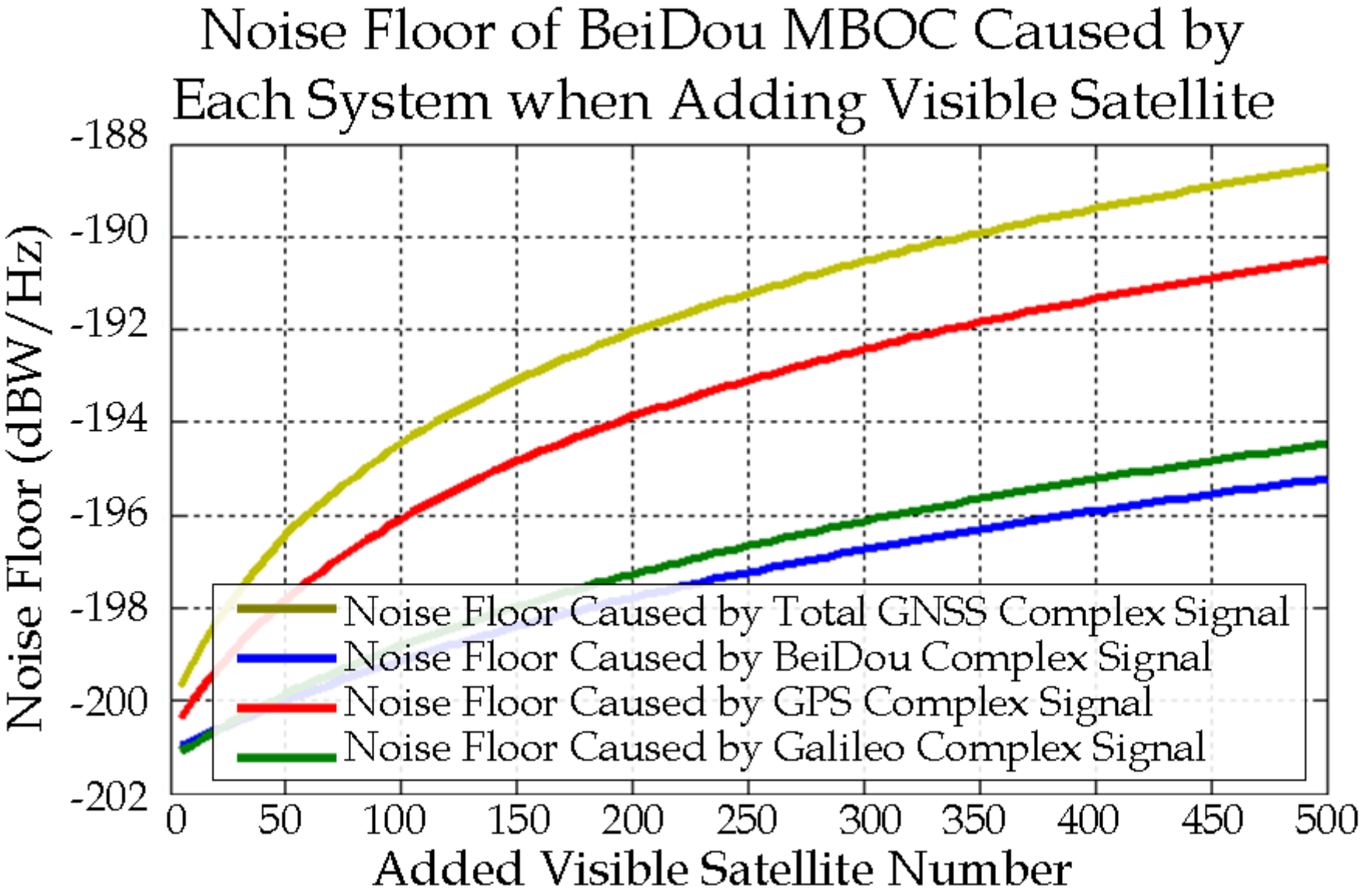
Noise Floor of Current Constellation



Noise Floor of Designed Constellation

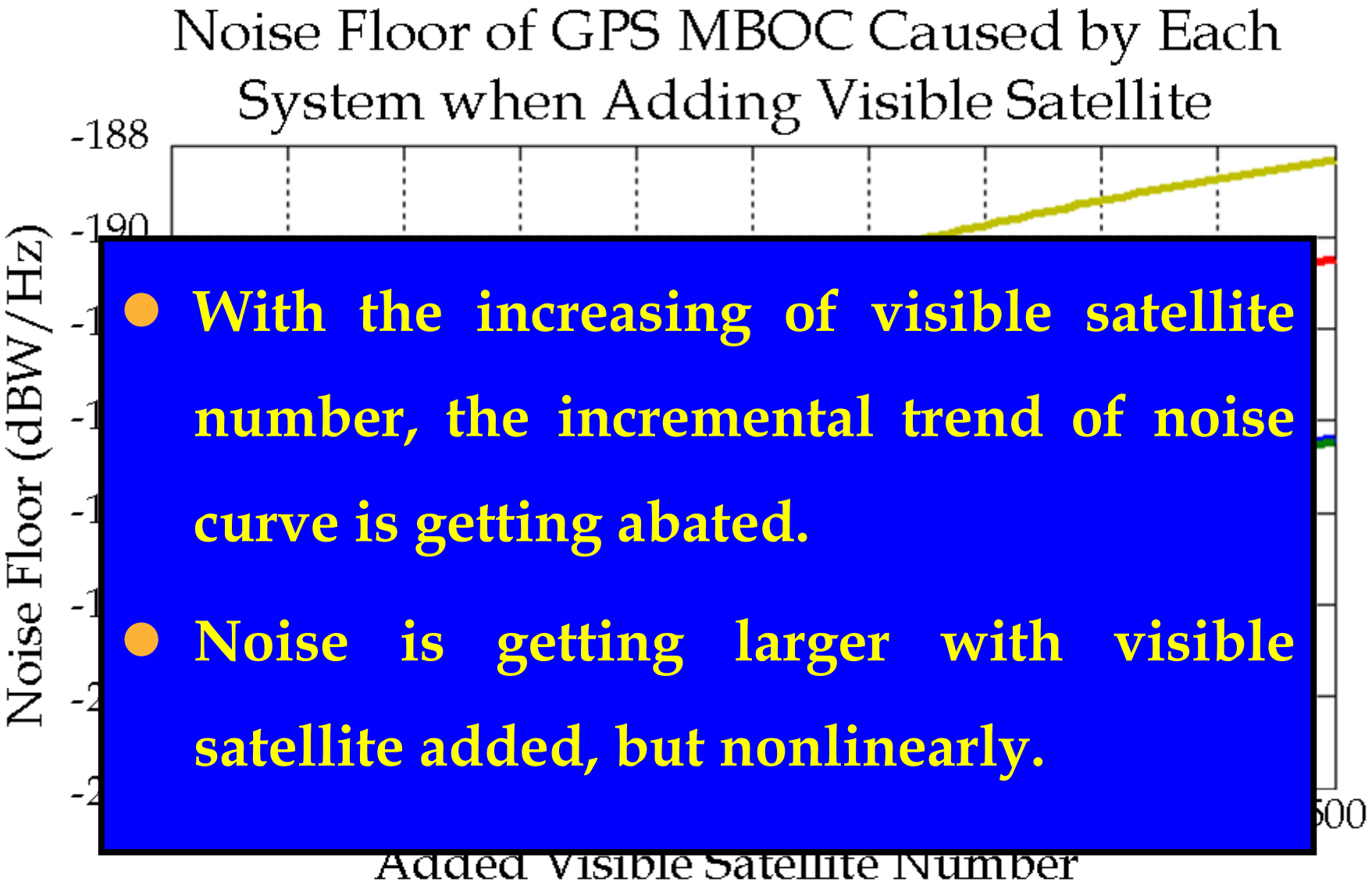


Noise Floor of Adding Visible Sat. No.



Noise Floor of Adding Visible Sat. No.

Secondly, choose the target signal be *GPS MBOC*.



- **With the increasing of visible satellite number, the incremental trend of noise curve is getting abated.**
- **Noise is getting larger with visible satellite added, but nonlinearly.**

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Influence of Ranging Accuracy

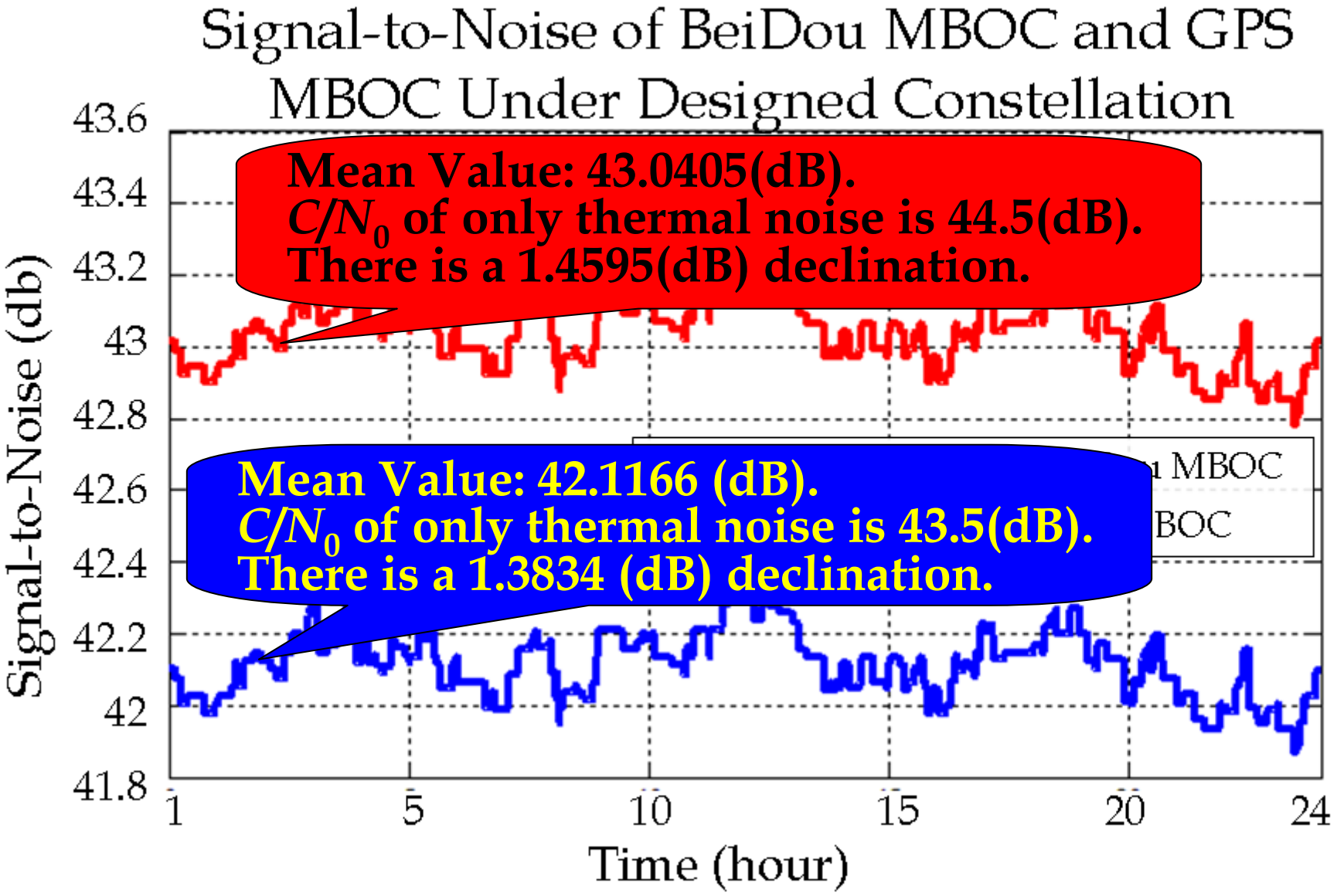
- Adding Visible satellite number
- Increasing receiver noise floor
- Reducing C/N_0
- Reducing S/N
- Increasing Ranging error

Influence of Ranging Accuracy

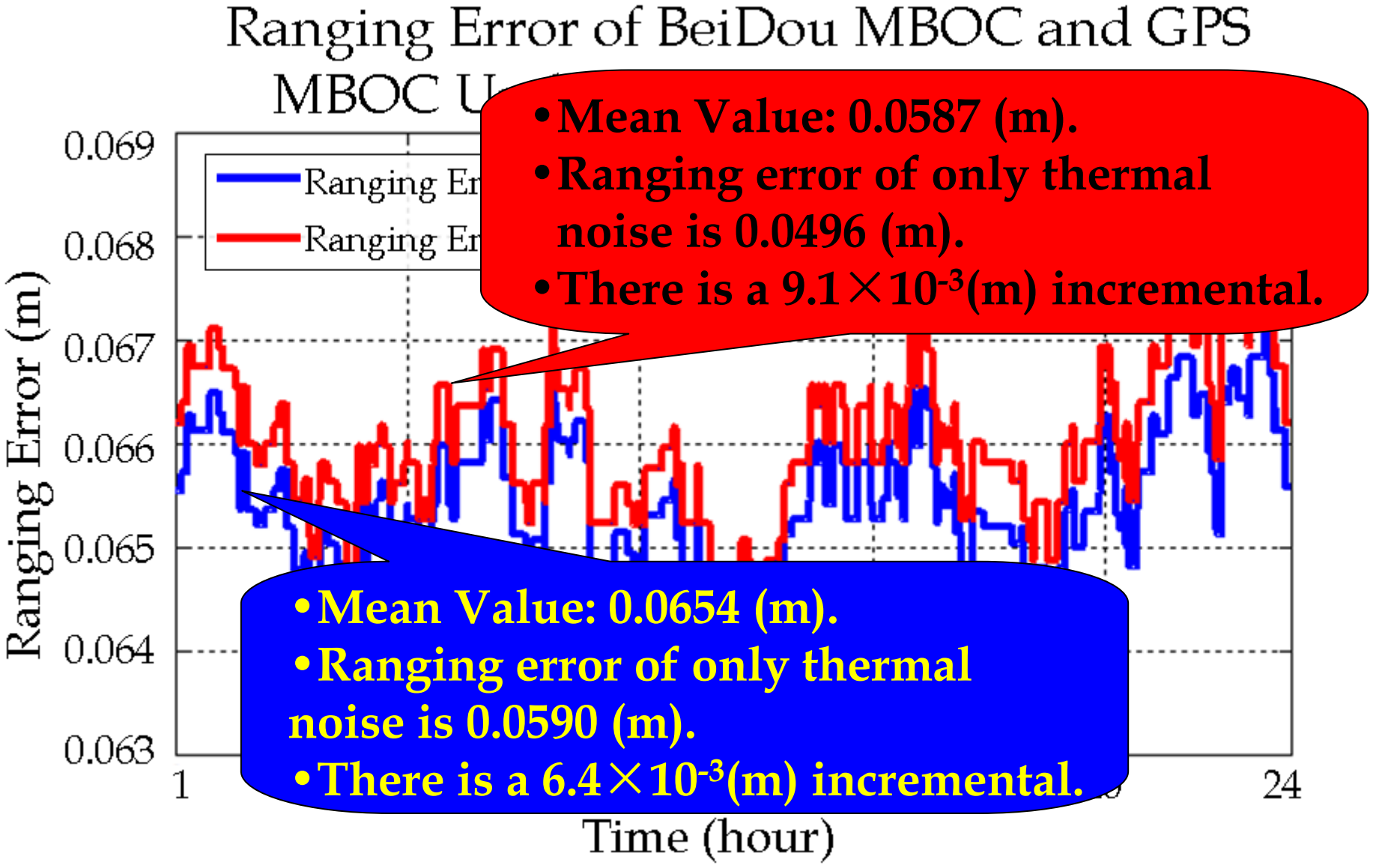
Variance of Ranging Error:

$$\sigma^2_{NELP} = \frac{B_L(1-0.25B_LT)\int_{-\beta_r/2}^{\beta_r/2} G_S(f)\sin^2(\pi f\Delta)df}{\frac{C}{N_0}\left(2\pi\int_{-\beta_r/2}^{\beta_r/2} fG_S(f)\sin(\pi f\Delta)df\right)^2} \times\left[1+\frac{\int_{-\beta_r/2}^{\beta_r/2} G_S(f)\cos^2(\pi f\Delta)df}{T\frac{C}{N_0}\left(\int_{-\beta_r/2}^{\beta_r/2} G_S(f)\cos(\pi f\Delta)df\right)^2}\right]$$

Influence of Ranging Accuracy



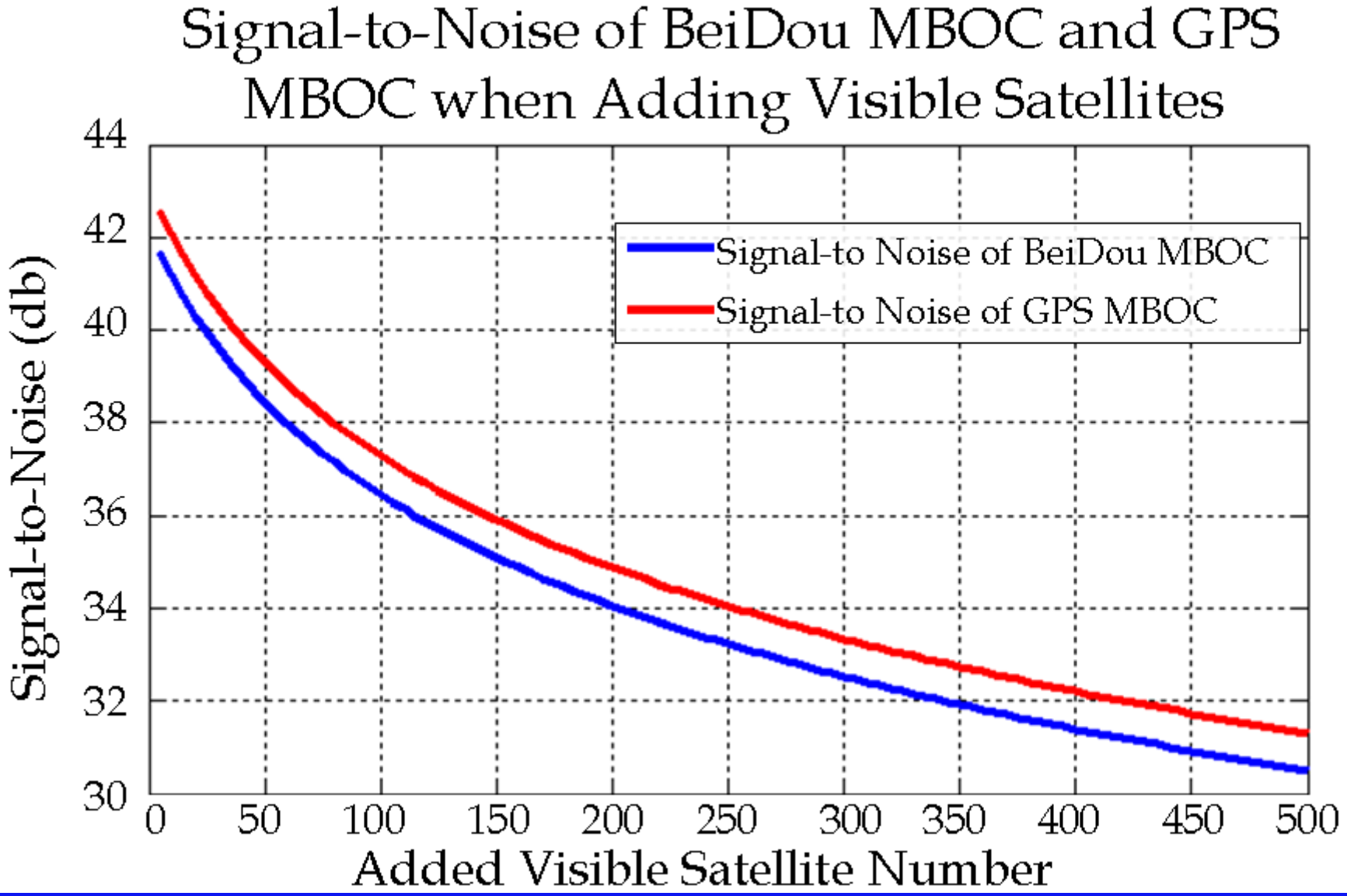
Influence of Ranging Accuracy



Influence of Ranging Accuracy

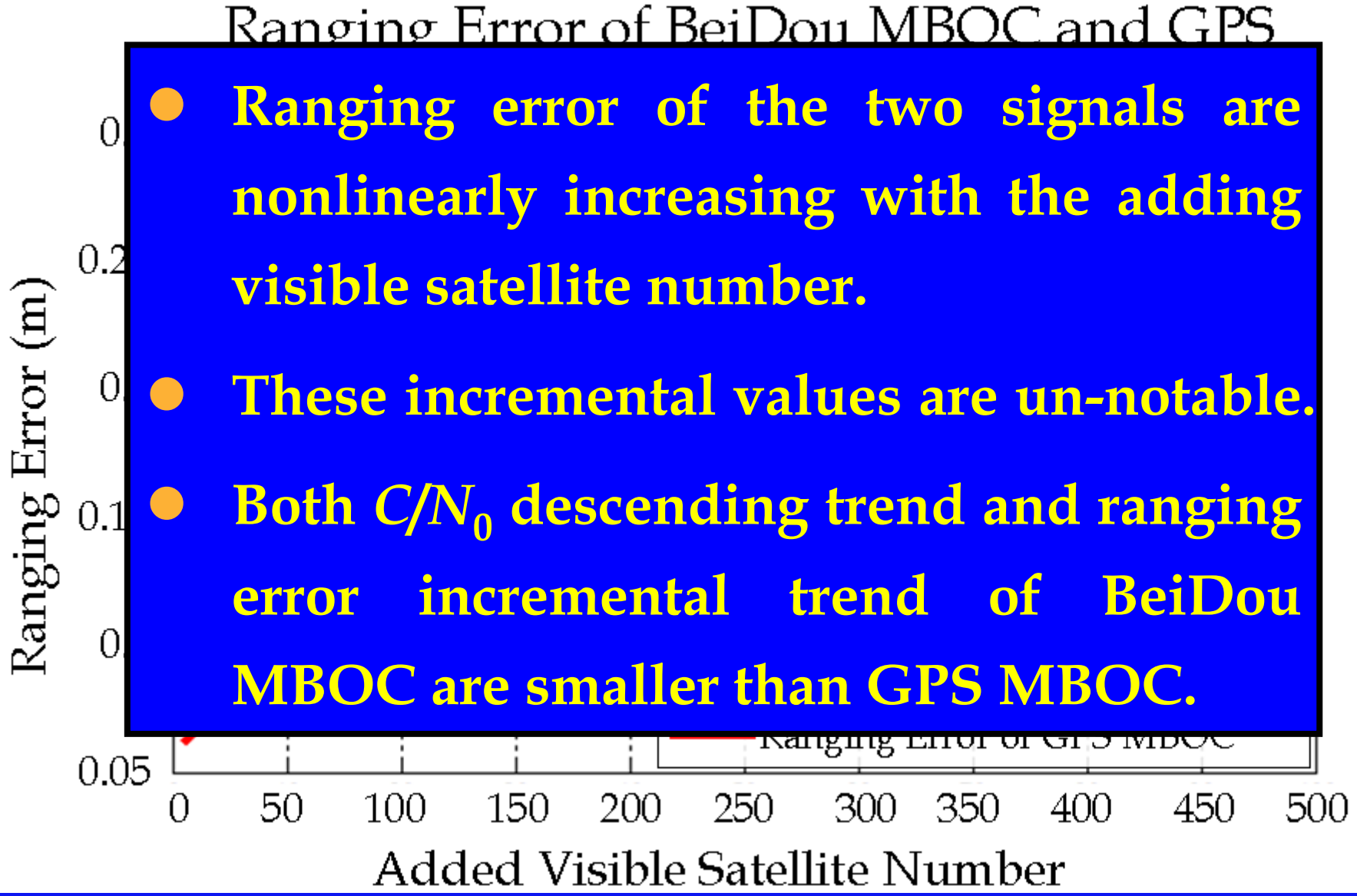
Target Signal	GPS MBOC		BeiDou MBOC	
Value	C/N_0 (dB)	Ranging Error (m)	C/N_0 (dB)	Ranging Error (m)
Only thermal noise	44.5	0.0496	43.5	0.0590
Thermal noise + GNSS noise	43.0405	0.0587	42.1166	0.0654
Change	1.4595 ↓	9.1×10^{-3} ↑	1.3834 ↓	6.4×10^{-3} ↑
Added Visible Satellite No.	19			

Influence of Ranging Accuracy



Influence of Ranging Accuracy

- Ranging error of the two signals are nonlinearly increasing with the adding visible satellite number.
- These incremental values are un-notable.
- Both C/N_0 descending trend and ranging error incremental trend of BeiDou MBOC are smaller than GPS MBOC.



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Conclusion

1. Relationship between noise floor and visible satellite number is that, noise floor is getting larger with visible satellite added, this incremental trend is nonlinearly and is getting abate.
2. Ranging errors of BeiDou MBOC and GPS MBOC are slightly increasing with the largen of noise floor.

Conclusion

3. Interoperability has a great potential capability to promote GNSS service performance. This issue has been concerned and debated by both the Providers and the users. The co-relationship between interoperability and service as well as other related issues should be thoroughly researched by a subgroup set up under the framework of ICG. The work done in this regard will contribute to the general work of interoperability of WG-A.

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