Space Service Volume (SSV) Characteristics of BDS

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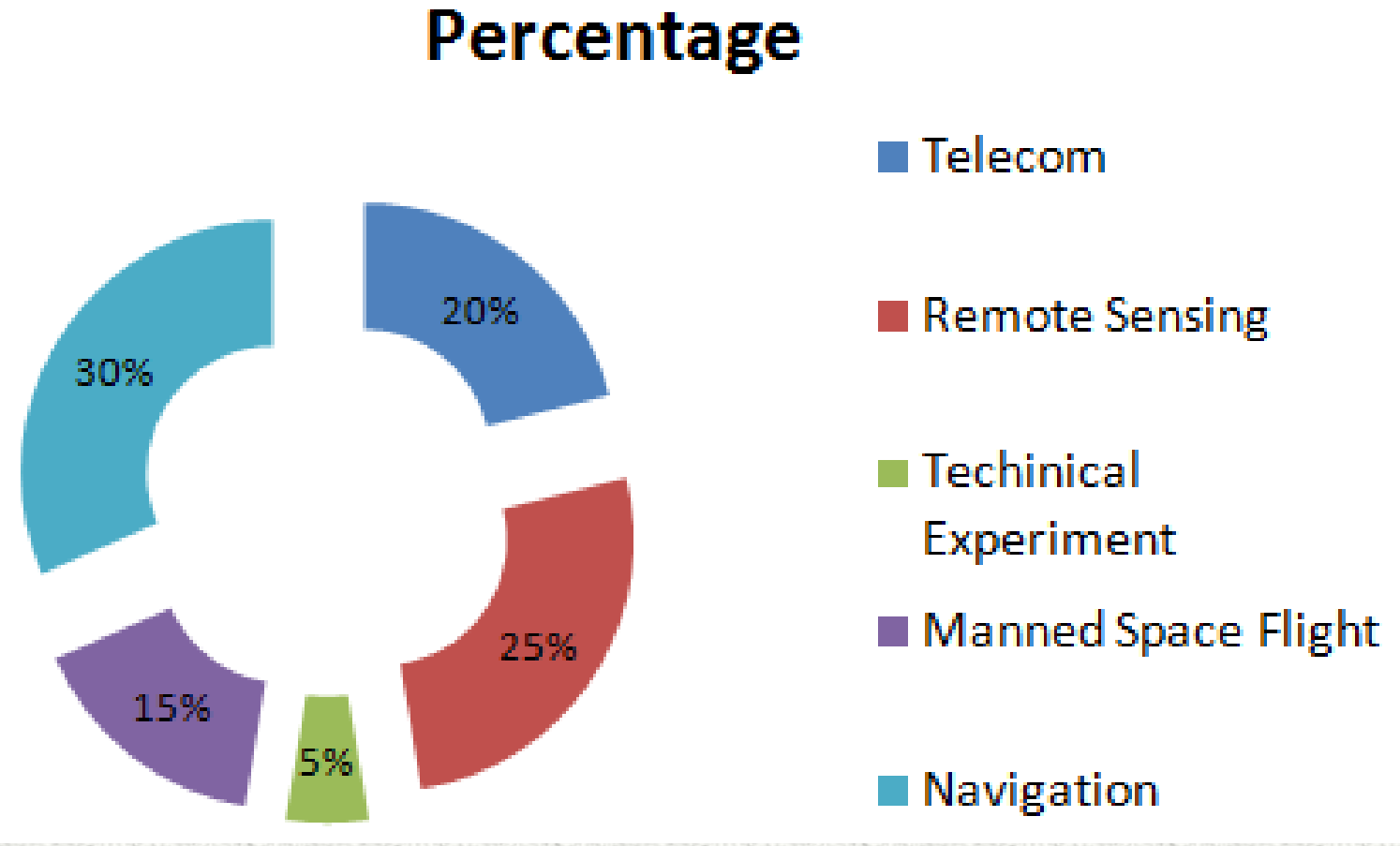
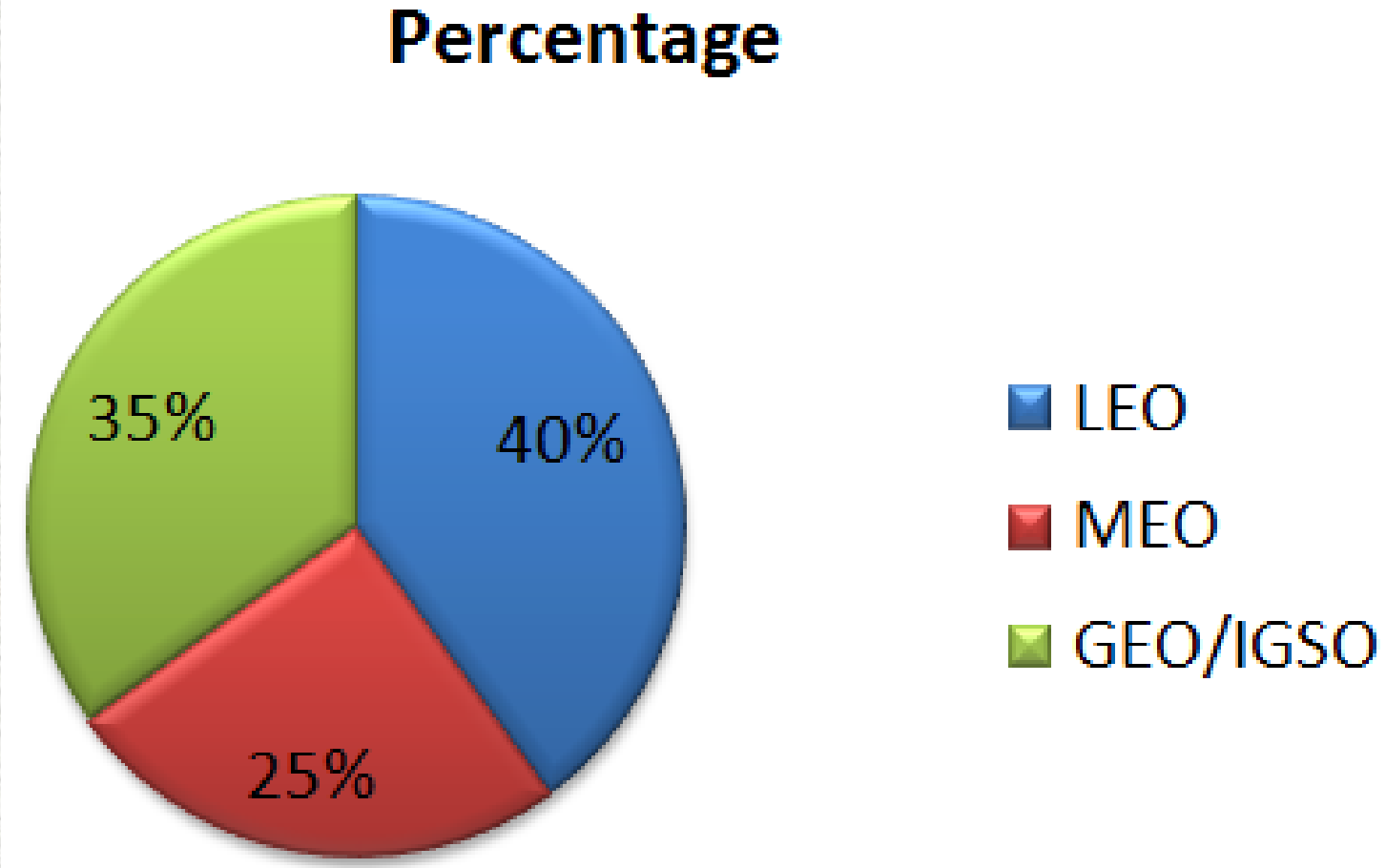


GNSS Space Applications in China

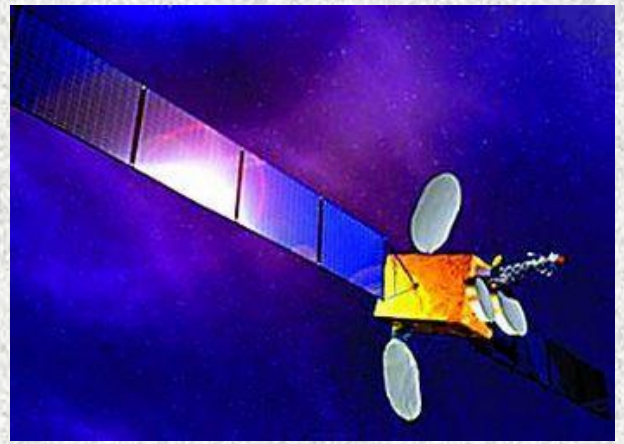
CHN Planned Missions within 5 years (2014~2019)



GNSS Space Applications in China

Shenzhou manned spacecraft

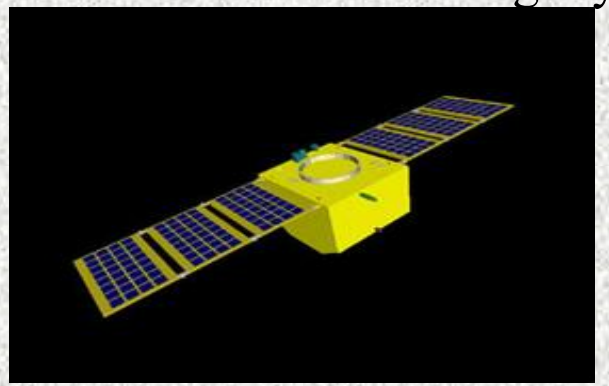
Yaogan satellite



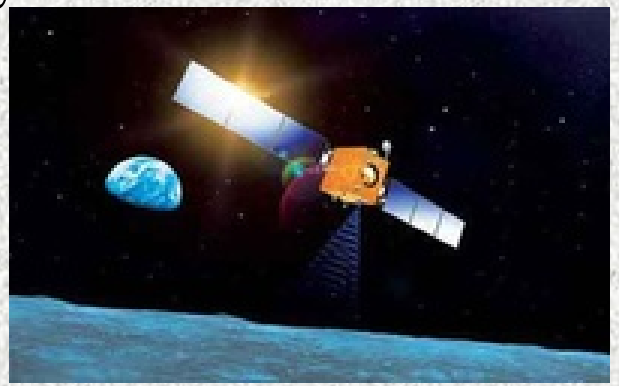
Sinosat telecom satellite

- Main applications of GNSS in space concentrate on LEO (<3000km) and up to GEO (36000km), about 60% of space missions will operate in the domain of SSV over the following 5 years.

Tianlian relay satellite

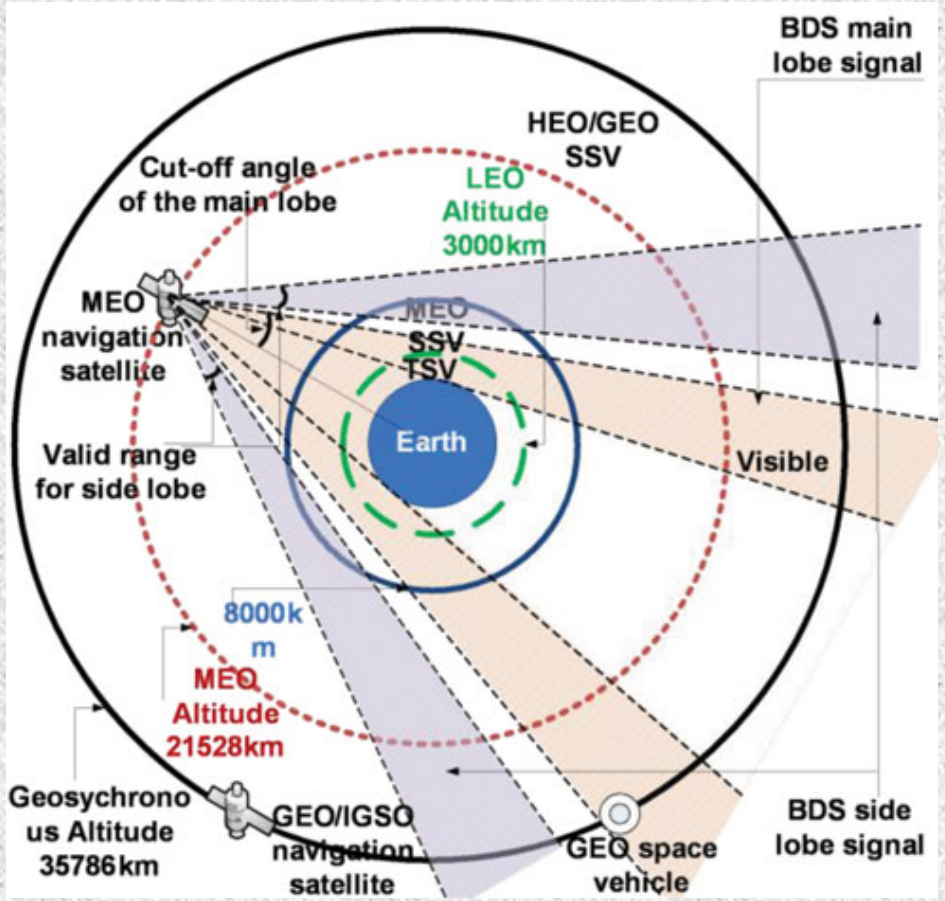


Shijian experimental satellite

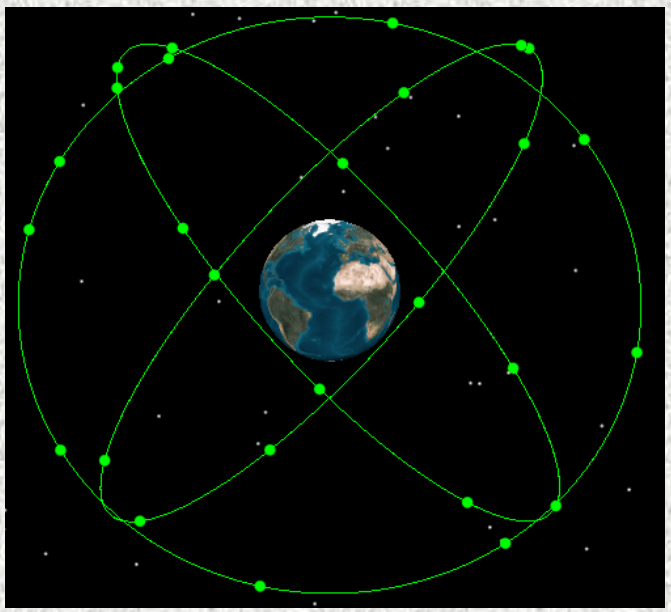


Chang'e lunar spacecraft

SSV Characteristics with Walker MEO Constellation



- The assumed constellation used for simulation consists of **27 MEO** satellites, 24 out of 27 **MEO** satellites shape up into Walker 24/3/1, and the remaining 3 ones are separately taken as spare satellites in each orbit plane.



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SSV Characteristics with Walker MEO Constellation

Minimum Received Power with Assumed MEO Constellation

Orbit Type	MEO		
Signal Type	B1	B2	B3
Carrier Frequency (GHz)	1.575	1.192	1.269
Maximum Distance (km)	68806	68806	68806
Maximum Free Space Loss (dB)	193.1	190.7	191.3
Atmospheric Loss (dB)	0.5	0.5	0.5
Receiving Antenna Gain (dBil)	3	3	3
Polarization Mismatch (dB)	4	4	4
Minimum Received Power (dBW)	-183.1	-182.0	-183.8

Signal Availability with Assumed MEO Constellation

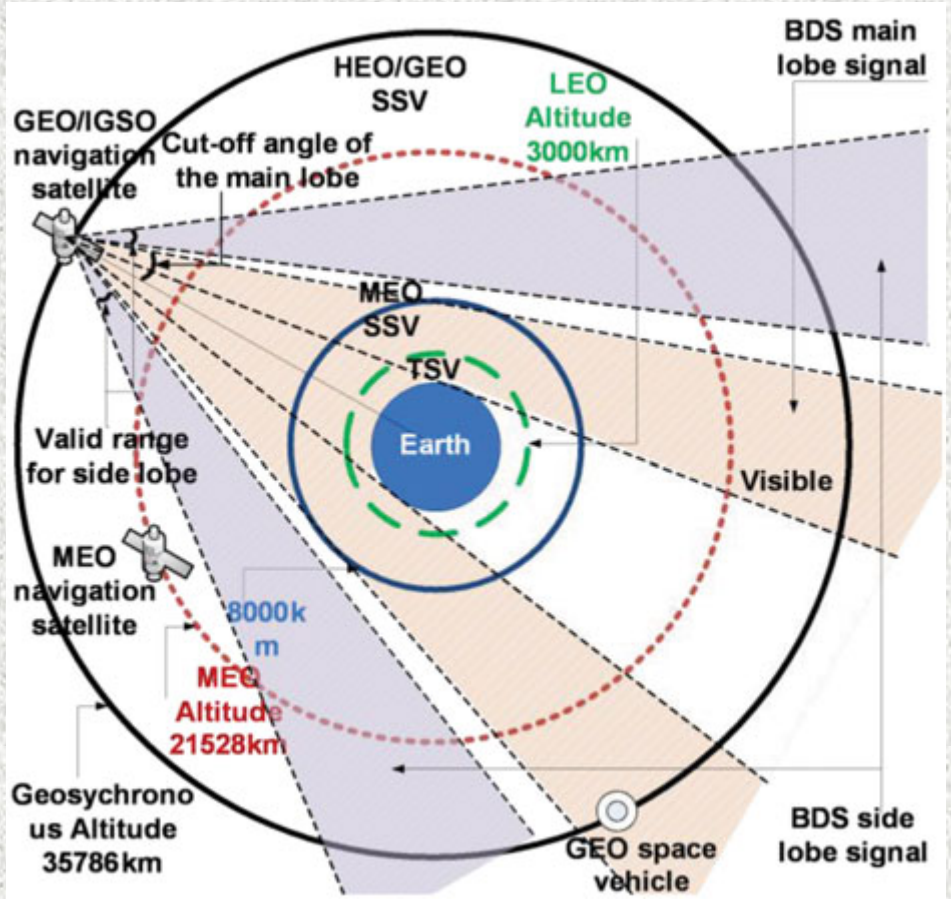
Signal Type	MEO SSV		HEO/GEO SSV	
	At least 1 signal	4 or more signals	At least 1 signal	4 or more signals
B1	100%	98%	≥80%	≥1.5%
B2,B3	100%	100%	≥93%	≥7.8%

PDOP Satisfaction with Assumed MEO Constellation

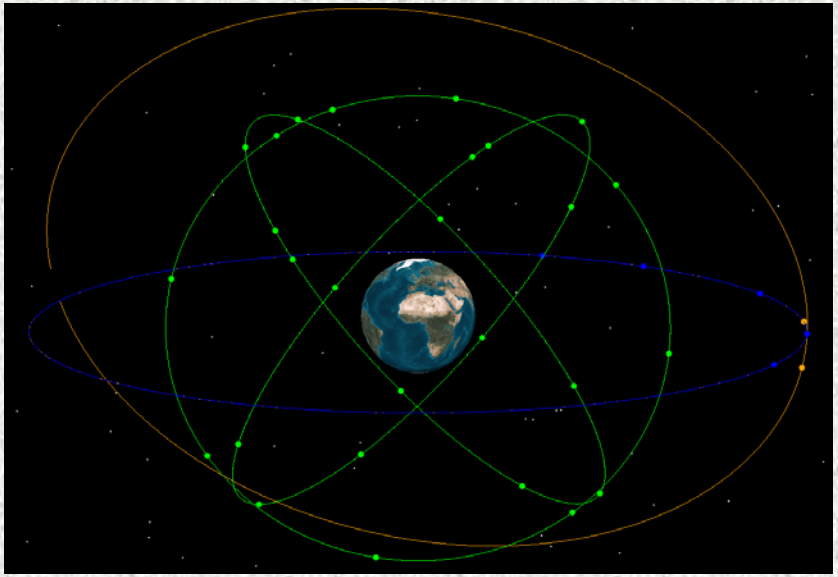
Signal Type	MEO SSV		HEO/GEO SSV	
	PDOP<1	PDOP<3	PDOP<5	PDOP<30
B1	92.18%	100%	≥6.07%	≥7.61%
B2,B3	92.98%	100%	≥6.50%	≥8.23%

- Using assumed MEO constellation alone, the SSV characteristics are similar as that of GPS constellation.

SSV Characteristics with MEO+GEO/IGSO



- Assuming that the equatorial projections of the 5 **GEO** satellites are 58.75ºE, 80ºE, 110.5ºE, 140ºE and 160ºE and numbered **GEO1 ~ GEO5**
- Assuming that the crossing longitudes of the 3 **IGSO** satellites numbered **IGSO1 ~ IGSO3** locate at 118ºE



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SSV Characteristics with MEO+GEO/IGSO

Minimum Received power with MEO+GEO/IGSO sat.

Orbit Type	GEO/IGSO		
Signal Type	B1	B2	B3
Carrier Frequency (GHz)	1.575	1.192	1.269
Maximum Distance (km)	83346	83346	83346
Maximum Free Space Loss (dB)	194.8	192.4	192.9
Atmospheric Loss (dB)	0.5	0.5	0.5
Receiving Antenna Gain (dBil)	3	3	3
Polarization Mismatch (dB)	4	4	4
Minimum Received Power (dBW)	-183.3	-182.4	-184.3

Signal Availability with MEO+GEO/IGSO sat.

Signal Type	MEO SSV		HEO/GEO SSV	
	At least 1 signal	4 or more signals	At least 1 signal	4 or more signals
B1	100%	99%	≥82%	≥4.5%
B2,B3	100%	100%	≥95%	≥13.1%

PDOP Satisfaction with MEO+GEO/IGSO sat.

Signal Type	MEO SSV		HEO/GEO SSV	
	PDOP<1	PDOP<3	PDOP<5	PDOP<30
B1	99.11%	100%	≥16.70%	≥25.98%
B2,B3	99.28%	100%	≥18.15%	≥27.61%

- **Signal availability** and **PDOP satisfaction** are dramatically improved if MEO and GEO/IGSO are taken into consideration.

SSV Template Replenishment

Performance characteristics for the Space Service Volume (3000 km to geosynchronous altitude)

- **GNSS space user performance templates have been distributed to the ICG WG-B and to the Interagency Operational Advisory Group (IOAG)**

Space Service Volume

Definitions	Notes
Lower Space Service Volume (also known as 'MEO altitudes'): 3,000 to 8,000 km altitude	Four GPS signals available simultaneously a majority of the time but GNSS signals over the limb of the Earth become increasingly important.
Upper Space Service Volume (also known as 'HEO/GEO altitudes'): 8,000 to 36,000 km altitude	Nearly all GPS signals received over the limb of the Earth. Users will experience periods when no GPS satellites are available.

Parameters	Value		Geometry
User Range Error			
Minimum Received Civilian Signal Power		Reference Half-Beamwidth	
Signal Availability			
Lower Space Service Volume (MEO)	**At least 1 signal**	**4 or more signals**	
Upper Space Service Volume (HEO/GEO)	**At least 1 signal**	**4 or more signals**	

SSV Template Replenishment

Signal availability (Level-1 primary template) with MEO solely

- The signal type X1 here involves B1, L1 and E1 which have a smaller half beam-width, while X2 includes E5a, E5b and E6 besides B2, B3, L2 and L5 which have a larger half beam-width.

Parameters	Value with MEO sat. solely	
User Range Error		
Minimum Received Civilian Signal Power	0 dBi RCP antenna at GEO	Reference Off-Boresite Angle
X1		
X2		
…		
…		
Signal Availability		
Lower Space Service Volume (MEO)	**At least 1 signal**	**4 or more signals**
X1		
X2		
Upper Space Service Volume (HEO/GEO)	**At least 1 signal**	**4 or more signals**
X1		
X2		
PDOP Satisfaction		
Lower Space Service Volume (MEO)	**PDOP<1**	**PDOP<3**
X1		
X2		
Upper Space Service Volume (HEO/GEO)	**PDOP<5**	**PDOP<30**
X1		
X2		

SSV Template Replenishment

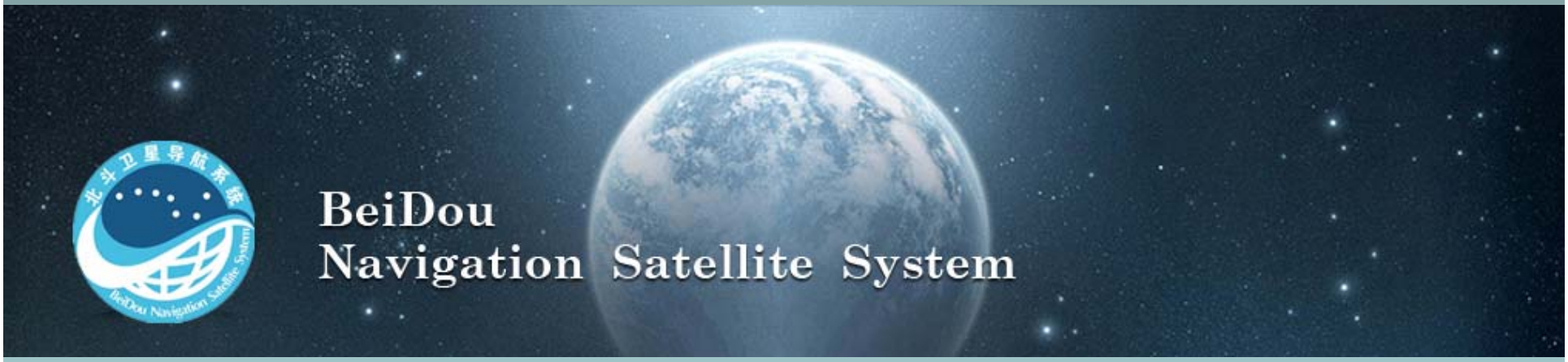
Signal Availability (Level-2 enhanced template) with MEO+GEO/IGSO sat.

Parameters	Value with MEO+GEO/IGSO	
User Range Error		
Minimum Received Civilian Signal Power	0 dBi RCP antenna at GEO	Reference Off-Boresite Angle
X1		
X2		
…		
…		
Signal Availability		
Lower Space Service Volume (MEO)	**At least 1 signal**	**4 or more signals**
X1		
X2		
Upper Space Service Volume (HEO/GEO)	**At least 1 signal**	**4 or more signals**
X1		
X2		
PDOP Satisfaction		
Lower Space Service Volume (MEO)	**PDOP<1**	**PDOP<3**
X1		
X2		
Upper Space Service Volume (HEO/GEO)	**PDOP<5**	**PDOP<30**
X1		
X2		

Summaries & Recommendations

①	②	③
●Benefited from the hybrid constellation containing IGSO and GEO satellites, BDS hybrid constellation has its distinct advantage in SSV performance compared with other GNSS.	●Interoperable GNSS SSV is primarily responsible for improving the performance of signal availability and PDOP satisfaction, especially for HEO/GEO navigation users.	●The parameter, PDOP satisfaction, should be added into original SSV template in order to analyze and assess the capability of GNSS SSV more comprehensively.

The end



Thank you for your attention !

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