



# GBAS/SBAS Implementation in China

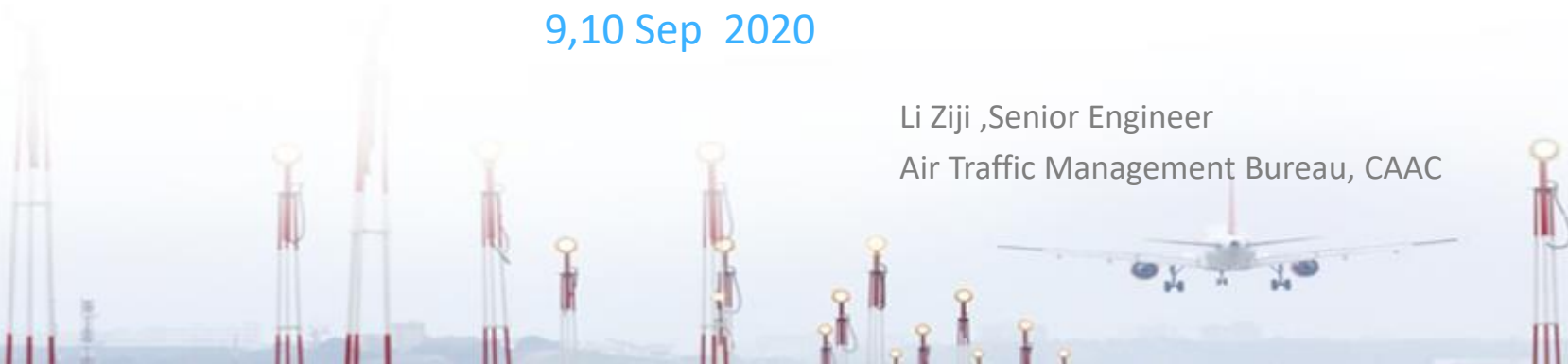
ICAO ASIA/PACIFIC GBAS/SBAS

Implementation Task Force

9,10 Sep 2020

Li Ziji ,Senior Engineer

Air Traffic Management Bureau, CAAC





- Background and Strategy
- BDS Status
- GBAS R&D and Certification
- SBAS R&D and Test



# Strategy- ASBU by ICAO

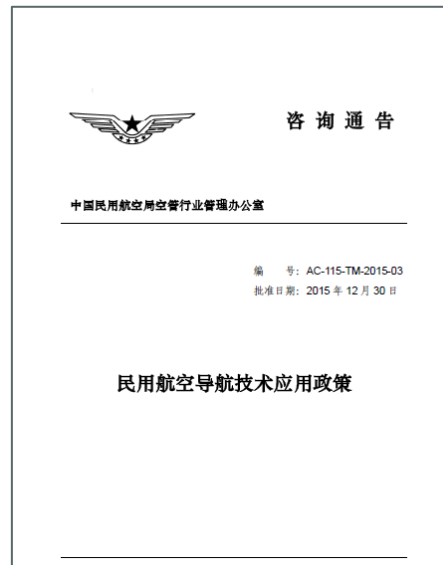


NAVIGATION	BLOCK 0 2018	BLOCK 1 2024	BLOCK 2 2030	BLOCK 3
ENABLERS (CONVENTIONAL)	ILS/MLS Retain to support precision approach and mitigate GNSS outage			
	DME Optimize existing network to support PBN operations			
	VOR/NDB Rationalize based on need and equipage			
ENABLERS (SATELLITE-BASED)	Core GNSS Constellations Single frequency (GPS/GLDNASS) Multi-Frequency/Multi-Constellation (GPS/GLDNASS/Beidou/Galileo)			
	GNSS Augmentations SBAS GBAS Cat I GBAS Cat II/III Multi-Freq GBAS/SBAS			
	~2020		~2030	2030~
GBAS	<ul style="list-style-type: none"> <li>Complete development and certification of CAT-I SF GBAS</li> <li>Initiate development of DFMC(BDS/GAL/GPS) GBAS</li> <li>Initiate deployment of CAT-I SF GBAS in specific airport</li> </ul>		<ul style="list-style-type: none"> <li>Complete development and certification of DFMC GBAS (CAT-I/II/III)</li> <li>Deploy CAT-I DFMC GBAS in airport which can not use ILS, and in busy airports as backup for ILS</li> <li>Initiate deployment of CAT-II/III GBAS in specific airport</li> </ul>	<ul style="list-style-type: none"> <li>Deploy GBAS as the main precise Approach/Landing Nav aids, and keep ILS as backup in minimum level.</li> </ul>
SBAS	<ul style="list-style-type: none"> <li>Initiate deployment of BDSBAS</li> <li>Initiate performance test of BDSBAS</li> </ul>		<ul style="list-style-type: none"> <li>Complete test and certification of BDSBAS for air navigation services by CAAC</li> <li>Provide qualified service, under monitor and endorse by CAAC, gradually</li> </ul>	<ul style="list-style-type: none"> <li>Fully provide BDSBAS service up to CAT-I for China and neighboring area</li> </ul>

The global implementation Road Map of GBAS/SBAS has been defined in ASBU.

CAAC has issued the Navigation Technology Application Policy in 2015 to develop and promote the GNSS navigation implementation in China according to the ASBU.

With deployment progress of BDS, CAAC need to verify and apply BDS' s core and augmentation service for air navigation ,and make it more reliable and safety.



Navigation technology application policy  
—Issued by CAAC

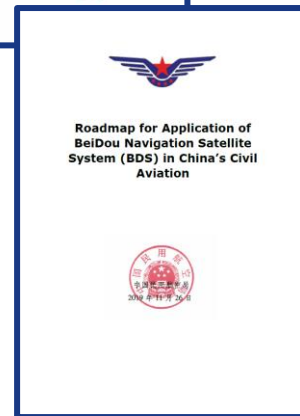


# Strategy-BDS Civil Aviation Roadmap



The Roadmap for Application of BDS in Civil Aviation of China was released on 26, November 2019.

Present the approach, action and objective of BDS application in General Aviation, Transportation Aviation, ATC system, etc., in three phases of short Term (2019~2021) , Medium Term (2022~2025) and Long Term (from 2026~2035) .





# Strategy-BDS Civil Aviation Roadmap



## ● Short Term Objective (2019~2022)

- provide surveillance service of BDS positioning + short message for general aviation
- Demonstrate transport aircraft tracking & surveillance based on BDS positioning and short message, and encourage the corresponding retrofit of BDS avionics equipment
- Demonstrate the BDS navigation on China domestic large aircraft (e.g. C919)
- Introduce GNSS timing system (with BDS) for ATC initially
- Achieve continuous monitoring on GNSS signals (with BDS) to meet the safety requirement of civil aviation application.



# Strategy-BDS Civil Aviation Roadmap



## ● Medium Term Objective(2022~2025)

- Achieve the surveillance system for general aviation, based on BDS positioning and compatible with multiple surveillance technologies.
- Global aircraft tracking and monitoring is to be realized in the whole transport aviation fleet, and GNSS multi-mode navigation including BDS System is to be realized in part of the fleet.
- Multi-mode GNSS timing with BDS System as its core is totally achieved in related operation systems of airports, ATC, and airlines.
- Multi-Mode Receiver (MMR) based on BDS System is to be installed on China made large aircraft (e.g. C919), and the airworthiness certification and operational approval is to be obtained.
- Standards of BDS System avionics and ground equipment is to be primarily set up.



# Strategy-BDS Civil Aviation Roadmap



## ● Long Term Objective(2026~2035)

- Dual-frequency multi-constellation GNSS with BDS system as core part and its augmentation system is able to meet the performance requirements of primary navigation source for domestic en-route and terminal area, and the performance requirements of primary or secondary navigation source for CAT I precision approach operation.
- All the air transport and general aviation aircraft shall be equipped with multi-mode receiver compatible with BDS so as to be navigated by BDS.
- Provide BDS services for civil aviation industry of "The Belt and Road" countries, and promote the application of dual-frequency multi-constellation GNSS in international civil aviation



- Background and Strategy
- **BDS Status**
- GBAS R&D and Certification
- SBAS R&D and Test



# BDS Status update



The BDS is one of the 4 core satellite constellations in ANNEX 10 by ICAO . And the validation of BDS is being discussed and promoted in NSP of ICAO.

The BDS has provided the worldwide service in 2020.

The BD SBAS constellation and ground system will be completed in end of 2020.



ICAO

International Standards  
and Recommended Practices

Annex 10 to the Convention on International Civil Aviation

Aeronautical Telecommunications

**Volume I**  
Radio Navigation Aids  
Seventh Edition, July 2018

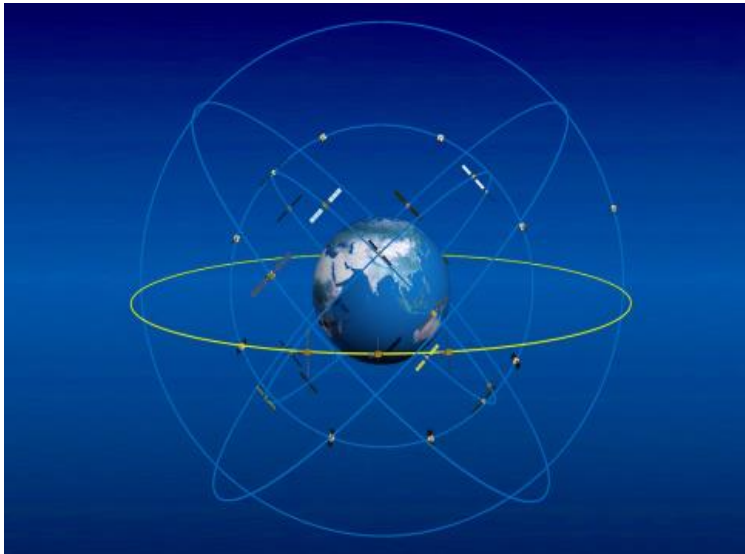


This edition supersedes, on 8 November 2018, all previous editions of Annex 10, Volume I.  
For information regarding the applicability of the Standards and Recommended Practices, see Foreword.

INTERNATIONAL CIVIL AVIATION ORGANIZATION



# BDS Status update



BDS-3 constellation includes:

- 24 MEOs
- 3 IGSOs
- 3 GEOs
  
- The last GEO satellite has been launched in June 2020.
- Then BDS has provided the worldwide service from July 2020.





# BDS Status update

- BDS SIS ICD Open Service Signal B1C (Version 1.0), 2017-12.
- BDS SIS ICD Open Service Signal B2a (Version 1.0), 2017-12.
- BDS SIS ICD Open Service Signal B1I (Version 3.0), 2019-2
- BDS SIS ICD Open Service Signal B2b (Beta Version), 2019-12

4 ICD have been published





# Ratification of BDS ICAO Standards

- The validations of B1C, B2a and B1I signals have been preliminarily completed and is planned to complete the ratification of BDS by the ICAO SARPs in 2020.
- BDS and BDSBAS related material has been supplemented in DFMC SBAS SARPs.
- The applicability of DFMC SBAS SARPs to BDSBAS has been verified continuously, and DFMC SBAS SARPs will be completed by the end of 2020, and then be submitted to ICAO ANC for approval.



- Background and Strategy
- BDS Status
- GBAS R&D and Certification
- SBAS R&D and Test



# GBAS Technical Classification



## GAST C

● Service level - CAT I

● Service Signal - GPS L1, GLN L1, BDS B1

## GAST D

● Service level - CAT II/III

● Service Signal - GPS L1, GLN L1, BDS B1

## GAST E

● Service level - CAT I

● Service Signal - GAL E5, BDS B2a

## GAST F

● Service Signal - CAT III

● Service Signal - GPS L1/L5, GAL E1/E5, GLN L1/L3, BDS B1/B2a



2008

**2006-2008  
GBAS Test Bed**

Nyingchi Airport LAAS Test Project

**2009-2010**

**GAST C Technical Research**

GPS GBAS Key technology research  
and over 80 precision approaches

2010



2015

**2011-2015**

**GNSS GBAS Technical Research**

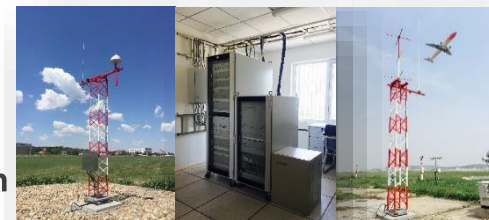
GNSS Key technology research, engineering prototype  
development and demonstration in Tianjin airport

**2016-Now**

**GAST C Equipment Certificate**

**GAST D/F Technical Research**

Now



- GBAS Signal-in-Space Interface Control Document
- CAT I GBAS Ground Equipment Technical Requirements
- CAT I GBAS Ground Equipment Test Methods
- GBAS Ground Equipment Site Specification





# GBAS R&D - Certification (2016~2019)



Main Station  
equipment cabinet



Reference receiver



VDB antenna

## LGF-1A GBAS Features

### Support DFMC GNSS

Supports GPS, monitors BDS signals, and  
can be configured to monitor GAL and  
GLO signals

### Support extended VDB

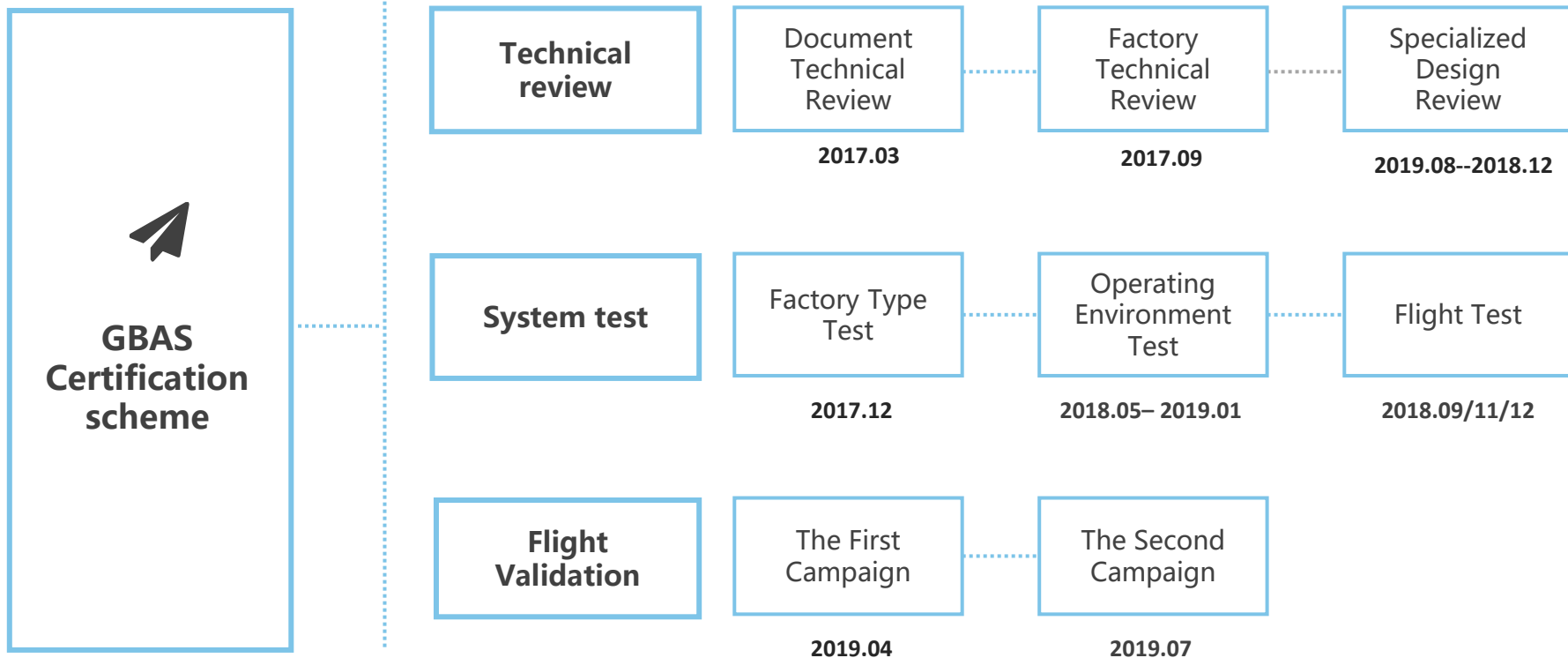
1 local VDB station,  
Up to 3 remote VDB stations

### Support Positioning Monitoring

Monitoring position performance



# GBAS R&D – Certification (2016~2019)





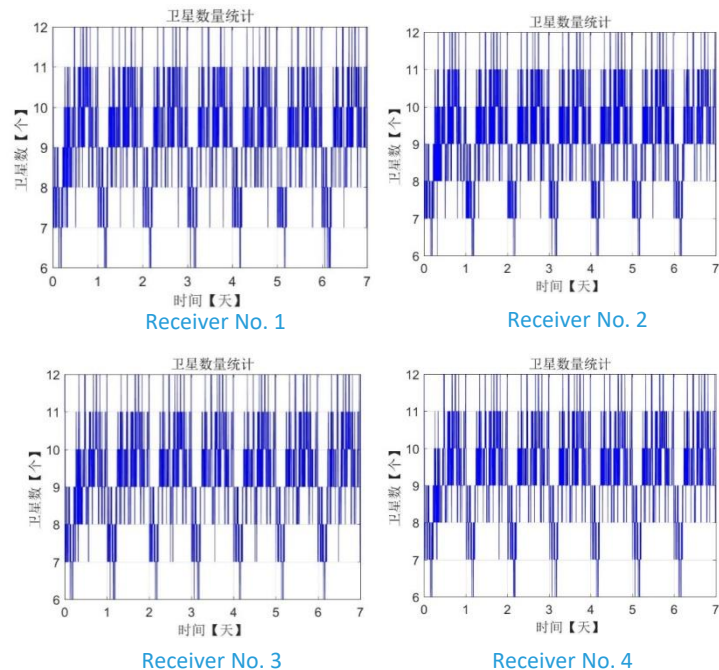
# GBAS R&D – Certification (2016~2019)



## Service Performance Analysis - Receiving Satellite Counting Statistics

Receiver number	Minimum number of satellites	Maximum number of satellites	Mean number of satellites
Rev1	6	12	9.4524
Rev 2	6	12	9.4290
Rev 3	6	12	9.4712
Rev 4	6	12	9.4995

### Satellite number chart



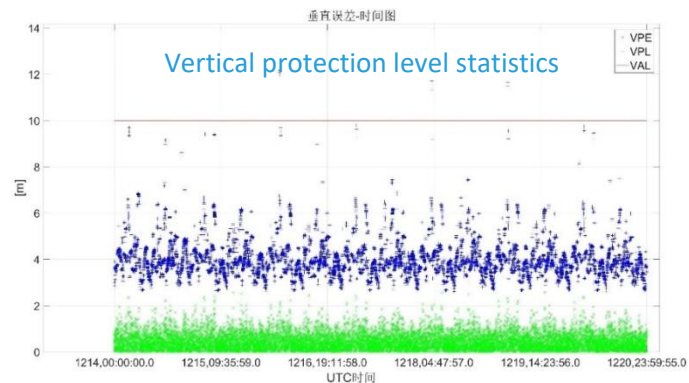
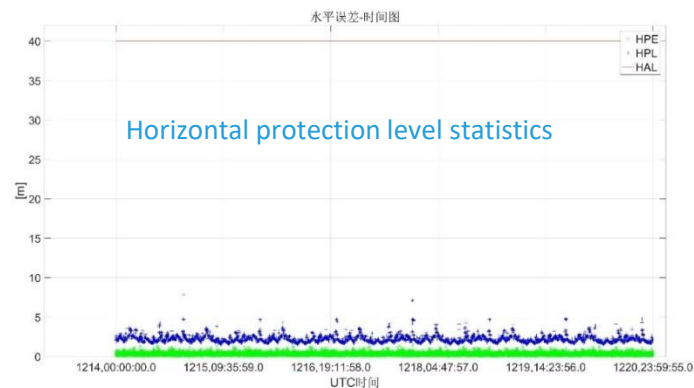


# GBAS R&D – Certification (2016~2019)



## Service Performance Analysis - Protection level statistics

	99%	95%	50%	Mean	Variance
HPL	3.714	2.692	2.113	2.212	0.441
VPL	6.460	5.620	3.861	3.992	0.839

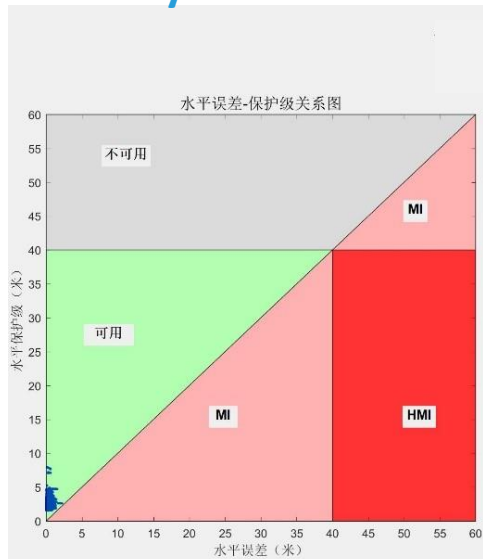




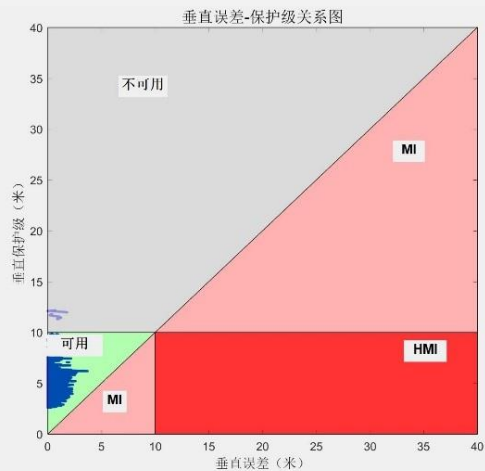
# GBAS R&D – Certification (2016~2019)



## Service Performance Analysis - Error and Protection Level Relationship



## Error and Protection Level Relationship



	Total	Available number	Percentage available	HMI	MI
Horizontal	1209286	1209286	100%	0	0
Vertical	1209286	1208446	99.9305%	0	0

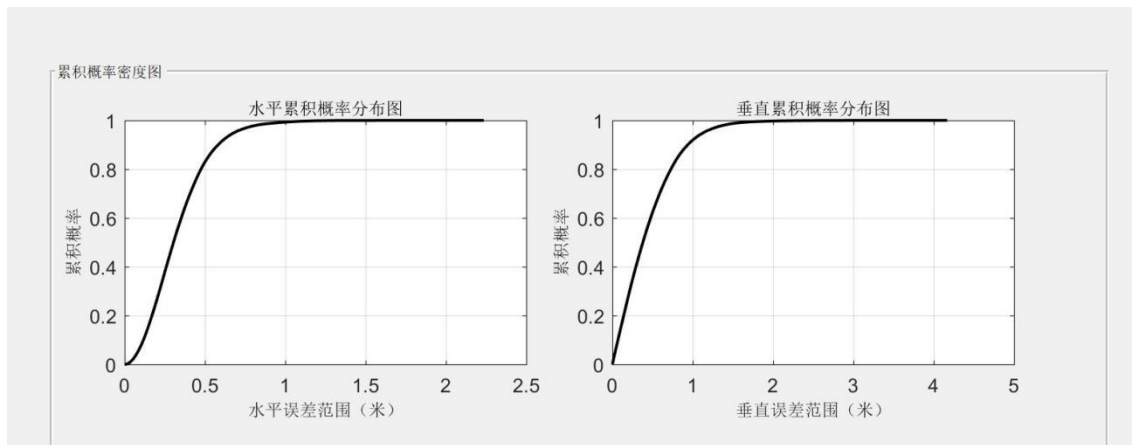


# GBAS R&D – Certification(2016~2019)



## Service Performance Analysis - Error cumulative probability distribution

### Error cumulative probability distribution



	99%	95%	50%	Mean	Variance
HPE	0.932	0.682	0.305	0.335	0.193
VPE	1.574	1.149	0.386	0.464	0.367



# GBAS R&D – Certification (2016~2019)



## Inspection Aircraft - Flight Test



卫星着陆系统飞行测试报告表

第1页 共3页		天津/滨海		34L		B-9301		ZBTJ		2018.09.08	
1.机场名称		2.进离场		3.机型		4.机场识别		5.日期		6.校飞种类	
投产		定期		特殊		17.频率		116.75M		8.波道号	
20350		9.状态		正常		10.报告编号		GZBTJ34L20180908			
10. FAS 数据飞行校验结果											
参数	校验显示	校验结果	参数	校验显示	校验结果						
台站识别	ZBTJ	正确	LTP 点高度 (m)	-4.4	正确						
跑道号	34L	正确	频率 (M)	116.75	正确						
下滑角 (°)	3.00	正确	入口高度 (m)	15.0	正确						
LTP 点经度 (°)	N 39-06-41.0688	正确	FPAP 点经度 (°)	N 39-08-14.3124	正确						
LTP 点纬度 (°)	E 117-21-14.8680	正确	FPAP 点纬度 (°)	E 117-20-17.6496	正确						
11. VDB 信号飞行校验结果											
圆周飞行 1	高度 m	1500	半径	20nm	角度°	281.98	VDB 最小信号强度 dBm(dBW/M)	-79.3/-90.41			
圆周飞行 2	高度 m	3000	半径	20nm	角度°	267.05	VDB 最小信号强度 dBm(dBW/M)	-66.3/-77.41			
12. 进近飞行校验结果											
开始距离 15 海里											
程序的一致性	一致	进近精度	满意	VDB 最小信号强度 dBm(dBW/M)	-47.3/-78.41						
航向偏差 ° / ±A	-0.00/-0.28	航向结构 ±ANM	0/15.06	1/0.61	0/0.17						
下滑角入口高度° m	2.90/15.67	下滑结构 ±ANM	1/6.56	9/0.57	5/0.16						
可见卫星数量	12		可用卫星数量	9							
可用卫星编号	11	18	28	30	07	08	17	22	03		
信噪比	46	48	47	50	51	46	50	49	45		
开始距离 10 海里											
程序的一致性	一致	进近精度	满意	VDB 最小信号强度 dBm(dBW/M)	-52.3/-63.41						
航向偏差 ° / ±A	-0.00/-0.27	航向结构 ±ANM	1/12.21	0/0.58	0/0.23						
下滑角入口高度° m	2.90/15.28	下滑结构 ±ANM	1/6.56	5/0.58	3/0.16						
可见卫星数量	12		可用卫星数量	10							
可用卫星编号	01	11	28	18	30	07	17	22	08	03	
信噪比	50	47	48	49	49	49	48	49	46	48	
开始距离 20 海里											
程序的一致性	一致	进近精度	满意	VDB 最小信号强度 dBm(dBW/M)	-52.3/-63.41						
航向偏差 ° / ±A	0.01/0.64	航向结构 ±ANM	0/20.33	0/1.22	0/0.17						
下滑角入口高度° m	3.01/17.4	下滑结构 ±ANM	1/6.62	1/0.57	4/0.16						
可见卫星数量	12		可用卫星数量	9							
可用卫星编号	18	07	08	01	30	28	27	10	16		
信噪比	49	49	50	48	50	47	47	46			



卫星着陆系统飞行测试报告表

第2页 共3页

报告编号: GZBTJ34L20180908

13. 水平飞行校验结果											
距离 NM	16/-2.5	高度 m	900	宽度及对称性° %	0.75/60.02	VDB 最小信号强度 dBm(dBW/M)	-65.3/-78.41				
距离 NM	16/-2.5	高度 m	900	宽度及对称性° %	0.75/60.04	VDB 最小信号强度 dBm(dBW/M)	-63.3/-74.41				
距离 NM	16/-2.5	高度 m	1200	宽度及对称性° %	0.75/60.06	VDB 最小信号强度 dBm(dBW/M)	-60.3/-71.41				
14. 圆弧飞行校验结果											
半径高度 NM/m	20/600	角度°	±35	宽度及对称性° %	3.41/50.24	VDB 最小信号强度 dBm(dBW/M)	-53.3/-64.41				
半径高度 NM/m	15/900	角度°	±35	宽度及对称性° %	3.43/50.17	VDB 最小信号强度 dBm(dBW/M)	-55.3/-66.41				

Flight inspection result:  
Meet the performance requirement of  
CAT-I GBAS ground system



卫星着陆系统飞行测试报告表

第3页 共3页

报告编号: GZBTJ34L20180908

15. 电磁环境情况	良好
16. 校验结论:	符合《“GBAS 地面设备-I 类精密进近”的天津机场飞行校验方案》中给定的容限要求。
17. 备注:	<ol style="list-style-type: none"> <li>1、本次为对安装在天津机场的二十所 GBAS 地面设备进行合格审定而进行的飞行测试（第一次）。</li> <li>2、本次飞行测试的方法依据来源于二十所出具的《“GBAS 地面设备-I 类精密进近”的天津机场飞行校验方案》。</li> <li>3、本次飞行测试的标准依据来源于二十所出具的《“GBAS 地面设备-I 类精密进近”的天津机场飞行校验方案》。</li> <li>4、机长建议: GBAS 机载系统中应增加距离指示功能。</li> </ol>
机长签字	飞行校验员签字

## Transport aircraft - Flight Validation supported by AIRBUS



### The First Campaign 2019.04

- Ground Test: Static checks, 2 low speed taxi full runway length
- Flight Test: 4 automatic GLS approaches ( long pattern and standard pattern)



### The Second Campaign 2019.07

- Ground Test: Static checks, 2 low speed taxi full runway length
- Flight Test: 8 automatic GLS approaches ( long pattern, standard pattern and short pattern)



# GBAS R&D – Certification (2016~2019)



On December 24, 2019, CAAC issued the Provisional Certificate of Approval to CETC LGF-1A GBAS ground equipment.

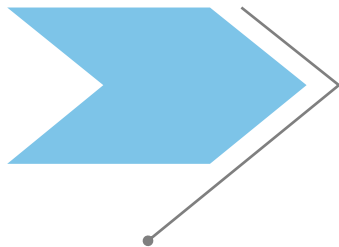




# GBAS R&D - CAT-II/III Research (2018~)

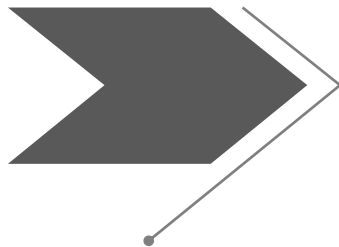


2018



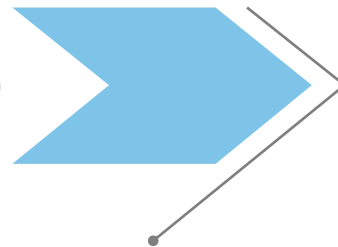
- **CAT II/III GBAS**  
GAST-D GBAS prototype

2019



- **CAT II/III GBAS**  
GAST-D GBAS prototype
- **Ionospheric Monitoring**  
installed three monitoring stations around Guangzhou airport, started data collection

2020

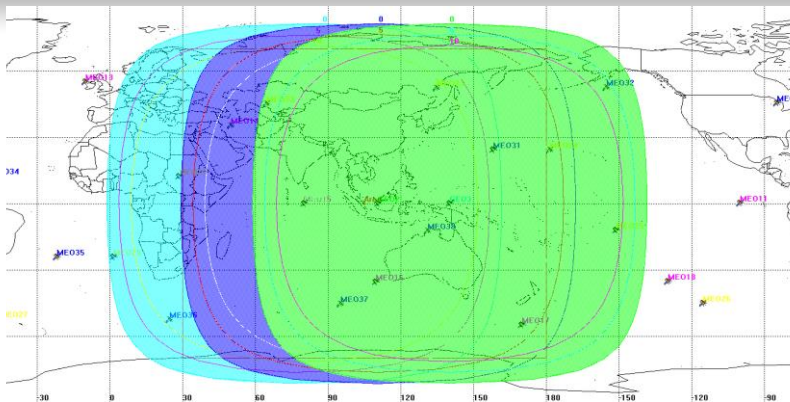


- **CAT II/III GBAS**  
DFMC GAST F GBAS research (GPS L1/L5, BDS B1C/B2a)  
GAST D/F flight verification
- **Ionospheric Monitoring**  
installed three monitoring stations around Shenzhen airport, started data collection
- **CAT I GLS Trail Operation**  
Two years of GLS trail operation in Tianjin airport

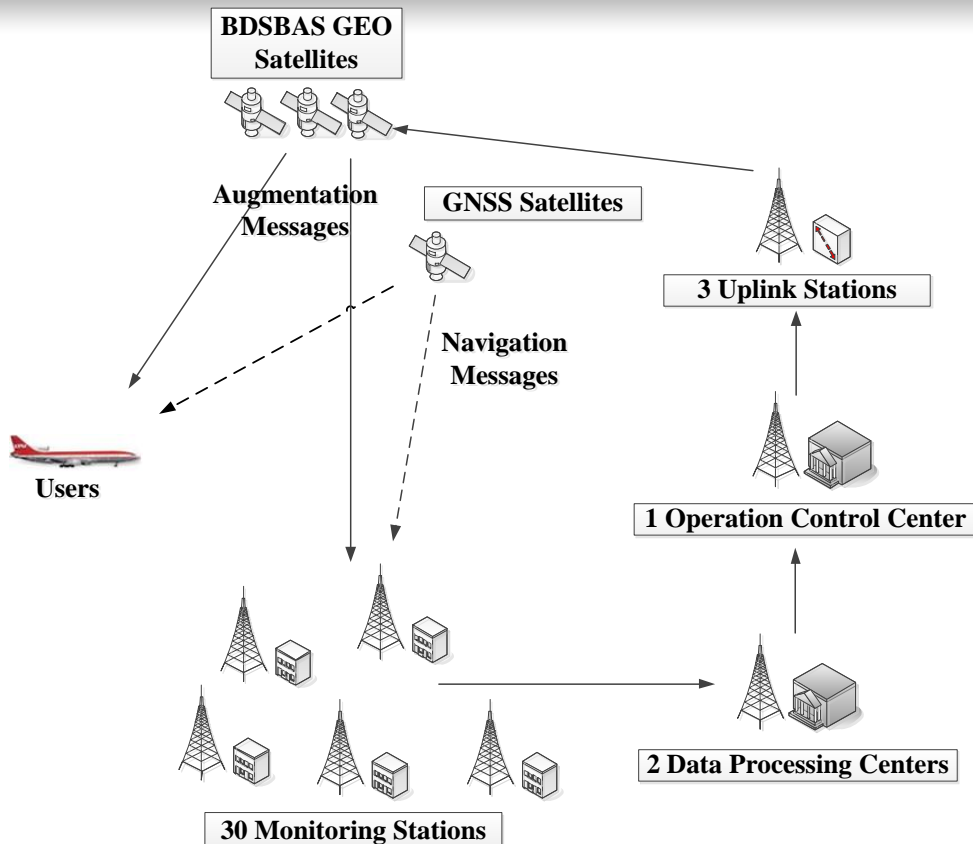


- Background and Strategy
- BDS Status
- GBAS R&D and Certification
- SBAS R&D and Test

# BDSBAS Architecture



<b>Augmented Constellation</b>	SF Service: GPS DFMC Service: BDS and GPS
<b>Performance Aim</b>	SF Service: APV-I DFMC Service: CAT-I
<b>Interface</b>	SF SBAS ICD/ DFMC SBAS ICD
<b>Frequency</b>	SF Service: B1C(1575.42MHz) DFMC Service: B2a(1176.45MHz)
<b>Satellite</b>	3 GEOs(80°E, 110°E, 140°E)





# BDSBAS In-Orbit Test Performance



- BDSBAS GEO-1 satellite (PRN 130) has broadcasted signal since November 9 2018.
- BDSBAS GEO-2 satellite (PRN 144) has broadcasted signal since April 9 2020.
- **RF characteristics**  
BDSBAS RF characteristics Comparison with ICAO requirements

NO	item	signal	ICAO requirement	BDSBAS Test results
1	Carrier FRE	<b>SBAS B1C</b>	1575.42MHz	1575.42MHz
2		<b>SBAS B2a</b>	1176.45MHz	1176.45MHz
3	spurious	<b>SBAS B1C</b>	$\leq -40\text{dBc}$	<b>-56.66</b>
4		<b>SBAS B2a</b>	$\leq -40\text{dBc}$	<b>-62.34</b>
5	modulation	<b>SBAS B1C</b>	BPSK ( 1 ) , symbol rate 500sps , code length 1023 , Chip rate 1.023Mchip/s	BPSK ( 1 ) , symbol rate 500sps , code length 1023 , Chip rate1.023Mchip/s
6		<b>SBAS B2a</b>	BPSK ( 10 ) , symbol rate 500sps , code length 10230 , Chip rate 10.23Mchip/s	BPSK ( 10 ) , symbol rate 500sps , code length 10230 , Chip rate 10.23Mchip/s
7	Phase noise	<b>SBAS B1C/B2a</b>	PLL of 10 Hz one-sided noise bandwidth is able to track the carrier to an accuracy of 0.1 radian	<b>0.00578 rad</b>
8	spectrum	<b>SBAS B1C</b>	At least 95 contained within 3 dB bandwidth	<b>Band wide: <math>\pm 18.414\text{MHz}</math></b>
9		<b>SBAS B2a</b>	At least 95 contained within 3 dB bandwidth	<b>Band wide: <math>\pm 35.805\text{MHz}</math></b>
10	FRE stability	<b>SBAS B1C</b>	$< 5e-11(1s\sim 10s)$	<b>1.5e-12/1s</b>
11		<b>SBAS B2a</b>	$< 6.7e-11(1s\sim 10s)$	<b>5.2e-13/10s</b>
12	Coherence of code & carrier	<b>SBAS B1C</b>	short-term: $< 0.15\text{m}$ long-term: $< 0.19\text{m}$	<b>0.12m</b> <b>0.133m</b>
13		<b>SBAS B2a</b>	Short-term: $< 0.2\text{m}$ long-term: $< 0.255\text{m}$	<b>0.1m</b> <b>0.16m</b>
14	Coherent of L1 & L5	<b>SBAS B1C/B2a</b>	short-term: $< 0.2\text{m}$ long-term: $< 0.255\text{m}$	<b>0.13m</b> <b>0.178m</b>



# BDSBAS SF Service Performance



- **Accuracy Performance**

The accuracy of BDSBAS SF Service satisfies the requirement of APV-I.

- **Integrity Performance**

The minimum horizontal and vertical safety index are both larger than 1, which means no integrity risk happened during the test period, which also satisfies the requirement of APV-I.

## Positioning Accuracy of BDSBAS (95%)

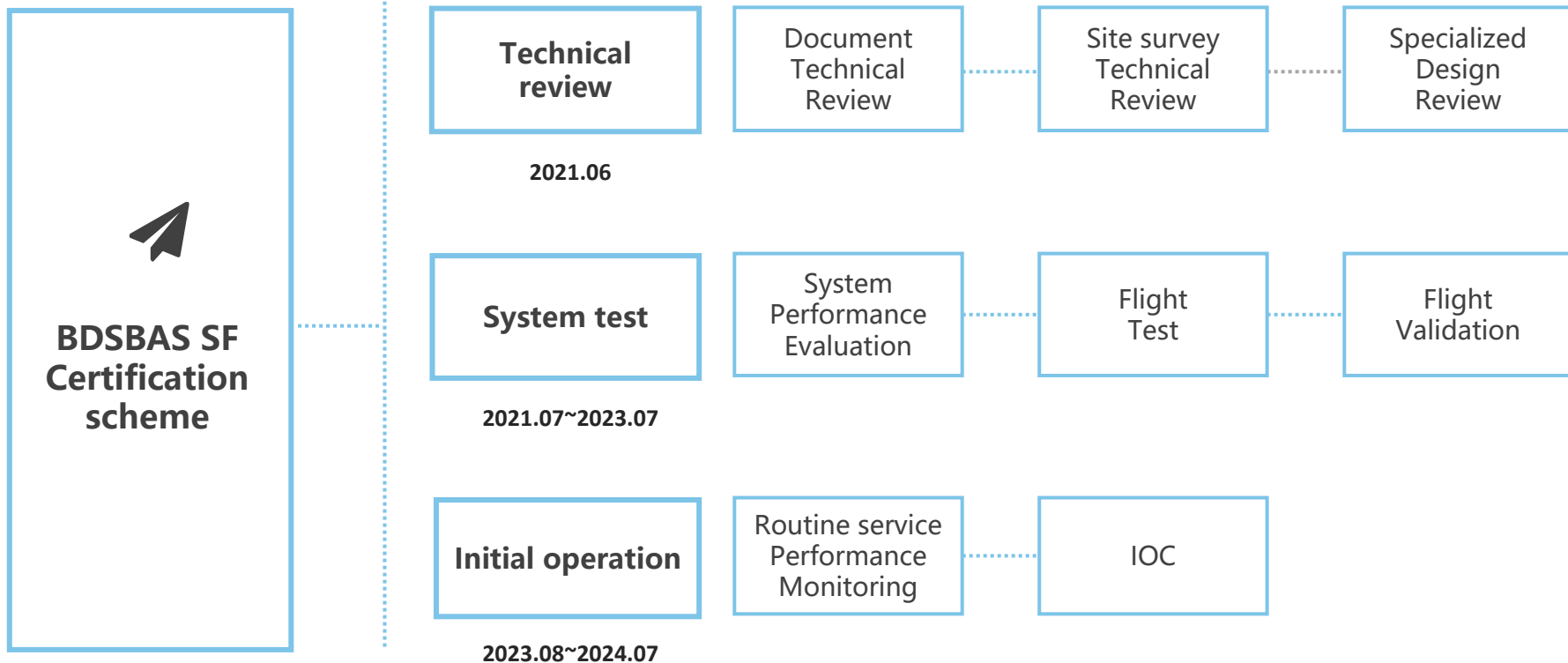
iGMAS Station	bjf1	sha1	wuh1
Horizontal Accuracy (95%)	2.23m	2.89m	2.35m
Vertical Accuracy (95%)	3.38m	3.89	3.85m

## Safety Index of BDSBAS

iGMAS Station	bjf1	sha1	wuh1
Minimum Horizontal Safety Index min(HPL/HPE)	3.29	1.65	1.90
Minimum Vertical Safety Index min(VPL/VPE)	2.90	1.45	5.00

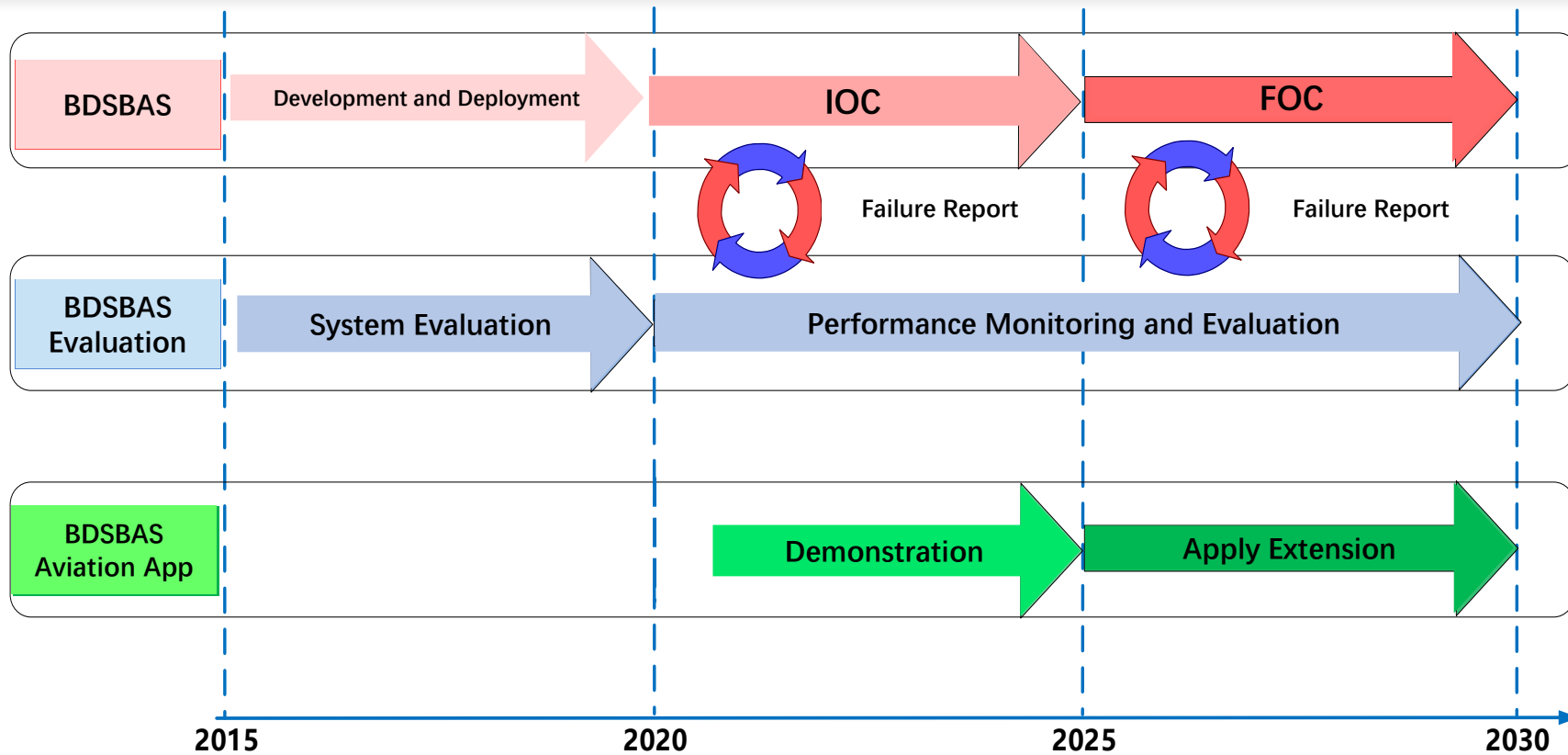


# BDSBAS SF Certification Scheme(2021~2024)





# BDSBAS Implementation Baseline



North American  
Central American  
and Caribbean  
(NACC) Office  
Mexico City

South American  
(SAM) Office  
Lima

ICAO  
Headquarters  
Montréal

Western and  
Central African  
(WACAF) Office  
Dakar

European and  
North Atlantic  
(EUR/NAT) Office  
Paris

Middle East  
(MID) Office  
Cairo

Eastern and  
Southern African  
(ESAF) Office  
Nairobi

Asia and Pacific  
(APAC) Sub-office  
Beijing

Asia and Pacific  
(APAC) Office  
Bangkok



THANK YOU