सत्यमेव जयते

नागर विमानन मंत्रालय, भारत सरकार

MINISTRY OF CIVIL AVIATION, GOVERNMENT OF INDIA

भारतीय विमानपत्तन प्राधिकरण

AIRPORTS AUTHORITY OF INDIA

ICAO APAC SBAS-GBAS IMPLEMENTATION WORKSHOP FOR AIRSPACE USERS

"Enhancing airport accessibility and safety on final approach with SBAS and GBAS"

14th to 16th October 2025

Bengaluru, India

GAGAN System

G.K. VENUGOPAL,

ED(CNS-P-I), AAI India

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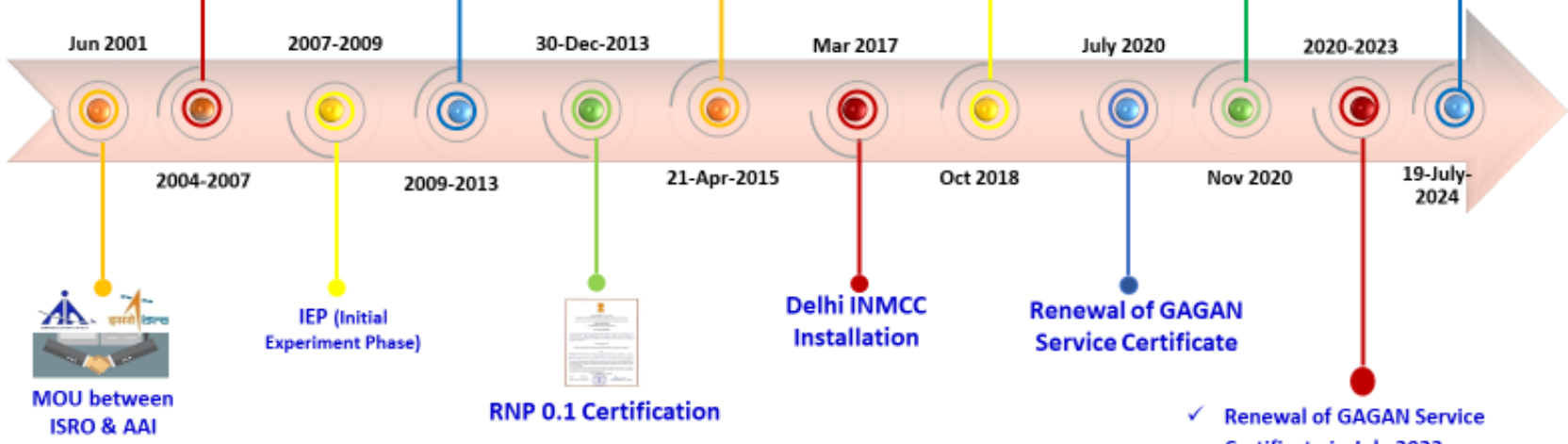
01

GAGAN Time line and Service

GAAGN System:
- **Jointly developed by ISRO & AAI**
- **4th certified SBAS in the world**
- **3rd SBAS to achieve APV -1 certification**
- **1st SBAS in equatorial region**

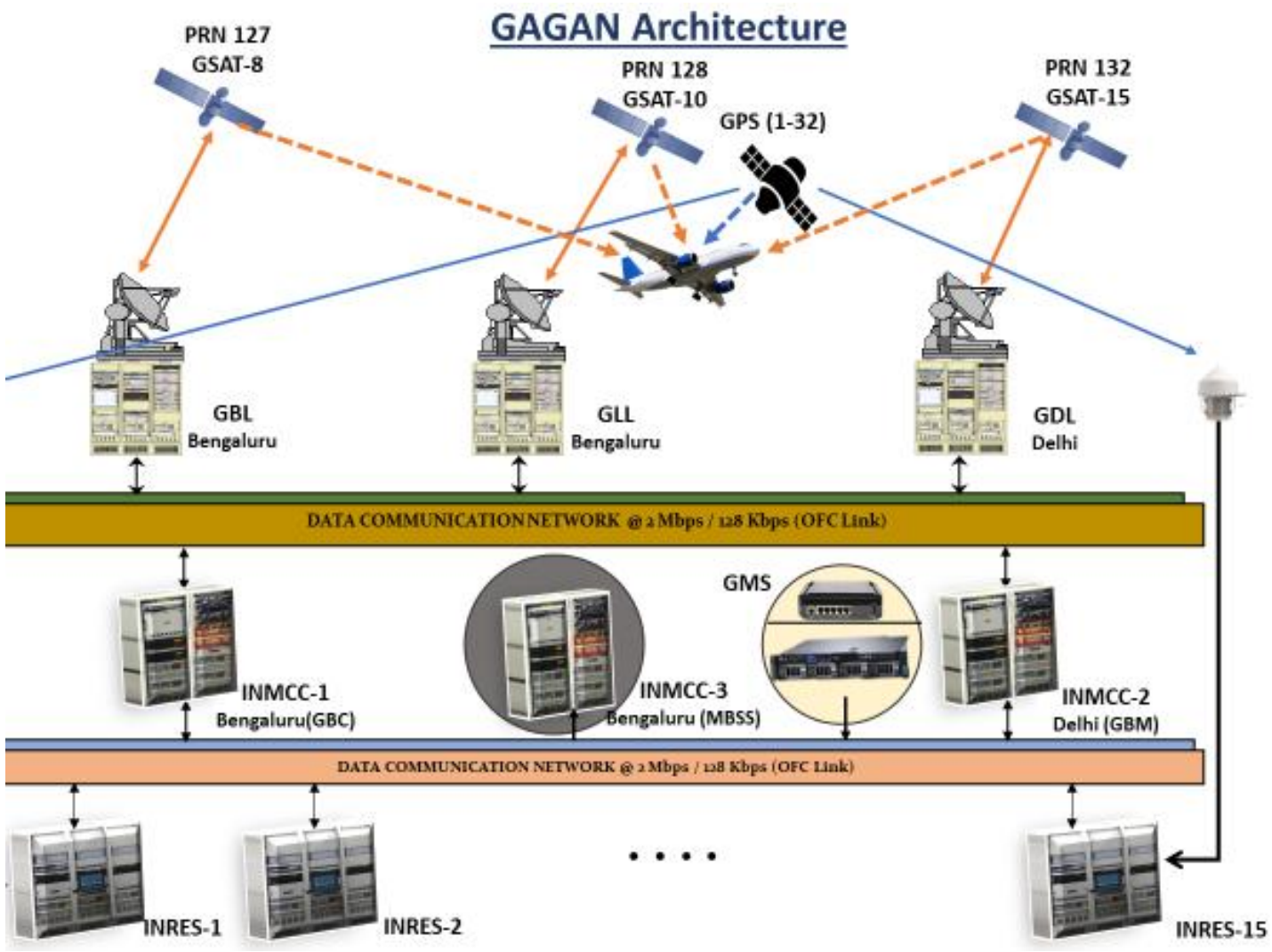


Provides seamless navigation over Indian Airspace through:
- ✓ **En-route,**
- ✓ **Non Precision Approach (NPA) and**
- ✓ **Precision Approach (PA) to the level of LPV 250**

India being in Equatorial region, facing severe Ionospheric challenges.

02

GAGAN Architecture



03

GNSS / GAGAN INTERFERENCE ISSUES & MITIGATION

Issues:

- **Sporadic GNSS jamming/spoofing affecting GAGAN signal integrity in Indian FIRs.**
- **Sources: unintentional emissions, portable jammers near borders/urban zones.**

DGCA Actions:

- **Advisory Circular (Nov 2023): Monitor 121.5 MHz & NOTAMs, report anomalies, maintain alternate nav readiness.**
- **Sensitization Meeting (Oct 2023): Airlines, OEMs, ANSP shared spoofing experiences & SOPs.**
- **Standard reporting format for all GNSS interference events.**

AAI Actions:

- **SOP (Apr 2023): Procedure for reporting & responding to GNSS anomalies.**
- **Workshop (Feb 2024): GNSS Interference Awareness with Airbus, Boeing, Collins, academia.**
- **Mitigation: Maintain Ground Nav-Aids to ensure CNS backups, issue NOTAMs on affected zones, multi-source GAGAN timing.**

"India safeguards GAGAN operations through proactive DGCA policies, AAI SOPs, and multi-layer redundancy—ensuring safety, continuity & resilience."

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04

Policy on GAGAN equipage and status

1. Policy Background:

- As per **National Civil Aviation Policy (NCAP-2016)**, all new aircraft registered in India must be **GAGAN-enabled** to support satellite-based navigation and approach operations.
- **DGCA Public Notice:** Mandated **GAGAN-capable GPS receivers** onboard all aircraft registered from **1 January 2019**, later revised to **1 July 2021** for implementation.

2. Exemptions / Relaxations

- **Legacy aircraft types certified prior to 2019 are temporarily exempted until major avionics retrofit or fleet renewal.**
- **Imported or leased aircraft delivered without SBAS receivers are allowed under conditional DGCA approval, subject to retrofit during major maintenance or modification phase.**

3. Current Equipage Status (as of 2025)

- **Total SBAS-equipped aircraft: 278**
- Major operators with GAGAN/SBAS-enabled fleets:
  - **IndiGo:** ATR 72, A320/A321 family (179 aircraft)
  - **Vistara:** A320/321 – 25 aircraft
  - **Air India & Air India Express:** B777, A321 – 25 aircraft
  - **Akasa Air / AIX Connect / SpiceJet:** B737 MAX / Q400 – 49 aircraft

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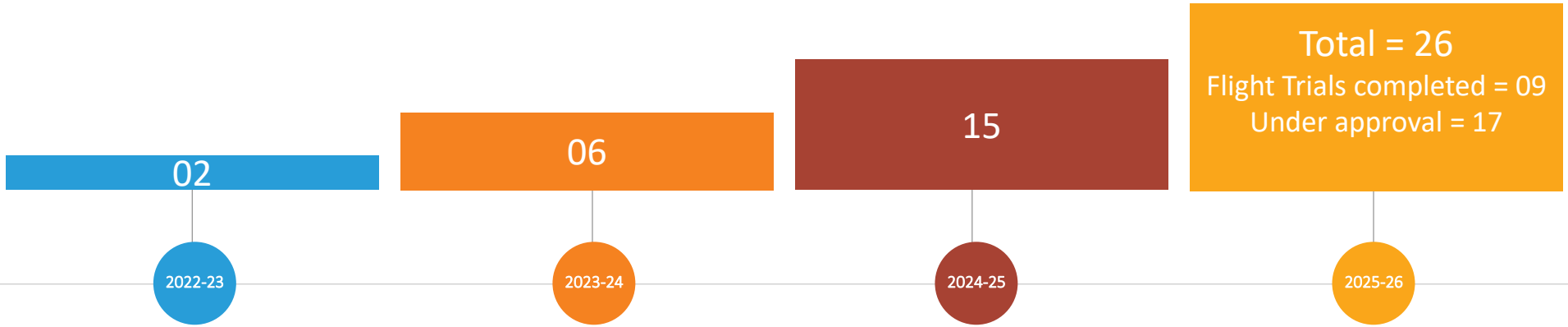
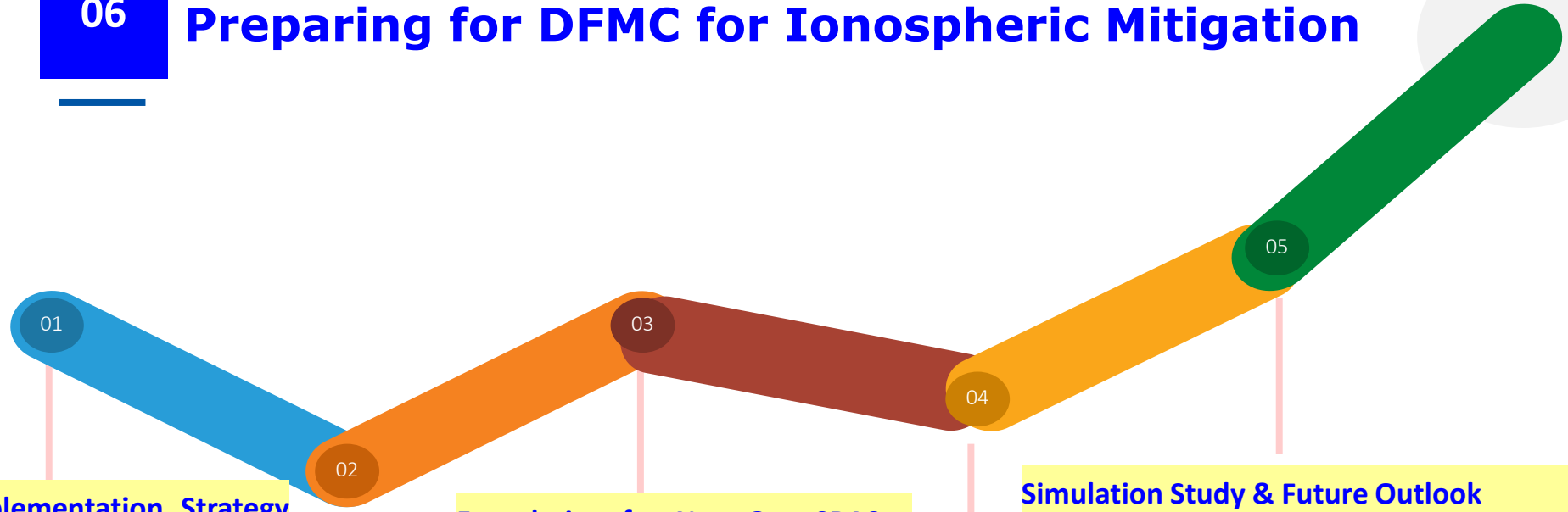
05 LPV (GAGAN) Procedure Status

Total ICAO SBAS Channel number Allocated for LPV Procedures	63
Procedures Promulgated	23
Flight Trials Completed (Awaiting Promulgation Approval from DGCA)	09
Procedures sent to AIS for promulgation	03
GAGAN LPV Procedures Submitted to DGCA for Flight Trials Approval	09
GAGAN LPV Procedures Flight Trials Pending/Under Design	05



06 Preparing for DFMC for Ionospheric Mitigation



Step-wise Implementation Strategy – Beginning with DF operations before expanding to full multi-constellation integration.

Validation and Testing – Early focus allows validation of ionospheric correction models and algorithms in real-time conditions.

Foundation for Next-Gen SBAS – Establishes the groundwork for evolving towards DFMC SBAS aligned with ICAO standards.

Integration of Dual Frequency Receivers in Reference stations - AAI has upgraded Reference stations to meet dual frequency operations

Simulation Study & Future Outlook

Prototype Testing – Compared with L1-SBAS values of HPL/VPL availability.

Performance Benchmarking – Evaluated against Multi-Frequency Multi-Constellation (MFMC) GNSS receiver in DFMC SBAS mode.

Safety-of-Life Demonstration - Evaluated reliable SBAS operations under high solar activity and disturbed ionospheric conditions.

Enhanced Aviation Confidence - Strengthens trust in precision approaches and safety-critical navigation.

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07

Factors Limiting GAGAN Utilisation

Key Factors Limiting GAGAN Utilization

- **Equatorial Ionospheric Disturbances:**
  Severe scintillation and plasma irregularities degrade signal continuity during solar peaks.
- **Technical & Environmental Limitations:**
  Existing ICAO Standards and RTCA MOPS were designed for mid-latitude conditions (like WAAS/EGNOS), making them less effective in equatorial environments
- **GNSS Interference & Spoofing:**
  Increasing RF disruptions and spoofing incidents affect user confidence and operational reliability.
- **Low Aircraft Equipage:**
  Limited SBAS-capable avionics across domestic fleets delay widespread LPV adoption.
- **Regulatory Transition:**
  DGCA mandate (post-July 2021) promotes progressive equipage, but legacy fleets remain exempt.

08

Ionospheric challenges and Mitigation by ICAO

A. Present Scenario

- Global Solar Impact: Recent solar activity has affected GNSS systems; WAAS/EGNOS (mid-latitudes) saw minimal impact.
- Severe Effect on GAGAN: Operating in the equatorial region, GAGAN faces major disruptions, especially during equinox peaks (2023–25).
- Ionospheric Challenges: High plasma bubbles, scintillation, and TEC gradients unique to equatorial belt.
- Standard Limitation: Existing ICAO SARPs and RTCA MOPS are based on mid-latitude models—not suitable for equatorial conditions.

B. ICAO Mitigation (Global Level)

- Dual-Frequency Multi-Constellation (DFMC GNSS): Adopted in ICAO SARPs (Nov 2021) to mitigate ionospheric effects.
- Implementation Gap: Full operationalization expected only in 10–15 years due to constellation, infrastructure, and avionics readiness.

09

India's Proposal on Ionospheric mitigation

C. India's Proposal

Short-Term Technical Measures:

- Develop equatorial ionospheric algorithms for SBAS.
- Integrate via software/firmware updates (similar to SBAS Authentication).
- Revise ICAO SARPs/MOPS to include equatorial models and correction algorithms.

Regional Initiatives:

- Establish Regional Space Weather Centers focused on equatorial ionosphere.
- Ensure inclusion of equatorial data in ICAO Space Weather Advisory Services.

D. Goal

"To ensure safe, reliable, and equitable GNSS service for all regions — fulfilling ICAO's *No Country Left Behind* vision through equatorial-inclusive standards and capabilities."

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Way forward for GAGAN

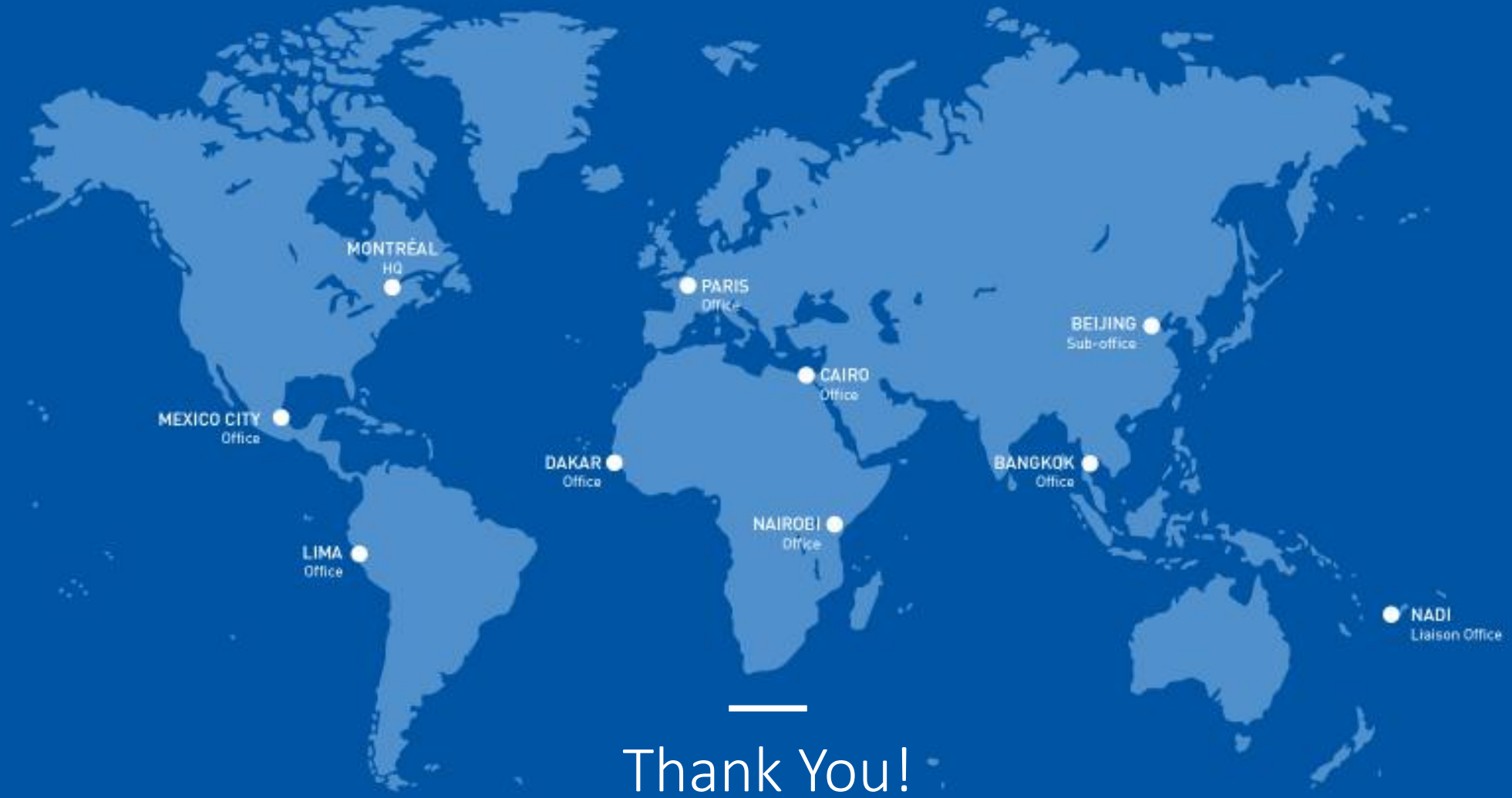
Way Forward

- **Develop equatorial-specific ionospheric models and software-based mitigation within GAGAN.**
- **Accelerate equipage through policy and OEM collaboration.**
- **Expand LPV procedures and crew training across regional airports.**
- **Diversify applications — agriculture, rail, maritime, and disaster management — to maximize national benefit.**
- **Transition to Dual-Frequency Multi-Constellation (DFMC) SBAS for long-term resilience.**

"GAGAN's untapped potential lies not in its design, but in the path to

- ✓ **wider equipage,**
- ✓ **interference and ionospheric resilience, and**
- ✓ **cross-sector adoption [Non-Aviation applications]**

— transforming India's SBAS into a true national asset."



Thank You!

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