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RESEARCH, INNOVATION, RESULTS



**TOSHKENT DAVLAT  
TRANSPORT UNIVERSITETI**

Tashkent state  
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## Implementation of performance based navigation (pbn) in civil aviation

I.S. Maturazov<sup>1</sup><sup>a</sup>, A.M. Juraev<sup>1</sup><sup>b</sup>

<sup>1</sup>Tashkent state transport university, Tashkent, Uzbekistan

**Abstract:** This article provides a comprehensive analysis of the transition to a modern, technology-based approach in civil aviation — Performance Based Navigation (PBN). It examines the core principles of the PBN concept, its technological solutions, and the advantages it offers over traditional ground-based navigation systems. Particular attention is given to the role of PBN in optimizing air traffic, reducing fuel consumption, minimizing environmental impact, and enhancing flight accuracy and safety. The article also explores the technical, legal, and organizational challenges encountered during the implementation of PBN, and draws upon international experience to propose solutions. Specifically, it reviews the practical application, outcomes, and future prospects of the United States' NextGen program and the European Union's SESAR (Single European Sky ATM Research) initiative. The significance of implementing the PBN system for improving global aviation safety, increasing the efficiency of air traffic management, and modernizing aviation infrastructure is emphasized throughout the article.

**Keywords:** PBN, RNAV, RNP, GNSS, flight safety, navigation systems

## Performance based navigation tizimining fuqarolik aviatsiyasida joriy etilishi

Maturazov I.S.<sup>1</sup><sup>a</sup>, Jo'rayev A.M.<sup>1</sup><sup>b</sup>

<sup>1</sup>Toshkent davlat transport universiteti, Toshkent, O'zbekiston

**Annotatsiya:** Mazkur maqolada fuqarolik aviatsiyasida zamonaviy texnologiyalarga asoslangan yondashuv — xususiyatlar asosidagi navigatsiya (PBN — Performance Based Navigation) tizimiga bosqichma-bosqich o'tishning dolzarb jihatlarini atroflicha tahlil qilingan. Unda PBN konsepsiyasining asosiy tamoyillari, texnologik yechimlari hamda ushbu yondashuvning an'anaviy yerga asoslangan navigatsiya tizimlariga nisbatan ustunliklari, xususan, havo harakatini optimallashtirish, yoqilg'i sarfini kamaytirish, ekologik ta'sirni pasaytirish va parvozlarning aniqligi va xavfsizligini oshirishdagi roli batafsil yoritilgan. Shuningdek, maqolada PBN tizimini joriy etish jarayonida duch kelinayotgan texnik, huquqiy va tashkiliy muammolar tahlil qilinib, ularni bartaraf etish bo'yicha xalqaro tajribalarga murojaat qilingan. Xususan, AQShda amalga oshirilayotgan NextGen dasturi va Yevropa Ittifoqining SESAR (Single European Sky ATM Research) tashabbuslari misolida PBNning amaliy qo'llanilishi, natijalari va istiqbollari ko'rib chiqilgan. PBN tizimining global aviatsiya xavfsizligi, havo harakatini boshqarish samaradorligini oshirish va aviatsion infratuzilmani modernizatsiya qilishdagi ahamiyati alohida ta'kidlangan.

**Kalit so'zlar:** PBN, RNAV, RNP, GNSS, parvoz xavfsizligi, navigatsiya tizimlari

### 1. Kirish

Zamonaviy aviatsiya navigatsiyaning asosiy jihatlariga ta'sir qiluvchi texnologik o'zgarishlarni boshdan kechirmoqda. Ushbu o'zgarishlarning muhim yo'nalishlaridan biri bu — xarakteristikaga asoslangan navigatsiyani (PBN — Performance Based Navigation) joriy etishdir. Mazkur kontsepsiya nafaqat parvozlarning aniqligi va xavfsizligini oshirishni, balki havo makonidan foydalanish samaradorligi va barqarorligini ta'minlashni ham va'da qiladi. Ushbu maqolada PBN tamoyillari, an'anaviy tizimlarga nisbatan ustunliklari va uni joriy etishdagi muammolar ko'rib chiqiladi. [1; 2].

Performance Based Navigation (PBN) — bu Xalqaro Fuqaro Aviatsiyasi Tashkiloti (ICAO) tomonidan ishlab chiqilgan aeronavigatsiya kontsepsiyasidir. Unda

navigatsiya jarayonlari yer usti radiomayaklariga bog'liq bo'lmagan, bortdagi uskunalar va sun'iy yo'ldosh tizimlari ta'minlaydigan aniqlik va ishonchlik xususiyatlariga asoslanadi.

### 2. Tadqiqot metodologiyasi

PBN ning asosiy tarkibiy qismlari:

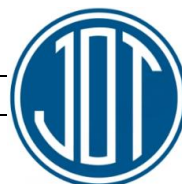
— RNAV (Area Navigation) — belgilangan yo'nalishlar bo'yicha, yer usti navigatsion nuqtalardan o'tmasdan parvoz qilish imkonini beruvchi tizim;

— RNP (Required Navigation Performance) — bu RNAV ning qo'shimcha aniqlik, monitoring va nosozliklar haqida xabardor qilish talablariga ega shaklidir.

PBN yordamida yer usti tizimlarining joylashuviga bog'liq bo'lmagan, samolyotning haqiqiy navigatsion imkoniyatlariga asoslangan yo'nalishlar va protseduralarni

<sup>a</sup> <https://orcid.org/0009-0003-4781-1601>

<sup>b</sup> <https://orcid.org/0009-0002-1219-8168>





ishlab chiqish mumkin. Bu tog'li hududlar, zich havo harakati va infratuzilma cheklovlari mavjud bo'lgan joylarda ayniqsa muhimdir.

Quyidagi jadvalda yillar kesimida an'anaviy tizimlar va PBN tizimlarni 2010-2030 yillarda foydalanish tendensiyalarini ko'rishimiz mumkin.

1-jadval

| Yil  | An'anaviy tizimlar (%) | PBN tizimlari (%) |
|------|------------------------|-------------------|
| 2010 | 90%                    | 10%               |
| 2015 | 75%                    | 25%               |
| 2020 | 55%                    | 45%               |
| 2025 | 30%                    | 70%               |
| 2030 | 10%                    | 90%               |

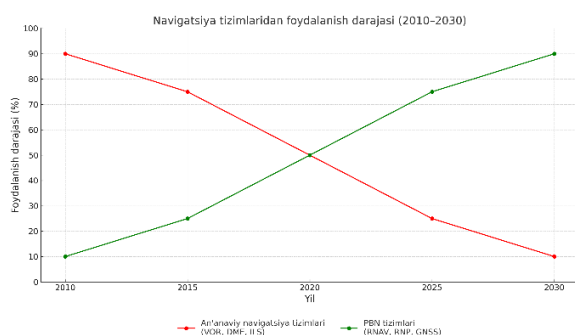
An'anaviy navigatsiya vositalari — VOR, DME va ILS kabi tizimlar hanzugacha ishonchli bo'lib kelmoqda, biroq ular bir qancha cheklovlarga ega:

- Geografik bog'liqlik: yo'nalishlar radiomayaklarning joylashuviga bog'liq;
- Yuqori ekspluatatsion xarajatlar: yer usti stansiyalari doimiy texnik xizmatni talab qiladi;
- Zaiflik: magnit maydon o'zgarishlari, Quyosh chaqnashlari va uskuna eskirishi ularning samaradorligini pasaytiradi.

Sun'iy yo'ldosh asosidagi GNSS texnologiyalari va raqamli tizimlar bu cheklovlardan xoli bo'lib, yo'nalishlarni moslashuvchan qilish, yoqilg'i sarfini kamaytirish, CO<sub>2</sub> chiqindilarini kamaytirish va xavfsizlikni oshirish imkonini beradi.

PBN tizimining afzalliklari:

- Navigatsiya aniqligining oshishi
- Yo'nalishlarni optimallashtirish va kechikishlarni kamaytirish
- Dispetcherlar va radiochastotalar yuklamasining pasayishi
- Yomon ko'rinish sharoitida xavfsiz qo'nish imkoniyati
- Yer usti infratuzilmasiga bog'liqlikning kamayishi
- Havo makonining o'tkazuvchanlik salohiyatining oshishi.



### 1-rasm. Aviatsiya an'anaviy va PBN tizimlardan foydalanish tendensiyasi

An'anaviy navigatsiya tizimlaridan foydalanish:

2010–2020 yillar: Bu davrda an'anaviy navigatsiya tizimlari (masalan, VOR, DME, ILS) hali ham asosiy rolni o'ynagan. Ammo shu paytdayoq ularning texnik eskirishi va xizmat ko'rsatish xarajatlari ortib borayotgani kuzatilgan.

2020–2025 yillar: An'anaviy tizimlardan foydalanish pasayishda davom etgan. Bu davrda ko'plab mamlakatlar

PBN ga o'tish strategiyalarini ishlab chiqish va amalga oshirishni boshladi.

2025–2030 yillar: Qizil chiziq keskin pastlab, an'anaviy tizimlar foydalanish darajasi minimal darajaga tushgan. Bu esa ularning ehtiyot vosita sifatida qolib ketishini anglatadi.

PBN (Performance Based Navigation) tizimlaridan foydalanish:

2010–2015 yillar: PBN faqat ayrim marshrutlar va aeroportlarda tajriba tariqasida joriy etilgan. Yashil chiziq sekin o'sishni boshlagan.

2015–2025 yillar: Bu davrda PBN jadal rivojlana boshladi. AQSH, Yevropa, Yaponiya va boshqa mintaqalarda NextGen va SESAR dasturlari orqali PBN keng joriy etildi.

2025–2030 yillar: Yashil chiziq yuqoriga keskin o'sib, PBN tizimlaridan foydalanish asosiy standartga aylandi. Umumjahon miqyosida PBN hududiy, terminal va yetib kelish navigatsiyasi uchun asosiy asosga aylanadi.

EUROCONTROL'ning so'nggi statistik ma'lumotlariga ko'ra, Yevropa Ittifoqi mamlakatlaridagi uchish-qo'nish yo'laklarining 11 foizidan ortig'i hozirda an'anaviy ILS (Instrument Landing System) tizimisi, faqatgina PBN (Performance Based Navigation) asosida CAT II toifasidagi past ko'rinish sharoitlarida qo'nishni amalga oshirish imkonini bermas. Bu holat, ayniqsa RNP AR (Required Navigation Performance with Authorization Required) kabi ilg'or navigatsion tizimlarning aniqligi va ishonchligi yuksak darajada ekanini ko'rsatadi. Bunday tizimlar og'ir meteorologik sharoitlarda ham samolyotlarga xavfsiz va aniqligi yuqori bo'lgan yondashuvlar orqali qo'nishni ta'minlashga qodir.

Bugungi kunda ko'plab mamlakatlar PBN texnologiyasini milliy miqyosda joriy etish bo'yicha keng ko'lamli strategik dasturlarni ishlab chiqmoqda:

- AQSH: Federal aviatsiya boshqarmasi (FAA) tomonidan ilgari surilgan NextGen tashabbusi aviatsiya tizimining to'liq raqamlashtirilishini, jumladan, barcha bosqichlarda PBN asosidagi navigatsiyaga o'tishni nazarda tutadi. Bu dastur parvozlar samaradorligini oshirish, yoqilg'i sarfini kamaytirish va atrof-muhitga salbiy ta'sirni kamaytirish kabi maqsadlarni ko'zlaydi.

- Yevropa Ittifoqi: SESAR (Single European Sky ATM Research) dasturi orqali Yevropa havo makonida yagona va yuqori darajada uyg'unlashtirilgan PBN asosidagi havo harakati boshqaruv tizimi yaratilmoqda. Bu esa nafaqat xavfsizlikni oshiradi, balki transchegaraviy parvozlarni ham soddalashtiradi.

PBN tizimining afzalliklari — aniqlik, moslashuvchanlik, yoqilg'i tejami, ekologik foyda va xavfsizlik — qanchalik ravshan bo'lmasin, uni to'liq joriy etish uchun quyidagi muhim shart-sharoitlarni bajarish zarur:

1. Aviaparkni texnik modernizatsiya qilish. PBN asosidagi parvozlarni amalga oshirish uchun havo kemalari zarur bo'lishi mumkin bo'lgan RNAV va RNP tizimlarini qo'llab-quvvatlovchi zamonaviy avionika (navigatsion uskunalar) bilan jihozlanishi lozim. Bu, o'z navbatida, uchuvchilar va texnik xodimlar uchun qo'shimcha o'quv va qayta tayyorlash dasturlarini talab etadi.

2. Huquqiy-me'yoriy asosni ishlab chiqish. Har bir davlatda PBN'ni tartibga soluvchi aniq qonunchilik va reglamentlar bo'lishi zarur. Ular parvoz amaliyoti, xavfsizlik, ruxsatnomalar, sertifikatlash va nazorat jarayonlarini belgilab berishi kerak.



3. Xalqaro integratsiya va tizimlararo moslik. Turli davlatlar o'rtasida PBN tizimlarining uzviy uyg'unligi va o'zaro tan olinishini ta'minlash muhimdir. Aks holda, transchegaraviy parvozlarda noqulaylik va xavf yuzaga kelishi mumkin.

O'tish davrida zaxira sifatida an'anaviy tizimlarni saqlab turish. PBN tizimlariga to'liq o'tish darhol sodir bo'lmaydi. Shu sababli, o'tish davrida ILS, VOR kabi an'anaviy tizimlar xavfsizlik nuqtayi nazaridan zaxira sifatida faoliyat yuritishi lozim.

### 3. Xulosa

Xarakteristikaga asoslangan navigatsiya — bu fuqarolik aviatsiyasining ertangi istiqboli emas, balki ayni zamonning zarurati va amaliy haqiqatidir. Uning joriy etilishi butun dunyo bo'ylab havo harakati tizimining samaradorligini oshirish, ekologik barqarorlikka erishish va eng muhimi — parvozlarda xavfsizligini yuqori darajada ta'minlash imkonini bermog'da. An'anaviy navigatsion tizimlar bilan bog'liq geografik cheklavlar, texnik xizmat ko'rsatishdagi murakkabliklar hamda zamonaviy talablar PBNning ustunliklarini yanada yaqqol namoyon qilmoqda. Shu bilan birga, PBN tizimining to'liq joriy etilishi murakkab va ko'p bosqichli jarayon bo'lib, u aviatsiya infratuzilmasining barcha darajalarida izchil islohotlarni talab etadi. Aviaparkni modernizatsiya qilish, uchuvchilar va muhandis-texnik xodimlarni qayta tayyorlash, xalqaro me'yorlarga mos qonunchilik asoslarini yaratish hamda turli mamlakatlar o'rtasida texnologik moslashuvga erishish — ularning barchasi PBNning muvaffaqiyatli amalga oshirilishi uchun hal qiluvchi ahamiyatga ega. Biroq, ushbu yo'ldagi mavjud muammolar xalqaro tashkilotlar milliy aeronavigatsiya xizmatlari va aviakompaniyalar o'rtasidagi yaqin hamkorlik, bilim va tajriba almashinuvi orqali bosqichma-bosqich bartaraf etilmoqda. Bunday yondashuv nafaqat bugungi ehtiyojlarga javob beradi, balki global aviatsiya tizimini kelajak avlodlar uchun ham ishonchli, samarali va ekologik xavfsiz holatda saqlab qolish imkonini beradi.

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## Mualliflar to'g'risida ma'lumot/ Information about the authors

|                                                                 |                                                                                                                                                                                                                                                                                                                           |
|-----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Maturazov Izzat Solievich /<br>Maturazov Izzat Solievich        | Toshkent davlat transport universiteti "Aviatsiya transporti muhandisligi fakulteti" dekani, (PhD),<br>E-mail: <a href="mailto:maturazov_i@tstu.uz">maturazov_i@tstu.uz</a><br>Tel.: +998712990357<br><a href="https://orcid.org/0009-0003-4781-1601">https://orcid.org/0009-0003-4781-1601</a>                           |
| Jo'rayev Akmal Maxmudjonovich /<br>Juraev Akmal Makhmudjonovich | Toshkent davlat transport universiteti "aviatsiya transporti muhandisligi", "aviatsiya injnirigi" kafedrasida katta o'qituvchisi.<br>E-mail: <a href="mailto:Juraev_ma@tstu.uz">Juraev_ma@tstu.uz</a><br>Tel.: +998946411603<br><a href="https://orcid.org/0009-0002-1219-8168">https://orcid.org/0009-0002-1219-8168</a> |



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