AEROSPACE SYSTEMS OF MONITORING AND MANAGEMENT

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Satellite Aeronavigation Center of National Aviation University is presented: research directions, laboratory practicum, research equipment, developed problems.

Introduction

Satellite Aeronavigation Center was created at the Aeronavigation Department of the Institute of Information and Diagnostic Systems of the National Aviation University. The main goal of the center is to improve bachelor and master degree training for Ukraine and other countries enterprises and research institutions in the field of satellite information systems. The training is based on standards, requirements and recommended practices, which are developed by ICAO, IMO, EUROCONTROL. Training process is organized according to approved programs, which are adapted to Bologna process requirements. These programs give students possibilities to study theory of satellite information technologies, to solve practical problems while laboratory sessions and together with researchers and post-graduate students of the department carry out researches solving the problems in satellite radionavigational direction:

– GPS, GLONASS, EGNOS satellite systems radionavigation field monitoring;
– satellite radionavigation systems availability prediction during en-route, departure and landing of aircraft;
– satellite radionavigational systems noiseimmunity;
– technologies of object protection against offensive means equipped with satellite radionavigation devices;
– adaptive antenna systems for interferences suppression satellite navigation devices;
– integral information processing in aircraft navigation systems (GPS + EGNOS + GLONASS + inertial system +LORAN);
– differential satellite navigation systems;
– primary and secondary information processing algorithms in satellite radionavigation systems;
– airborne Integrity autonomous monitoring;
– aerodrome vehicles traffic control and management;
– real-time sensitive trajectory measurements on the basis of differential global positioning satellite systems;
– technological software for navigation receivers and control module station.

Laboratory researches

One of the laboratories is shown in fig. 1.

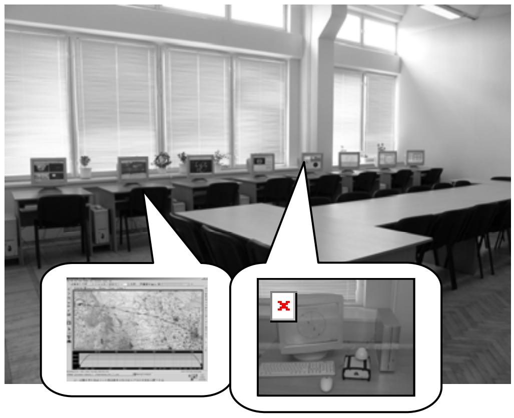


Fig. 1. Training laboratory

It is equipped with modern original software. Examples of work which can be done in the laboratory are shown in fig. 2–10.

Fig. 2, *a* shows GPS satellite structure, which helps to form optimal splitting of electromagnetic energy in navigation satellite range.

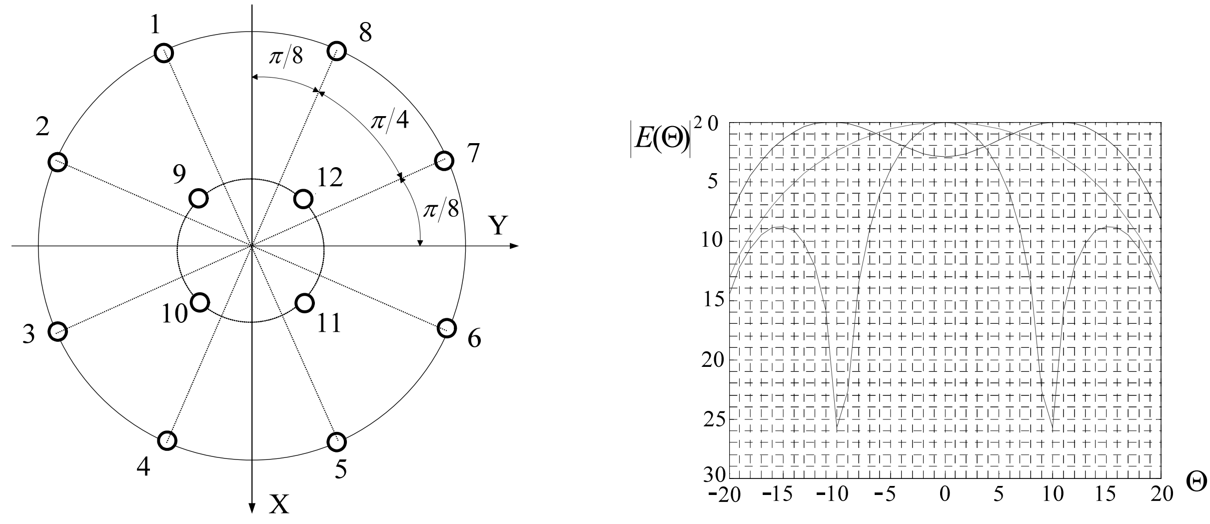
Optimal splitting of electromagnetic energy is made due to directional patterns of 4 and 8 elements sublattices.

These directional paths and resultant component are shown in the fig. 2, *b*, volume directional patterns and radiation area of earth surface are shown in fig. 3.

Fig. 4, 5 show pseudorandom spectrum of navigation satellite signal and sequence of C/A code. Some elements of GPS signal processing are shown in fig. 6, 7.

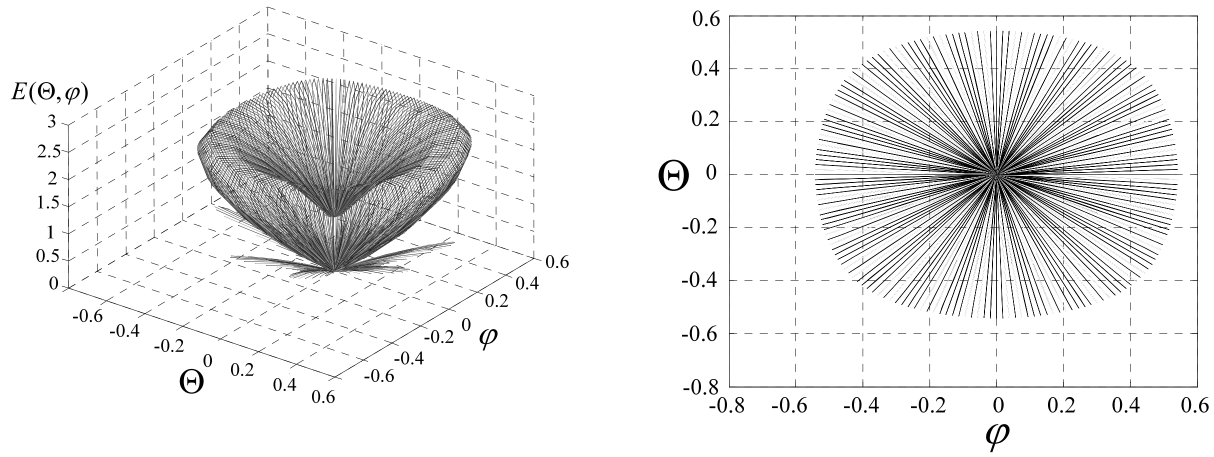
Fig. 8, 9 show navigation satellites orbits, which are calculated using ephemeris and almanac data.

Fig.10 shows relation of the spatial geometrical factor to angles of visibility of 5 navigation satellites.



a *b*

Fig. 2. GPS arrays antenna and sublattice satellite directional patterns:
a – arrays antenna design; *b* – directional patterns



a *b*

Fig. 3. Volume directional patterns of GPS satellite arrays antenna (*a*) and its surface track (*b*)

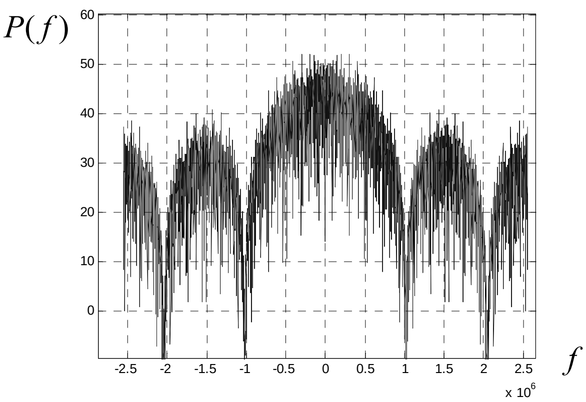


Fig. 4. Satellite 12 signal spectrum

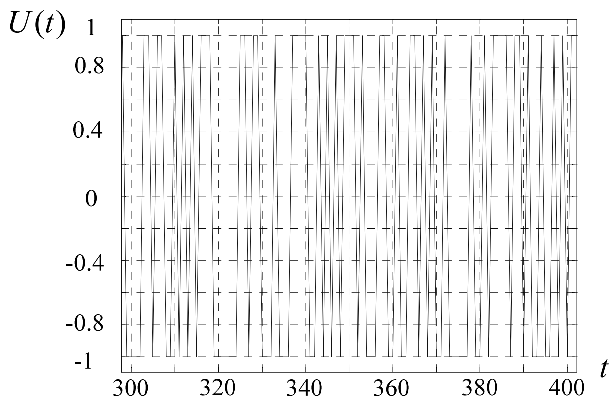


Fig. 5. Patch of C/A code GPS

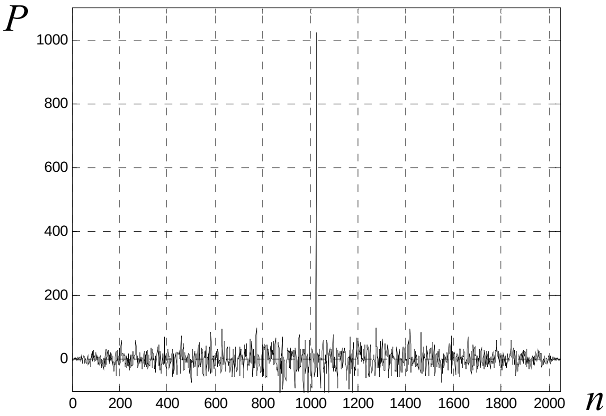


Fig. 6. C/A code GPS autocorrelation function

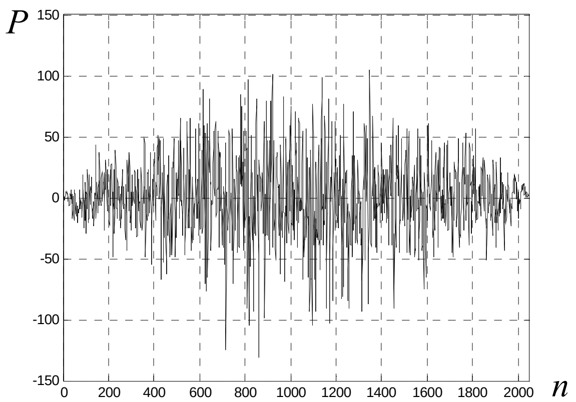


Fig. 7. 12 and 15 GPS satellites C/A codes cross correlation

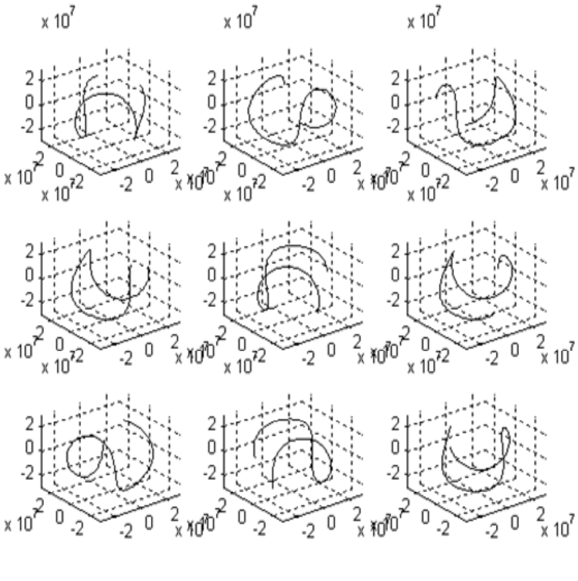


Fig. 8. GPS satellite orbits

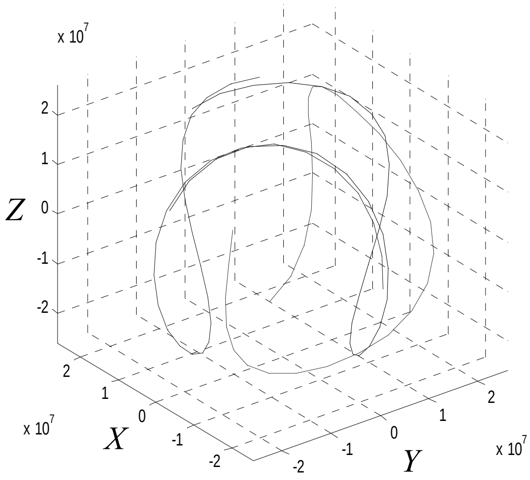


Fig. 9. GLONASS satellite orbits

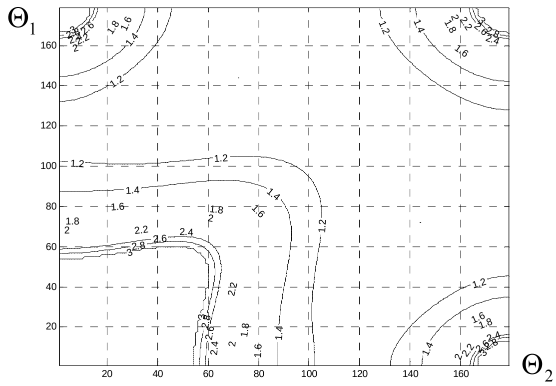


Fig. 10. Relation of the spatial geometrical factor to angles of visibility of 5 navigation satellites

Research equipment

The SANC is equipped with specialized satellite navigation equipment of state industrial enterprise "Orizon-Navigatsia" working simultaneously on satellite systems GPS and GLONASS; differential stations on the basis of elements OEM-4 (made by NovAtel), working on satellites of GPS, EGNOS systems and forming correcting information in various formats; navigation receivers of UBLOX, CMC ELECTRONICS firms, working in various modes. Satellite navigation equipment ASANS is used for practical development of satellite systems, their monitoring and carrying out research in some ministries, the industrial and scientific organizations of Ukraine are interested. Fig. 11, 12, 13 give examples of GPS monitoring which have been obtained by means of satellite systems (fig. 14) and developed in National Aviation University. The special software is developed in Satellite Aeronavigation Center for the development of adaptive antenna systems for interferences suppression. Fig. 15 illustrates a software fragment which is a result of an adaptive array antenna capacity distribution. Fig 16 shows the aerial with suppression of multipath, designed by Satellite Aeronavigation Center experts.

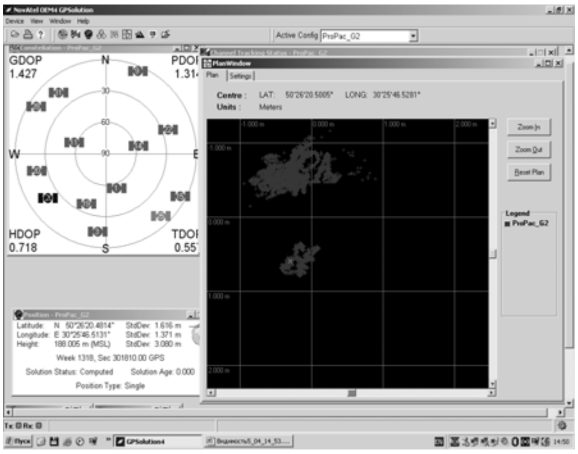


Fig. 11. Precision position data determination by GPS+EGNOS systems monitoring

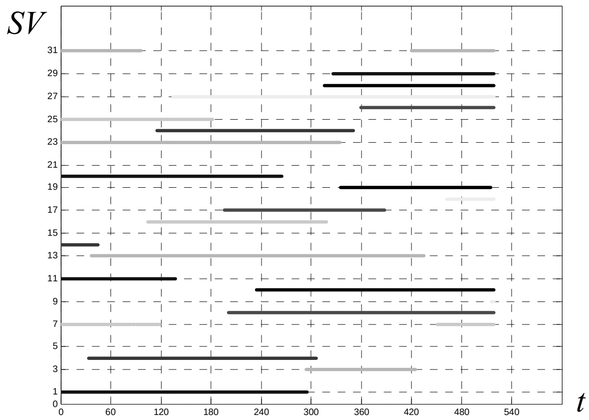


Fig. 12. GPS satellite visibility

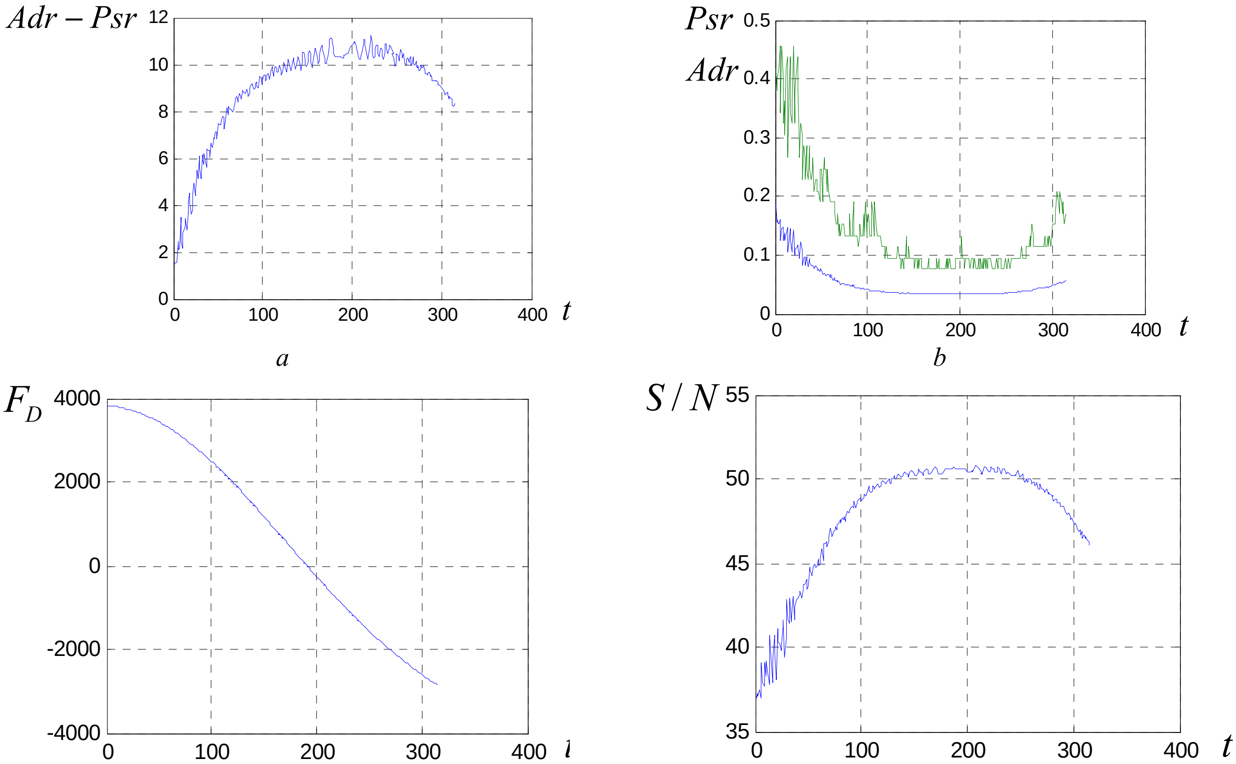


Fig. 13. Satellite 8 signals characteristics:
a – difference between code and phase measurements of pseudorandge; *b* – dispersion of code and phase measurements of pseudorandge; *c* – Doppler frequency measurement (kGz); *d* –measurement of sequence signal/noise (dB)

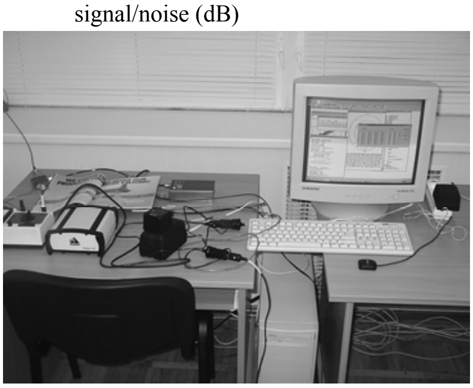


Fig. 14. General form of monitoring station, developed in National Aviation University

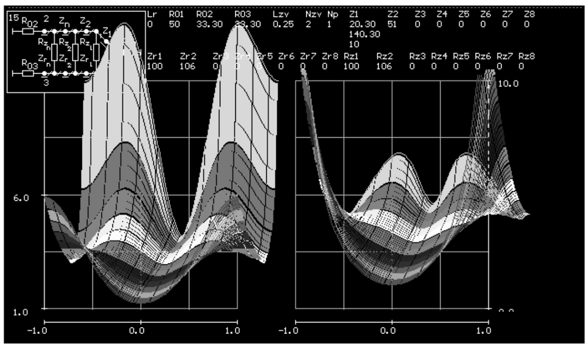


Fig. 15. Results of adaptive array patch modeling

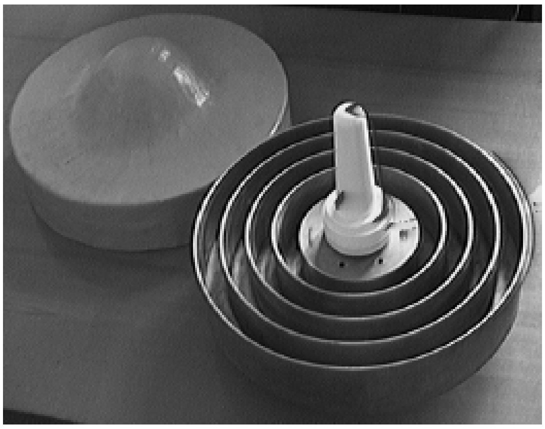


Fig. 16. Antimultipath antenna

Completed developments

Among the completed developments by employees and students SANC it is necessary to mention one of them – the automated system of forecasting of availability of navigation satellites (ASFANS) at movement of an aircraft on the route. The operation of system is the following.

Almanac data from navigation satellites are accepted 1–2 hours before the aircraft take-off. Then for each point of a route geometrical factors are determined as well as scenario of a sudden failures and malfunctions of satellites are modeled.

Results of calculations and modeling are documented. According to criteria availability of satellite navigation system is calculated at any point of the route. General form of ASFANS flow diagram and interface are shown on fig.17, 18, 19.

Fig. 17. General form of ASFANS

Conclusion

Peculiarities of Satellite Aeronavigation Center in National Aviation University, laboratory practicum, fragments of modeling, diagrams and characteristics were presented.

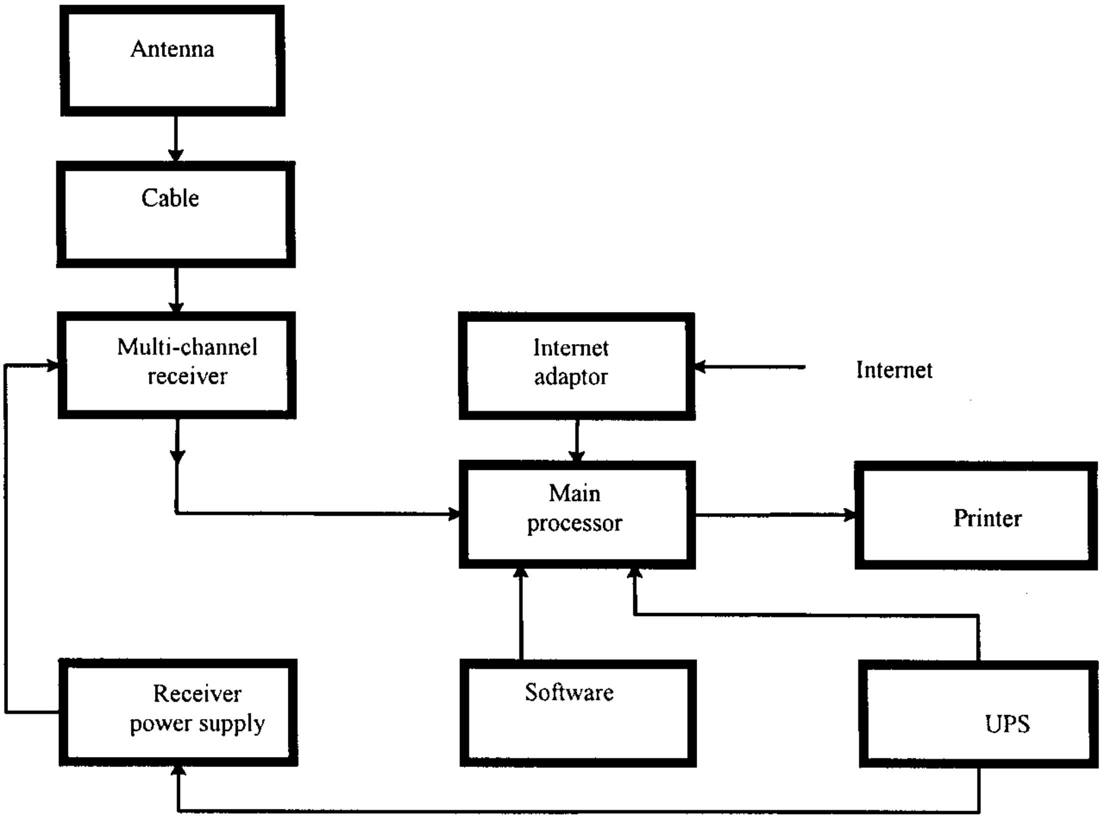
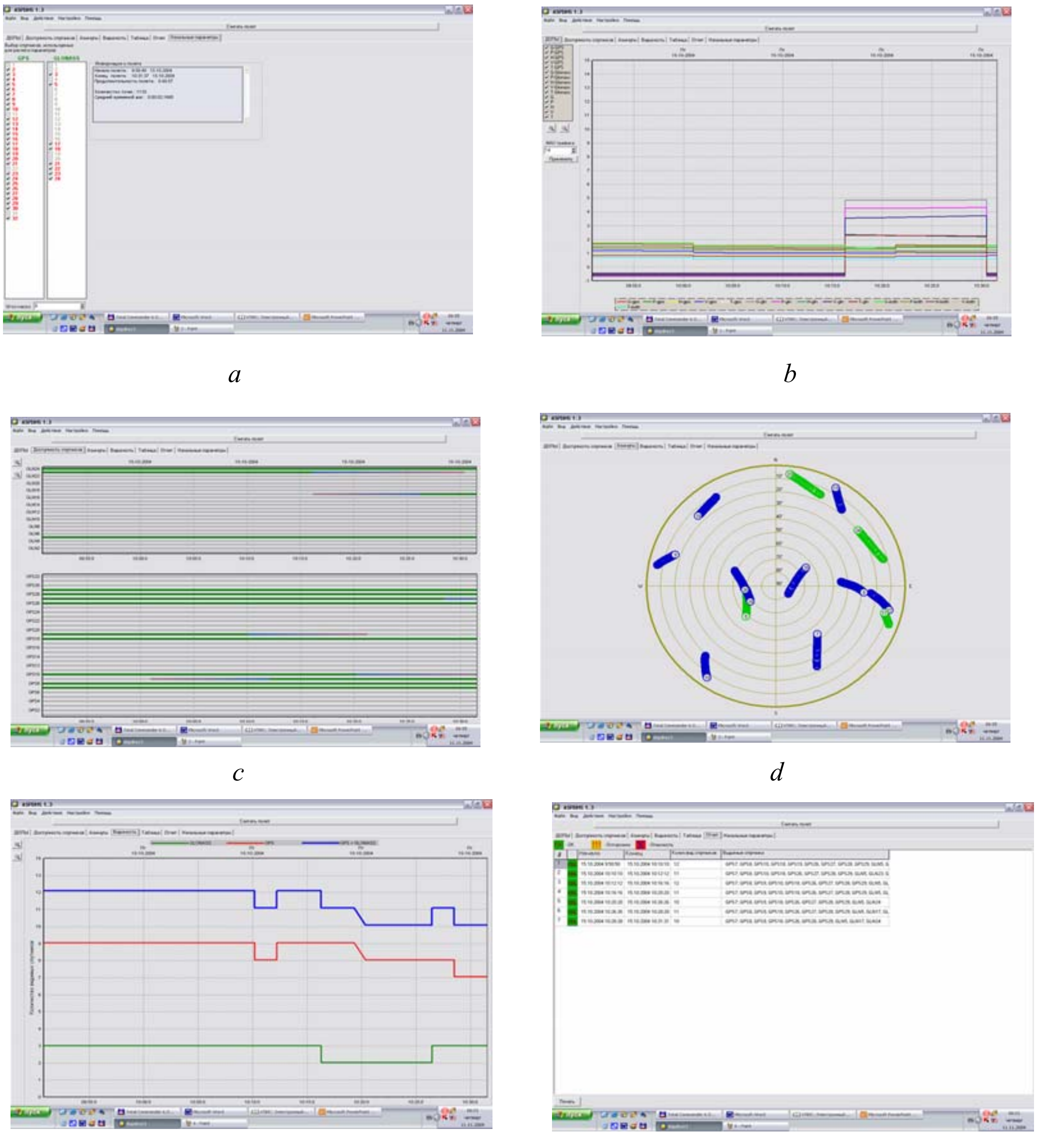


Fig. 18. Flow diagram of ASFANS



a *b* *c* *d* *e* *f*

Fig.19. Interface of ASFANS:
a – GPS, GLONASS satellites selection; *b* – geometrical factors indication; *c* – navigation satellite visibility; *d* – azimuth and elevation of navigation satellites; *e* –satellite failure indication; *f* – aircraft route forecasting note

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Розглянуто супутниковий аеронавігаційний центр Національного авіаційного університету: напрями наукових досліджень, лабораторні практикуми, обладнання для досліджень, завершені розробки.

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