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Contents and Modern Production Technologies for Preparing Geospatial Information for Aircraft

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Recently, airports of Russia and Europe have considerably increased their activity in preparing aeronautical information in accordance with the ICAO (International Civil Aviation Organization) standards. It is a particular job and aimed at flight safety. The basis of the aeronautical information is made by geospatial data prepared by geodesists and cartographers.

1 Roads on Land and in the Sky Are Laid by Geodesists

According to the ICAO nomenclature and classification, geodesists and cartographers are originators, i.e., suppliers of source information necessary for laying aircraft routes both in air and on land. Geodesists have to be extremely accurate like in jewelry while preparing source information for supporting the take-off and landing of aircraft. According to the World's Flight Safety Foundation [1], more than half of emergency situations occur at the take-off (12,8 %) and landing (49 %) of airplanes. During these moments pilots have to consider a huge number of factors like

- the layout of aeronautical facilities,
- the size-shape factor of the airfield,
- radiotechnical facilities,
- masts and other elements in the territory of the airfield,
- coordinates and elevations of obstacles, and etc.

The task of the geodesist is to prepare in advance all these data, warn pilots about the obstacles capable to get in the way of the plane, supply pilots with the information on the airfield, flight strips, taxi lanes (when the airplane touched down, it begins moving like any vehicle).

In modern life, aircraft traffic has significantly risen in volume and each airport is longing for attaining a maximal workload as its financial situation depends on the quantity of takes-off and landings. All these need additional geodetic information and – what is more important – its newer quality.

The ICAO Roadmap is a stage-by-stage plan of transition from registration to management of aeronautical information.

The aspects listed above are considered in the Roadmap of ICAO [2]. It envisages three phases (Phase 1. Consolidation. It includes information collecting, its systematization and establishment of an integrated system of standards of its quality; Phase 2. Transition to Digital Technologies. Throughout it geodetic and cartographical data are to be generated in a single electronic database in a corresponding format; Phase 3. Information Management.) that are planned to be finished till 2016.

The main demands for geospatial information are connected with Phases 1 and 2 implementations:

- Stage P 05 sets a unified system of coordinates for all the ICAO member states. A majority of the countries of the world accepted the WGS-84 as their common coordinate system. A number of the countries, say, Russia and China have their own national coordinate systems.
- Stage P 13 envisages the creation of a digital relief model of the whole territory of the state and those of the area within a radius of 45 km from a particular aerodrome,
- Stage P 14 projects the creation of a digital model of obstacles across the whole territory of the member state and those across the area within a radius of 45 km from a particular aerodrome,
- Stage P 15 has to deal with the creation of an electronic map of the territory of an airfield-aerodrome.

Thus, from the point of view of the geodesist and the cartographer, the technical support for implementation of the Roadmap provides the creation of:

- A unified coordinate system;
- Electronic maps of aerodromes,
- Electronic data on near-aerodrome territories and airways,
- Electronic databases on terrains and obstacles,
- An electronic collection of geoinformation.

They all are to meet unified approaches to quality of the data (P-17), their integrity, updating expediency (P-03), common standards of their storage and presentation to users.

In Europe and a majority of the countries of the world, Phase 1 implementation did not encounter problems and the transfer of geospatial information on aerodromes and airways for air navigation was finished in 1998. In Russia and in a number of other countries of Eastern Europe having earlier their own coordinate system, the transfer of the data is going to the end in 2012-13.

The second phase of the Roadmap is supposed to be the most difficult one in terms of labor efforts because the whole volume of geodetic and cartographical information will have to be transferred to modern digital technologies by its end. Its three essential steps defining problems for geodesists and cartographers are: P-13 – creation of a digital database on terrains; P-14 – creation of a digital database on obstacles and P-15 – transformation of the cartographical data of aerodromes. The above listed steps should be in line with the end of the implementation of Stages P-02 and P-01 – monitoring of data integrity and monitoring of data quality, correspondingly.

The third phase of the Roadmap is in a greater or lesser degree an administrative one; it defines the formation of an interaction system among the suppliers and users of aeronautical information. It also involves the organization of a system for expeditious updating of geoinformation, which again has to be performed by geodesists and cartographers.

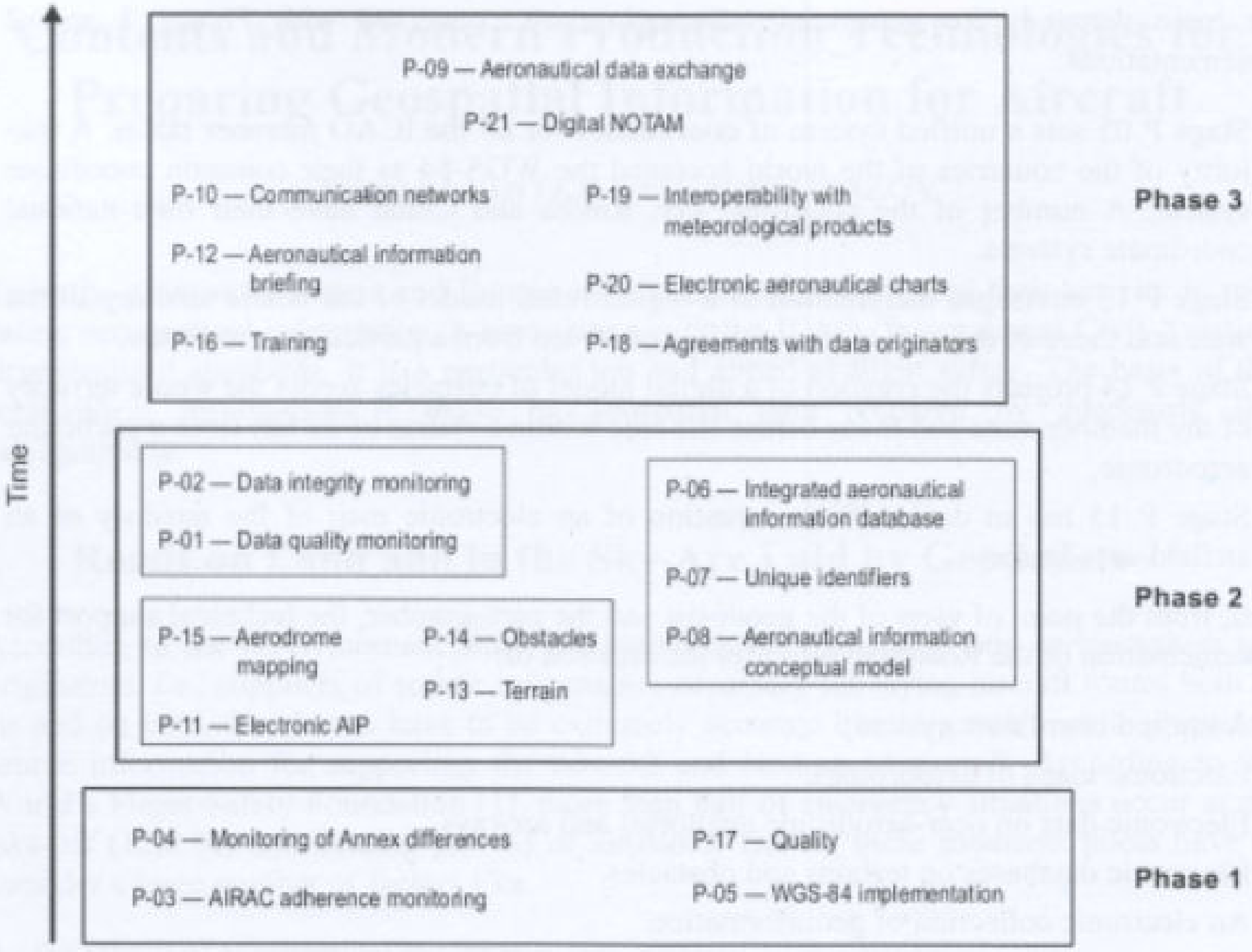

Fig. 1: Phases and stages of preparation of the aeronautical information from provided geodata

2 One Earth – One Coordinate System – Phase 1

All Russian airports have got certain geodetic information prepared in conformity with the core documents of the 1980-90s. Today, however, it does not meet any longer modern requirements to completeness, quality, storage formats, and presentation to the user. The problem of geodetic data insufficiency have become apparent due to transition to satellite navigation systems.

Now in the world, there are available two satellite navigation systems – the GPS (Global Positioning System, of the USA) and GLONASS (Global Navigation Satellite System, of Russia).

Originally, both of them were military and closed, partially or completely, but the role of their civil application began gradually to increase. Most of the countries tend to use both the GPS, and GLONASS, which improves greatly the quality of information. Besides, the European Union (EU) and the European Space Agency (ESA) are going to put into operation the European Global Navigation Satellite System GALILEO in several years.

Earlier applied aircraft take-off and landing systems and air traffic control systems did not impose heavy demands on the accuracy of defined coordinates by navigation aids, which was making it possible not to pay attention to differences in the coordinate systems of various countries. The SK-42 Coordinate System used in Russia was confidential to a certain level of accuracy of data presentation and data were accordingly published in air navigation documents to an accuracy of tens and in some cases of hundreds of meters. With an introduction of satellite technologies, the differences between coordinate systems and approaches to information secrecy started to slow down the application of a unified aircraft navigation system. Naturally, the ICAO insisted on adopting the WGS-84 as a common coordinate system that was the most widespread among the GPS users in the world, and defined that the aeronautical information influencing flight operating safety should be completely opened.

In Russia, the PZ-90.02 (ПЗ-90.02) coordinate system underlying the functioning of GLONASS has become a national coordinate system for navigation purposes.

The total amount of geospatial information necessary for preparing data throughout the implementation of Phase 1 with corresponding accuracy characteristics and technologies for coordination is described in (3); it provides coordination of the geometrical elements of airfields (from 200 to 500 and more elements) – Fig. 2; that of scores of radio engineering installations (Fig. 3) and a few thousand artificial and natural objects that could become obstacles for an airplane. Thus, the geodesist will have to execute coordination of some thousand various elements from which aircraft traffic patterns both in the sky and on land are calculated. The basis of measurement technology is classical geodesy with application of satellite receivers, total stations, leveling instruments, and magnetic surveying compasses, and other devices.

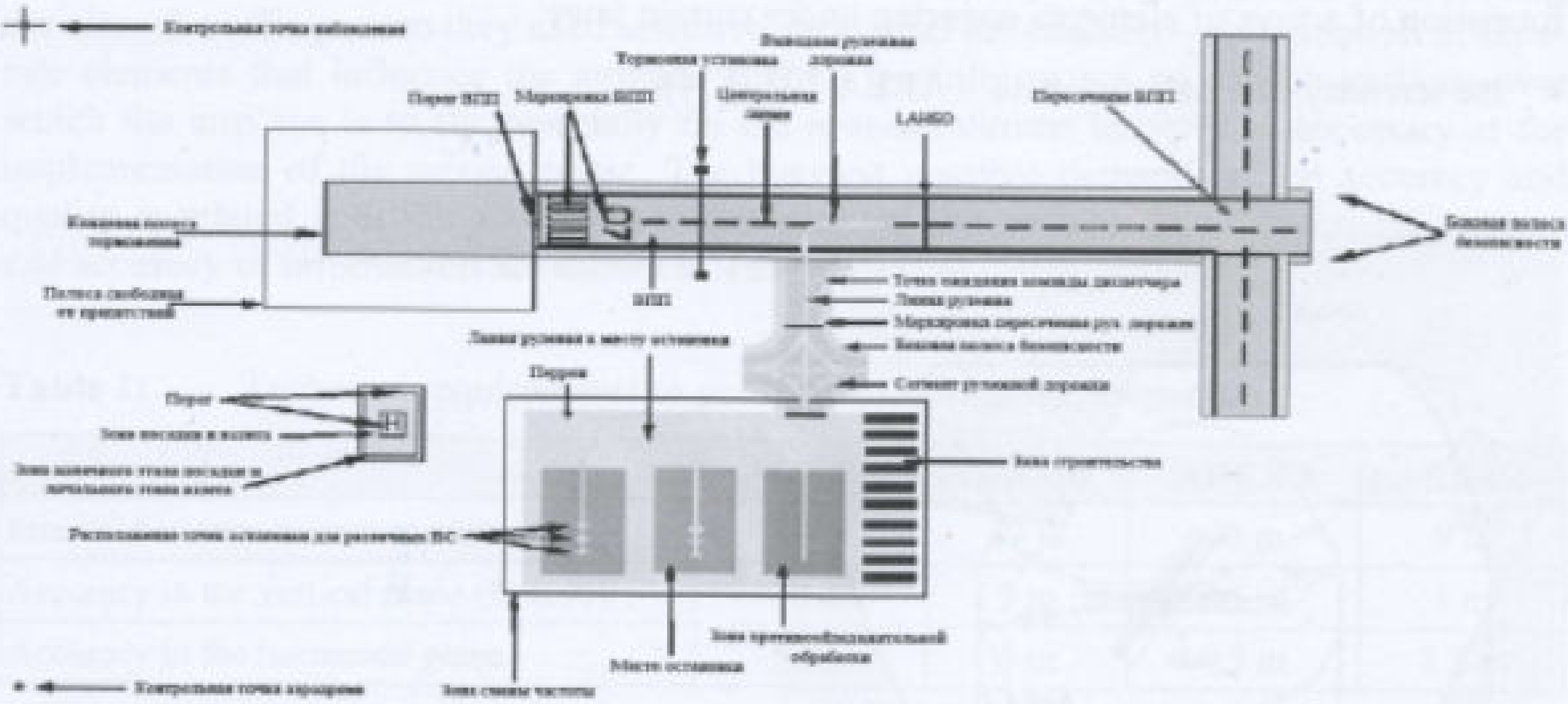

Fig. 2: A portion of geometrical elements of an airfield subject to coordination

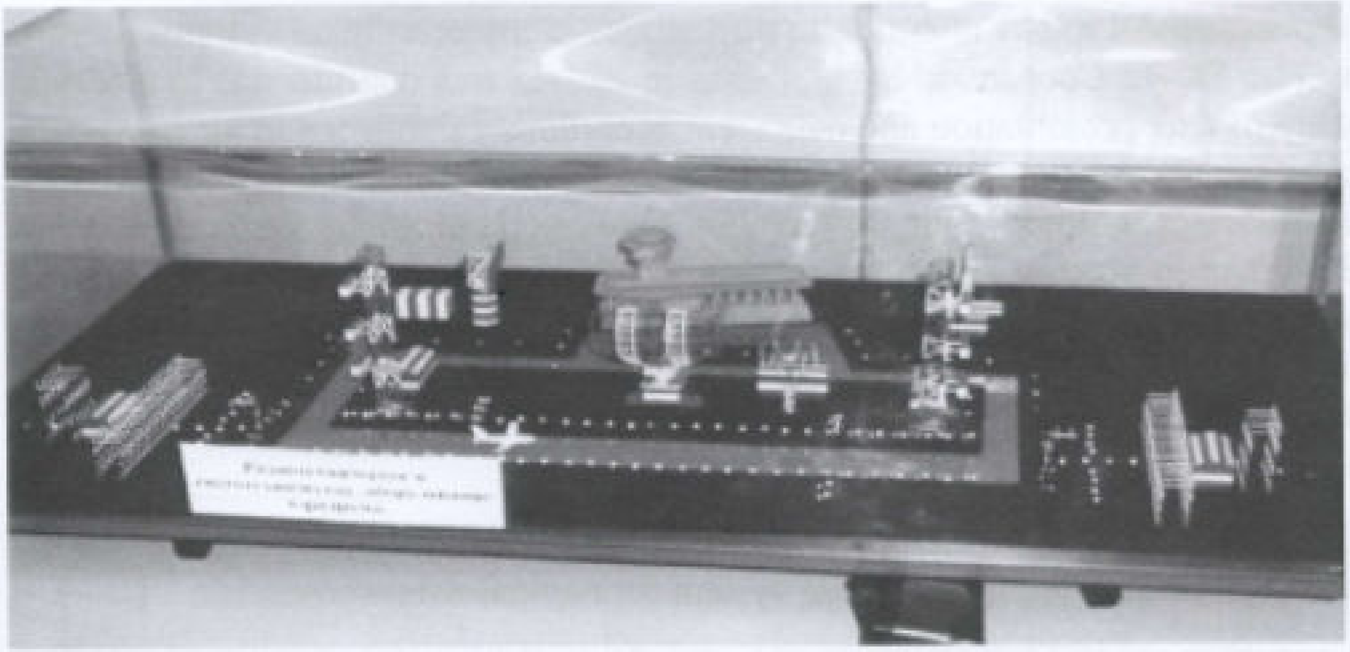

Fig. 3: Radio aids supporting the airplane take-off and landing subject to coordination

3 The Earth and the Airfield in a Digital Form – Phase 2

The implementation of the second phase of the Roadmap imposes considerably heavier demands on the volume and quality of aeronautical information and, accordingly, on its basis, i.e. on geodetic and cartographical data. If with the first phase, the total amount of geospatial data was thousands of elements, in the second phase it will be tens of millions of elements. Transition is being carried out from coordination of separate elements to formation of arrays of elements covering under certain laws:

- the territory of a national state – AREA 1 (Fig. 4),

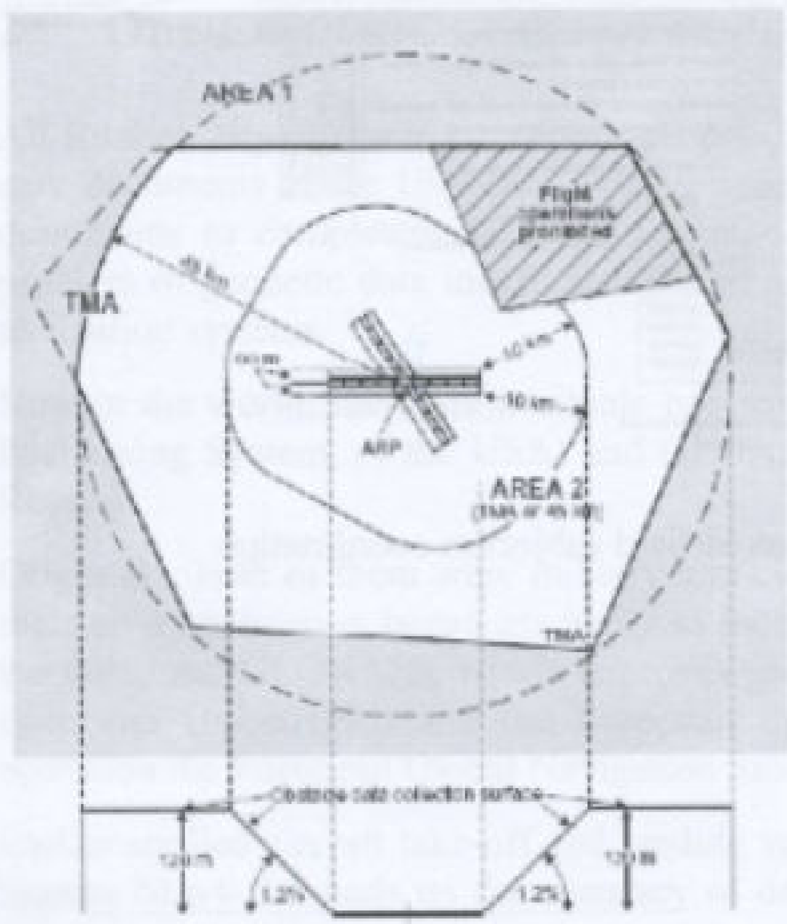

Fig. 4:
Areas 1 and 2 of geospatial information preparation

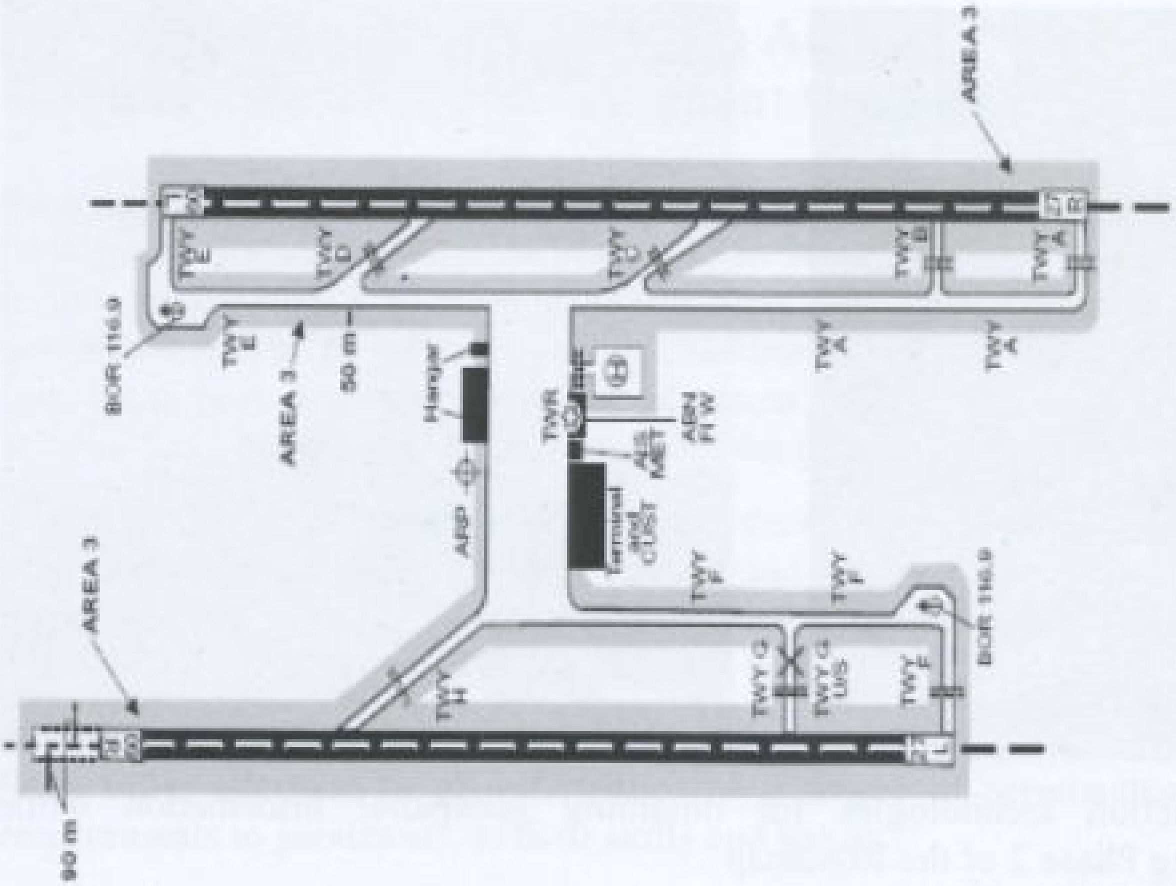

Fig. 5: Areas 3 and 4 of geospatial information preparation

- the territory of a circle of a radius of 45 km from aerodromes – AREA 2 (Fig. 4),
- portions of the airfield AREA 3 and AREA 4 (Fig. 5).

Now, requirements on the information volume have radically changed. If earlier for making the aircraft traffic pattern they used selective geospatial information – coordination of separate elements that influence the airplane flight – geoinformation on all the territory over which the airplane is to fly especially on the near-aerodrome territory is necessary at the implementation of the second phase. The heaviest possible demand on the accuracy and quality is related with the geospatial information on the airfield. The data on the volume and accuracy of information are shown in Table 1.

Table 1: Technical requirements to geospatial information preparation

	AREA 1	AREA 2	AREA 3	AREA 4
Interval between measurements	90 m	30 m	20 m	9 m
Accuracy in the vertical plane (P=0.90)	30 m	3 m	0.5 m	1 m
Accuracy in the horizontal plane	50 m	5 m	0.5 m	2.5 m

A great volume of needed information (only for AREA 2 it is necessary over 7 million values of coordinate axes) necessitates changing the approach to the data acquisition technology. With such a huge information volume the method of remote sensing of the relief and obstacles is becoming dominant. Aerial surveying, laser scanning and use of satellite stereo images of high resolution are regarded to be the basic production technologies (Fig. 6). These technologies in combination with materials of classical geodesy are sure to provide us with the required accuracy and quality of geospatial information.

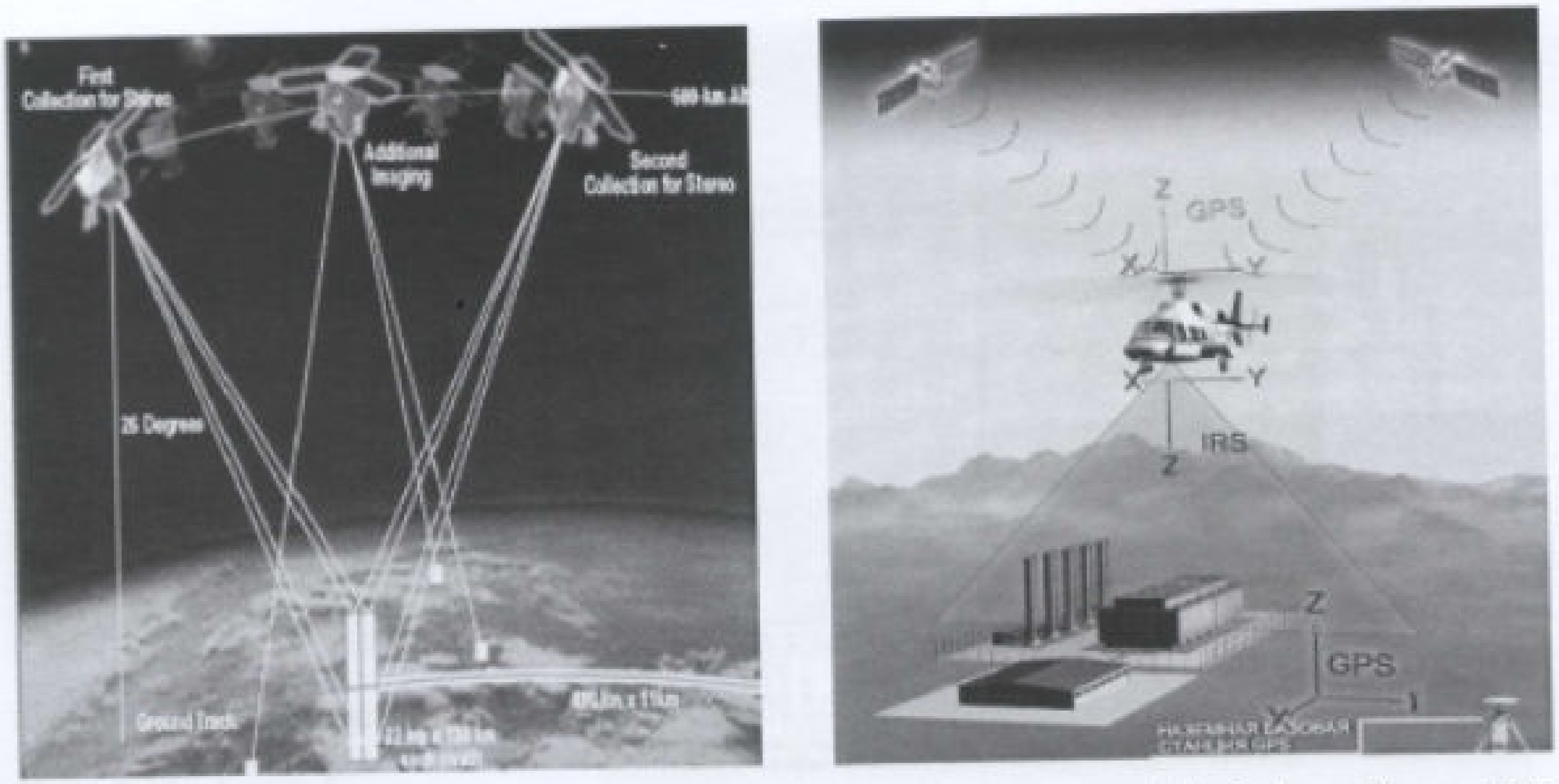

Fig. 6: Basic production technologies for obtaining geospatial information while implementing Phase 2 of the Roadmap

In most European countries, – judging from available information on France, Germany, Italy, – the laser scanning technology is applied as the basic production technology for data collecting. As for Russia with its vast territory, a combination of production technologies will be applied most likely, depending on the available information. As of today, the technology for using IKONOS, WORLDVIEW2, and GEOEYE stereo images of high resolution has been tested in the combination with classical geodesy. A number of man-made objects such as masts in the airfield cannot be identified be any remote sensing technology alone, but the method has provided a 2 m accuracy in generating digital models.

Fig. 7: Digital model of the Sochi aerodrome territory (s. auch Farbtafel 19, S. 327)

4 Geodesists for Maintaining Aerodromes Are to Be Selected like the Dentist for a Person: Only once and for Life

Back in the old days, geodetic types of work in the aerodrome (concerning the matter of preparing aeronautical information) were in some way one-time actions: geodata in conformity with national aviation standards were to be updated once every 3-5 years. Today, new requirements to relevant geodetic information are continuously being issued. Therefore, the airport, as a rule, invites the geodesist for life rather than for a temporary job, he or she will have much work to do throughout the period the airport complex operates.

Aeronautical engineering is changing and, thus, the demands posed on the information that it serves are changing. Changes on the ground that could go without any attention for long periods earlier, need to be taken into account actually as soon as they appeared. Application of aircraft computer-aided control systems both in air and in the airfield territory promotes the increase of requirements to the information actuality, its accuracy and integrity.

Such fuller attention to geoinformatics as a source of aeronautical data explains severe requirements to geodesists, to their skills and habits.

5 Scheduled Geodetic Service

It is worth mentioning one more thing. Aviation and air navigation are fast developing. New requirements to geoinformation are developing apace with them; they are set by both national developers and users of aeronautical data and by international structures represented by ICAO and Eurocontrol. Many changes can be foreseen, but in order to do that it is important to see all the phases and stages of the Roadmap as a whole, in their interconnection rather than separate periods. The output of each stage is the start of the next one. The Roadmap stages define also standard communication protocols. In the absence of the legalized national standards the ICAO and/or Eurocontrol unified international standards should be applied.

In what way should we timely consider new requirements to geoinformation and above all take steps to ensure their implementation? As practice shows, today it is advantageous for airports to conclude contracts on continuous scheduled geodetic service beginning with collecting, storing, updating and presenting data in required formats and ending with their correcting and adjusting at the change of the international and national standards.

References

BIZINVEST – Business Investment Fund. http://www.bizinvest.ru/ (e-mail: info@bizinvest.ru, phone: +7(095) 778-81-12).

ROADMAP FOR THE TRANSITION FROM AIS TO AIM. ICAO – 2009; Aeronautical Information Management.

WGS 84 IMPLEMENTATION MANUAL. Version 2.4. February 12, 1998.