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Evaluation of the Impact of the Time Synchronization Accuracy of Multistatic Radar Positions on Errors in Determining the Spatial Coordinates of Aerial Objects

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Abstract—A method for evaluating the impact of the time synchronization accuracy of multistatic radar positions on errors in determining the spatial coordinates of aerial objects has been proposed. The investigation of the influence of the characteristics of time references and their synchronization methods on the size of spatial uncertainty zones of object position for multistatic radars in the "delta" and "three-rayed star" configurations was carried out by using the developed models and the method of statistical simulation modeling. The above investigation involved the use of the time-of-arrival and time-difference-of arrival techniques of coordinate determination.

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PROBLEM STATEMENT, ANALYSIS OF RECENT INVESTIGATIONS AND PUBLICATIONS

Steadily rising requirements to the main characteristics of radars and the quality of radar data (RD) used in positioning systems of space objects, air traffic control, and the weapons control systems have determined the development of multistatic radars and systems (MSRS) [1–4].

The intensive development of such systems is also related to advances in science and technology that provide capabilities for their technical implementation. In this context the advances in the field of high-accuracy synchronization and timekeeping systems play an important part. The specified systems are required for time synchronization of the spaced-apart positions of MSRS and also for the precise binding of obtained RD to the unified (system) time scale [3].

The time synchronization of MSRS positions is required for organizing the data co-processing and air surveillance control and also in a number of cases for determining the spatial coordinates of aerial objects (AO) by the time-of-arrival (elliptical) and time-difference-of-arrival (hyperbolical) localization techniques ensuring high accuracy characteristics of RD [1–4]. In addition, the binding of the obtained RD to a unified time scale enables us to combine the correlation and the timekeeping methods of measuring time parameters of signals.

The relative instability of time references achieved up to date amounts to 1×10^{-15} s, and the methods of time synchronization are available that ensure the accuracy of matching the time scales equal to 10×10^{-12} s [5, 6]. However, the creation of MSRS often involves the need of taking into account a series of the operational, weight-and-dimensional, economic, and other restrictions that do not allow us to apply the above mentioned elements of the synchronization system with the highest characteristics. That is why it is necessary to investigate their influence on the MSRS characteristics.

The issues of time synchronization of MSRS are partially discussed in papers [1–4, 7–9].

As noted in papers [1–4], the time synchronization accuracy influences the errors of determining the sum and difference of ranges; the specified papers also indicate certain synchronization methods suitable for application.

Papers [7, 8] consider the issue of time synchronization of bistatic radars that can be viewed as an element of MSRS [3]. A criterion is proposed for choosing the time references depending on the admissible value of the time scale discrepancy between the positions and the period of synchronization that does not take into account the accuracy of the applied method of time synchronization. The specified papers do not mention the criteria or methods enabling us to determine an admissible value of the time scale discrepancy.