

Estimation of the Spatial Coordinates of Air Objects in Synchronous Radar Networks for Airspace Observation

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Abstract—In the presented work, a study was made of the influence of errors in assessing the location of receiving points of a multi-position radar system, as well as mismatch of time scales of points for receiving signals of a multi-position radar system, due to the finite stability of time generators in the considered synchronous information radar network for observing airspace, on the accuracy of assessing the location of observed air objects. This showed the possibility of implementing synchronous radar networks for observing the airspace on the basis of the existing fleet of primary and secondary radars.

Keywords—multi-position radar system (MPRS), air object (AO), data processing (DP), airspace control systems (ACS), air traffic control (ATC).

REFERENCES

- [1] Armed Forces of the United States, "Joint Airspace Control. Joint Publication 3-52", United States. Joint Chiefs of Staff, 2014.
- [2] S. Kingsley and S. Quegan, *Understanding radar systems*. SciTesh Publishing, Inc. Raleigh, 1999, p. 375.
- [3] M. Skolnik, "Improvements for air-surveillance radar," *Proceedings of the 1999 IEEE Radar Conference. Radar into the Next Millennium (Cat. No.99CH36249)*, 1999, pp. 18-21, doi: 10.1109/NRC.1999.767195.
- [4] I. Obod, I. Svyd, O. Maltsev, G. Zavolodko and D. Pavlova, "Optimization of Data Processing of Primary Radar Systems," *2020 IEEE 40th International Conference on Electronics and Nanotechnology (ELNANO)*, 2020, pp. 757-760, doi: 10.1109/ELNANO50318.2020.9088842.
- [5] I. Tsikin and E. Poklonskaya, "Secondary Surveillance Radar Signals Processing at the Remote Analysis Station", *St. Petersburg State Polytechnical University Journal. Computer Science, Telecommunications and Control Systems*, vol. 10, no. 2, pp. 58-74, 2017. doi: 10.18721/JCSTCS.10205.
- [6] I. Svyd, I. Obod, O. Maltsev and G. Zavolodko, "Optimizing Airborne Object Detection of Secondary Surveillance Radar in Intra-System Interference Conditions," *2021 IEEE 16th International Conference on the Experience of Designing and Application of CAD Systems (CADSM)*, 2021, pp. 33-37, doi: 10.1109/CADSM52681.2021.9385224.
- [7] Á. Jarama, J. López-Araquistain, G. Miguel and J. Besada, "Complete Systematic Error Model of SSR for Sensor Registration in ATC Surveillance Networks", *Sensors*, vol. 17, no. 10, p. 2171, 2017. doi: 10.3390/s17102171.
- [8] V. Chernyak, *Fundamentals of Multisite Radar Systems: Multistatic Radars and Multistatic Radar Systems*. Gordon and Breach Science Publishers, CRC Press, 1998.
- [9] S. Zhao, L. Zhang, Y. Zhou and N. Liu, "Signal Fusion-Based Algorithms to Discriminate Between Radar Targets and Deception Jamming in Distributed Multiple-Radar Architectures," in *IEEE Sensors Journal*, vol. 15, no. 11, pp. 6697-6706, Nov. 2015, doi: 10.1109/JSEN.2015.2440769.
- [10] A. Hume and C. Baker, "Netted radar sensing," *2001 CIE International Conference on Radar Proceedings (Cat No.01TH8559)*, 2001, pp. 110-114, doi: 10.1109/ICR.2001.984634.
- [11] N. Willis and H. Griffiths, *Advances in bistatic radar*. Raleigh, N.C.: Scitech Publishing, 2007, p. 522.
- [12] D. Zaitsev, *Multi-position radar systems. Methods and algorithms for information processing in conditions of interference*. Moscow: Radiotekhnika, 2007, p. 114.
- [13] S. Cohen, T. Gluck, Y. Elovici and A. Shabtai, "Security Analysis of Radar Systems", *Proceedings of the ACM Workshop on Cyber-Physical Systems Security & Privacy - CPS-SPC'19*, pp. 3-14, 2019. doi: 10.1145/3338499.3357363.
- [14] I. Svyd, I. Obod, O. Maltsev, O. Strelnytskyi, O. Zubkov and G. Zavolodko, "Method of Increasing the Identification Friend or Foe Systems Information Security," *2019 3rd International Conference on Advanced Information and Communications Technologies (AICT)*, 2019, pp. 434-438, doi: 10.1109/AICT.2019.8847853.
- [15] Z. Cao and L. Chen, "Security in application layer of radar sensor networks: detect friends or foe", *Security and Communication Networks*, vol. 8, no. 16, pp. 2712-2722, 2012. doi: 10.1002/sec.572.
- [16] I. Svyd, I. Obod, O. Maltsev and A. Hlushchenko, "Secondary Surveillance Radar Response Channel Information Security Improvement Method," *2020 IEEE 11th International Conference on Dependable Systems, Services and Technologies (DESSERT)*, 2020, pp. 341-345, doi: 10.1109/DESSERT50317.2020.9125018.

- [17] I. Svyd, I. Obod, O. Maltsev, O. Vorgul, G. Zabolodko and A. Goriushkina, "Noise Immunity of Data Transfer Channels in Cooperative Observation Systems: Comparative Analysis," *2018 International Scientific-Practical Conference Problems of Infocommunications. Science and Technology (PIC S&T)*, 2018, pp. 509-512, doi: 10.1109/INFOCOMMST.2018.8632019.
- [18] M. Greco, P. Stinco, F. Gini, A. Farina and M. Rangaswamy, "Cramér-Rao bounds and TX-RX selection in a multistatic radar scenario," *2010 IEEE Radar Conference*, 2010, pp. 1371-1376, doi: 10.1109/RADAR.2010.5494404.
- [19] L. Zhang, R. Yang and X. Guan, "A novel nonlinear multisensor multitarget tracking algorithm," *IET 3rd International Conference on Wireless, Mobile and Multimedia Networks (ICWMNN 2010)*, 2010, pp. 277-281, doi: 10.1049/cp.2010.0670.
- [20] I. Svyd, I. Obod, O. Maltsev, I. Shtykh and G. Zabolodko, "Model and Method for Detecting Request Signals in Identification Friend or Foe Systems," *2019 IEEE 15th International Conference on the Experience of Designing and Application of CAD Systems (CADSM)*, 2019, pp. 1-4, doi: 10.1109/CADSM.2019.8779322.
- [21] P. Stoica and J. Li, *MIMO radar signal processing*. Wiley-IEEE Press, 2008, p. 448.
- [22] X. Li and J. Du, "Performance optimization algorithm of radar signal processing system", *Cluster Computing*, vol. 20, no. 1, pp. 359-370, 2016. doi: 10.1007/s10586-016-0710-6.
- [23] O. Romanov, M. Oryschuk and Y. Hordashnyk, "Computing of influence of stimulated Raman scattering in DWDM telecommunication systems," *2016 International Conference Radio Electronics & Info Communications (UkrMiCo)*, 2016, pp. 1-4, doi: 10.1109/UkrMiCo.2016.7739622.
- [24] D. Pavlova, G. Zabolodko, I. Obod, I. Svyd, O. Maltsev and L. Saikivska, "Optimizing Data Processing in Information Networks of Airspace Surveillance Systems," *2019 10th International Conference on Dependable Systems, Services and Technologies (DESSERT)*, 2019, pp. 136-139, doi: 10.1109/DESSERT.2019.8770022.
- [25] J. Besada, G. de Miguel, A. Bernardos and J. Casar, "Generic multisensor multitarget bias estimation architecture", *IET Radar Sonar & Navigation*, vol. 6, no. 5, p. 365, 2012. doi: 10.1049/iet-rsn.2011.0183.
- [26] I. Obod, "Integrated Coordinate-and-Time Support for the Address Inquiry in the Secondary Radar Systems", *Telecommunications and Radio Engineering*, vol. 53, no. 3, pp. 54-56, 1999. doi: 10.1615/telecomradeng.v53.i3.100.
- [27] O. Romanov, D. Fediushyna and T. Dong, "Model And Method Of Li-Fi Network Calculation With Multipath Light Signals," *2018 International Conference on Information and Telecommunication Technologies and Radio Electronics (UkrMiCo)*, 2018, pp. 1-4, doi: 10.1109/UkrMiCo43733.2018.9047550.
- [28] I. Obod, I. Svyd, O. Maltsev, G. Zabolodko and D. Pavlova, "Evaluation of Measuring Accuracy of the Airborne Object Azimuth when Fusion the Primary Data Radar Observation Systems," *2020 IEEE 15th International Conference on Advanced Trends in Radioelectronics, Telecommunications and Computer Engineering (TCSET)*, 2020, pp. 644-648, doi: 10.1109/TCSET49122.2020.235511.
- [29] I. Obod, I. Svyd, O. Maltsev, G. Zabolodko, D. Pavlova and G. Maistrenko, "Fusion the Coordinate Data of Airborne Objects in the Networks of Surveillance Radar Observation Systems", *Data-Centric Business and Applications*, pp. 731-746, 2020. doi: 10.1007/978-3-030-43070-2_31.
- [30] L. Globa, M. Skulysh, O. Romanov and M. Nesterenko, "Quality Control for Mobile Communication Management Services in Hybrid Environment", *Lecture Notes in Electrical Engineering*, pp. 76-100, 2019. doi: 10.1007/978-3-030-16770-7_4.
- [31] O. Romanov and V. Mankivskiyi, "Optimal Traffic Distribution Based on the Sectoral Model of Loading Network Elements," *2019 IEEE International Scientific-Practical Conference Problems of Infocommunications, Science and Technology (PIC S&T)*, 2019, pp. 683-688, doi: 10.1109/PICST47496.2019.9061296.
- [32] M. Thomas and H. Buchanan, "The Need for Battle Managers in the Tactical Air Control System", *Air Power Journal*, vol. Summer, 1987.