Evaluation of the Responder Capacity of the Indication Channel of Near Navigation Radio Systems

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***Abstract*—In this work, the capacity of the transponders of the indication channel of short-range navigation systems is estimated under the action of intra-system and intentional correlated and uncorrelated interference in the request channel, based on the presentation of the indication channel of short-range navigation systems as an open single-channel queuing system with failures. It is shown that the implementation of time gating of the incoming signals "indication request" with a time gate for receiving the response signals of the range of radio beacons can reduce the intensity of the formation of response signals and, as a result, increase the throughput of the indication channel.**

Keywords—short-range navigation radio systems, Distance Measuring Equipment (DME), indication channel, secondary surveillance radars (SSR), Identification Identify Friend or Foe (IFF), throughput.

REFERENCES

[1] M. Stevens, D. Pompairac and N. Millet, "Multi-Static Primary Surveillance Radar assessment", *2014 International Radar Conference*, 2014, pp. 1-6, DOI: https://doi.org/10.1109/RADAR.2014.7060357.

[2] I. Obod, I. Svyd, O. Maltsev and B. Bakumenko, "Spatial Methods for Increasing the Bandwidth of a Mobile Information Network", *2020 IEEE 15th International Conference on Advanced Trends in Radioelectronics, Telecommunications and Computer Engineering (TCSET)*, 2020, pp. 50-54, DOI: https://doi.org/10.1109/TCSET49122.2020.235388.

[3] D. Pavlova, G. Zavolodko, I. Obod, I. Svyd, O. Maltsev and L. Saikivska, "Comparative Analysis of Data Consolidation in Surveillance Networks", *2019 10th International Conference on Dependable Systems, Services and Technologies (DESSERT)*, 2019, pp. 140-143, DOI: https://doi.org/10.1109/DESSERT.2019.8770008.

[4] G. Jiang, Y. Fan and H. Yuan, "Assessing the Capacity of Air Traffic Control Secondary Surveillance Radar System", *2019 Cross Strait Quad-Regional Radio Science and Wireless Technology Conference (CSQRWC)*, 2019, pp. 1-3, DOI: https://doi.org/10.1109/CSQRWC.2019.8799146.

[5] V. Semenets, I. Svyd, I. Obod, O. Maltsev and M. Tkach, "Quality Assessment of Measuring the Coordinates of Airborne Objects with a Secondary Surveillance Radar", *Data-Centric Business and Applications*, 2021, pp. 105-125, DOI: https://doi.org/10.1007/978-3-030-71892-3_5.

[6] X. Du, K. Liao and X. Shen, "Secondary Radar Signal Processing Based on Deep Residual Separable Neural Network", *2020 IEEE International Conference on Power, Intelligent Computing and Systems (ICPICS)*, 2020, pp. 12-16, DOI: https://doi.org/10.1109/ICPICS50287.2020.9202372.

[7] I. Svyd, I. Obod, O. Maltsev, G. Maistrenko, G. Zavolodko and D. Pavlova, "Fusion of Airspace Surveillance Systems Data", *2019 3rd International Conference on Advanced Information and Communications Technologies (AICT)*, 2019, pp. 430-433, DOI: https://doi.org/10.1109/AIACT.2019.8847916.

[8] I. Svyd, I. Obod, O. Maltsev, O. Vorgul, G. Zavolodko 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*, 2018, pp. 509-512, DOI: https://doi.org/10.1109/INFOCOMMST.2018.8632019.

[9] X. Du, K. Liao and X. Shen, "Secondary Radar Signal Processing Based on Deep Residual Separable Neural Network", *2020 IEEE International Conference on Power, Intelligent Computing and Systems (ICPICS)*, 2020, pp. 12-16, DOI: https://doi.org/10.1109/ICPICS50287.2020.9202372.

[10] I. Obod, I. Svyd, O. Maltsev and B. Bakumenko, "Comparative Analysis of Noise Immunity Systems Identification Friend or Foe", *2020 IEEE 40th International Conference on Electronics and Nanotechnology (ELNANO)*, 2020, pp. 751-756, DOI: https://doi.org/10.1109/ELNANO50318.2020.9088856.

[11] C. Reck, U. Berold and L. Schmidt, "Detection of SSR signals in multipath airport environments by a multichannel receiver," *2010 Asia-Pacific Microwave Conference*, 2010, pp. 1685-1688.

[12] I. Svyd, I. Obod, O. Maltsev, I. Shtykh and G. Zavolodko, "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: https://doi.org/10.1109/CADSM.2019.8779322.

[13] AIMS 03-1000B, Technical Standard for the ATCRBS/IFF/MARK XIIA Electronic Identification System and Military Implementation of Mode S, 25 January 2013.

[14] I. Obod, I. Svyd, O. Maltsev and S. Starokozhev, "The Effect of Masking Interference on the Quality of Request Signal Detection in Aircraft Responders of the Identification Friend or Foe Systems", *2020 IEEE International Conference on Problems of Infocommunications. Science and Technology (PIC S&T)*, 2020, pp. 721-726, DOI: https://doi.org/10.1109/PICST51311.2020.9467955.

[15] A. Strelnitskiy, V. Shokalo, E. Yagudina and M. Abdul-Hussein, "Method of calculating the detection zone boundaries of the Rayleigh Wi-Fi wireless channel with quasi-static fading", *Radioelectronics and Communications Systems*, vol. 55, no. 10, pp. 452-457, 2012. DOI: https://doi.org/10.3103/s0735272712100032.

[16] Steingass, A., "Analysis of DME/TACAN Interference on the Lower L-Band," *Proceedings of the 26th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2013)*, Nashville, TN, September 2013, pp. 3409-3416.

[17] I. Svyd, I. Obod, O. Maltsev, O. Vorgul, I. Vorgul and I. Shevtsov, "Method for Increasing the Interference Immunity of the Channel for Measuring of the Short-Range Navigation Radio System", *2022 IEEE 16th International Conference on Advanced Trends in Radioelectronics, Telecommunications and Computer Engineering (TCSET)*, 2022, pp. 802-807, DOI: https://doi.org/10.1109/TCSET55632.2022.9767069.

[18] J. Guo and X. Zhang, "DME pulse interference mitigation for airborne BDS and flight test results", *Advances in Space Research*, vol. 63, no. 9, 2019, pp. 3043-3052, DOI: https://doi.org/10.1016/j.asr.2018.05.012.

[19] G. Jiang and Y. Fan, "A Method for Analyzing the Impact of Intra-System and Inter-System Interference on DME Based on Queueing Theory", *Sensors*, vol. 19, no. 2, 2019, p. 348, DOI: https://doi.org/10.3390/s19020348.

[20] Lilley R., Robert E. DME/DME for Alternative Position, Navigation, and Timing (APNT) Federal Aviation Administration; Washington, DC, USA: 2012. APNT White Paper.

[21] I. Svyd, I. Obod and O. Maltsev, "Interference Immunity Assessment Identification Friend or Foe Systems", *Data-Centric Business and Applications*, 2021, pp. 287-306, DOI: https://doi.org/10.1007/978-3-030-71892-3_12.

[22] M. K. Abdul-Hussein, O. Strelnytskyi, I. Obod, I. Svyd and H. Alrikabi, "Evaluation of the Interference's Impact of Cooperative Surveillance Systems Signals Processing for Healthcare", *International Journal of Online and Biomedical Engineering (iJOE)*, vol. 18, no. 03, 2022, pp. 43-59, DOI: https://doi.org/10.3991/IJOE.v18i03.28015.

[23] E. Kim, "Analysis of DME/DME Navigation Performance and Ground Network Using Stretched-Front-Leg Pulse-Based DME", *Sensors*, vol. 18, no. 10, 2018, p. 3275, DOI: https://doi.org/10.3390/s18103275.

[24] A. Wolff, D. Akos and S. Lo, "Potential radio frequency interference with the GPS L5 band for radio occultation measurements", *Atmospheric Measurement Techniques*, vol. 7, no. 11, 2014, pp. 3801-3811, DOI: https://doi.org/10.5194/amt-7-3801-2014.

[25] W. Hawthorne and L. Daugherty, "VOR/DME/TACAN frequency technology", *IEEE Transactions on Aerospace and Navigational Electronics*, vol. 12, no. 1, 1965, pp. 11-15, DOI: https://doi.org/10.1109/TANE.1965.6592227.

[26] G. Jiang and Y. Fan, "A Method for Analyzing the Impact of Intra-System and Inter-System Interference on DME Based on Queueing Theory", *Sensors*, vol. 19, no. 2, 2019, p. 348, DOI: https://doi.org/10.3390/s19020348.

[27] I. Obod, I. Svyd, O. Maltsev, O. Vorgul, G. Maistrenko and G. Zavolodko, "Optimization of the Quality of Information Support for Consumers of Cooperative Surveillance Systems", *Data-Centric Business and Applications*, 2020, pp. 133-155, DOI: https://doi.org/10.1007/978-3-030-43070-2_8.

[28] W. Kim, S. Jung, Y. Lee and S. Chang, "Mark XIIA(Mode 5) IFF System Integration and Certification Test for Surface to Air Missile System", *Journal of the Korea Institute of Military Science and Technology*, vol. 25, no. 2, 2022, pp. 160-168, DOI: https://doi.org/10.9766/kimst.2022.25.2.160.

[29] Steingass, A., "Analysis of DME/TACAN Interference on the Lower L-Band," *Proceedings of the 26th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2013)*, Nashville, TN, September 2013, pp. 3409-3416.

[30] 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: https://doi.org/10.1109/DESSERT50317.2020.9125018.

[31] I. Svyd, I. Obod, O. Maltsev, V. Andrusevich, B. Bakumenko and O. Vorgul, "Optimal Measurement of Signal Data Parameters of Requesting Radar Systems", *2021 IEEE 3rd Ukraine Conference on Electrical and Computer Engineering (UKRCON)*, 2021, pp. 138-141, DOI: https://doi.org/10.1109/UKRCON53503.2021.9575235.

[32] I. Svyd, I. Obod, O. Maltsev, O. Vorgul, V. Chumak and A. Sierikov, "Analysis of the Impact of Interference on the Time Position of Signals in Requesting Airspace Observation Systems", *2021 IEEE 8th International Conference on Problems of Infocommunications, Science and Technology (PIC S&T)*, 2021, pp. 470-474, DOI: https://doi.org/10.1109/PICST54195.2021.9772138.

[33] R. Morales-Ferre, P. Richter, E. Falletti, A. de la Fuente and E. Lohan, "A Survey on Coping With Intentional Interference in Satellite Navigation for Manned and Unmanned Aircraft", *IEEE Communications Surveys & Tutorials*, vol. 22, no. 1, pp. 249-291, 2020. DOI: https://doi.org/10.1109/comst.2019.2949178.

[34] E. Kim and J. Seo, "SFOL Pulse: A High Accuracy DME Pulse for Alternative Aircraft Position and Navigation", *Sensors*, vol. 17, no. 10, 2017, p. 2183, DOI: https://doi.org/10.3390/s17102183.

[35] O. Strelnytskyi, I. Svyd, I. Obod, O. Maltsev, O. Voloshchuk and G. Zavolodko, "Assessment Reliability of Data in the Identification Friend or Foe Systems", *2019 IEEE 39th International Conference on Electronics and Nanotechnology (ELNANO)*, 2019, pp. 728-731, DOI: https://doi.org/10.1109/ELNANO.2019.8783397.

[36] I. Obod, I. Svyd, O. Vorgul, O. Maltsev, O. Datsenko and N. Boiko, "Optimization of Data Processing Structure for Multi-Position Radar Surveillance Systems", *2021 IEEE 3rd Ukraine Conference on Electrical and Computer Engineering (UKRCON)*, 2021, pp. 133-137, DOI: https://doi.org/10.1109/UKRCON53503.2021.9575286.

[37] I. Obod, I. Svyd, O. Maltsev, G. Maistrenko, O. Zubkov and G. Zavolodko, "Bandwidth Assessment of Cooperative Surveillance Systems", *2019 3rd International Conference on Advanced Information and Communications Technologies (AICT)*, 2019, pp. 1-6, DOI: https://doi.org/10.1109/AIACT.2019.8847742.