

# Interference Immunity Assessment Identification Friend or Foe Systems

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**Abstract.** In the work, based on the consideration of the place and role of Identification friend or foe (IFF) systems in the airspace control system, it is shown that the principle of building modern IFF systems in the form of an asynchronous network for transmitting request and response signals and the implementation of the principle of servicing request signals based on an open single-channel queuing system with refuses, as well as the use of primitive coding of request signals and response signals do not allow an acceptable level of information support for the air control space and air traffic control in conditions of significant intensities of intra-systemic, as well as deliberate correlated and uncorrelated interference. A general description of the considering information systems is given and a brief description of the signals used in IFF systems is given. Based on the presentation of IFF systems in the form of two-channel systems for transmitting request and response signals, the noise immunity of aircraft re-sponders is evaluated under the action of request signals and intentional as well as unintended (intrasystem), correlated and uncorrelated interference in the request channel, which made it possible to evaluate the noise immunity of the entire IFF system in the form estimates of the probability of detection of airborne objects by the considering system.

**Keywords:** Identification Friend or Foe, Aircraft Responder, Request Signal, Chaotic Impulse Noise, Air Object.

[https://link.springer.com/chapter/10.1007%2F978-3-030-71892-3\\_12](https://link.springer.com/chapter/10.1007%2F978-3-030-71892-3_12)

[https://doi.org/10.1007/978-3-030-71892-3\\_12](https://doi.org/10.1007/978-3-030-71892-3_12)

## References

1. Stevens, B., Lewis, F. and Johnson, E. (2016). *Aircraft Control and Simulation: Dynamics, Controls Design, and Autonomous*. John Wiley & Sons.
2. Air Force Doctrine Annex 3-52 Airspace Control. (2012) CreateSpace Independent Publishing Platform (October 26, 2012).
3. Air Force Doctrine Annex 3-52 Airspace Control. (2019) Independently published (September 30, 2019).
4. Bruckbauer, B. (2004) *The Airspace Control System- A Key To Operational Maneuver*. Newport, Rhode Island: Naval war coll newport ri joint military operations dept.
5. Buchanan, T. (1987) *Hetactical Air Control System: Its Evolution And Its Need For Battle Managers*. Research Report No. AU-ARI-87-1. Maxwell AFB, AL: Air University Press.
6. Bloisi, D., Iocchi, L., Nardi, D., Fiorini, M. and Graziano, G. (2012) Ground traffic surveillance system for Air Traffic control. 2012 12th International Conference on ITS Telecommunications, doi: 10.1109/ITST.2012.6425151.
7. Stevens, M. (1988). *Secondary Surveillance Radar*. Norwood: Artech House.
8. NATO. (2016) STANAG 4193 PT III. *Technical Characteristics Of IFF MK XA And MK XII Interrogators And Transponders. Part III: Installed System Characteristics*, 23 May 2016.
9. NATO. (2008) STANAG 4193 PT IV. *Technical Characteristics Of IFF MK XA And MK XII Interrogators And Transponders. Part IV: Technical Characteristics of Mode S in Military Interrogators and Transponders*, 3 October 2008.
10. Schuck, T., Shoemaker, B. and Willey, J., n.d. (2000) Identification friend-or-foe (IFF) sensor uncertainties, ambiguities, deception and their application to the multi-source fusion process. *Proceedings of the IEEE 2000 National Aerospace and Electronics Conference. NAECON 2000. Engineering Tomorrow (Cat. No.00CH37093)*, doi: 10.1109/NAECON.2000.894896.
11. Ramasamy, S., Sabatini, R. and Gardi, A. (2016) Cooperative and non-cooperative sense-and-avoid in the CNS+A context: A unified methodology. 2016 International Conference on Unmanned Aircraft Systems (ICUAS), doi: 10.1109/ICUAS.2016.7502676.
12. Syvd, I., Obod, I., Maltsev, O., Vorgul, O., Zavalodko, G. and Goriushkina, A. (2018) Noise Immunity of Data Transfer Channels in Cooperative Observation Systems: Comparative Analysis. In 2018 International Scientific-Practical Conference Problems of Infocommunications. Science and Technology (PIC S&T). IEEE, doi: 10.1109/INFOCOMMST.2018.8632019.
13. Siergiejczyk, M., Krzykowska, K. and Rosiński, A. (2014) Reliability Assessment of Cooperation and Replacement of Surveillance Systems in Air Traffic. *Proceedings of the Ninth International Conference on Dependability and Complex Systems DepCoS-RELCOMEX. June 30 – July 4, 2014, Brunów, Poland*, doi: 10.1007/978-3-319-07013-1\_39.
14. Obod, I., Syvd, I., Maltsev, O., Vorgul, O., Maistrenko, G. and Zavalodko, G. (2018) Optimization of Data Transfer in Cooperative Surveillance Systems. In 2018 International Scientific-Practical Conference Problems of Infocommunications. Science and Technology (PIC S&T). IEEE, doi: 10.1109/INFOCOMMST.2018.8632134.
15. Syvd, I., Obod, I., Maltsev, O., Tkachova, T. and Zavalodko, G. (2019). Optimal Request Signals Detection in Cooperative Surveillance Systems. In 2019 IEEE 2nd Ukraine Conference on Electrical and Computer Engineering (UKRCON), IEEE, doi: 10.1109/UKRCON.2019.8879840.

16. Pollack, J. and Ranganatha, P. (2018) Aviation Navigation Systems Security: ADS-B, GPS, IFF. International Conference on Security & Management, SAM'18, Las Vegas, Nevada, USA.
17. Svyd, I., Obod, I., Maltsev, O., Zavolodko, G., Maistrenko, G. and Saikivska, L. (2019) Method of Enhancing Information Security of Requesting Cooperative Surveillance Systems. 2019 IEEE International Scientific-Practical Conference Problems of Infocommunications, Science and Technology (PIC S&T), doi: 10.1109/PICST47496.2019.9061366.
18. Strelnytskyi, O., Svyd, I., Obod, I., Maltsev, O., Voloshchuk, O. and Zavolodko, G. (2019) Assessment Reliability of Data in the Identification Friend or Foe Systems. 2019 IEEE 39th International Conference on Electronics and Nanotechnology (ELNANO), IEEE, doi: 10.1109/ELNANO.2019.8783397.
19. Svyd, I., Obod, I., Maltsev, O., Strelnytskyi, O., Zubkov, O. and Zavolodko, G. (2019) Method of Increasing the Identification Friend or Foe Systems Information Security. 2019 3rd International Conference on Advanced Information and Communications Technologies (AICT), IEEE, doi: 10.1109/AICT.2019.8847853.
20. Svyd, I., Obod, I., Maltsev, O., Tkachova, T. and Zavolodko, G. (2019) Improving Noise Immunity in Identification Friend or Foe Systems. 2019 IEEE 2nd Ukraine Conference on Electrical and Computer Engineering (UKRCON), IEEE, doi: 10.1109/UKRCON.2019.8879812.
21. Obod, I., Svyd, I., Maltsev, O. and Bakumenko, B. (2020) Comparative Analysis of Noise Immunity Systems Identification Friend or Foe. 2020 IEEE 40th International Conference on Electronics and Nanotechnology (ELNANO), doi: 10.1109/elnano50318.2020.9088856.
22. Yarlykov, M. and Chernyakov, M. (1979) Optimization Of Asynchronous Address Radio Communication Systems. Svyaz': Moscow.
23. Otsuyama, T., Naganawa, J., Honda, J. and Miyazaki, H. (2017) An analysis of signal environment on 1030/1090MHz aeronautical L-band systems. 2017 International Symposium on Antennas and Propagation (ISAP), doi: 10.1109/ISANP.2017.8228911.
24. Otsuyama, T., Honda, J., Naganawa, J. and Miyazaki, H. (2018) Analysis of signal environment on 1030/1090MHz aeronautical surveillance systems. 2018 IEEE International Symposium on Electromagnetic Compatibility and 2018 IEEE Asia-Pacific Symposium on Electromagnetic Compatibility (EMC/APEMC), doi: 10.1109/ISEMC.2018.8394048.
25. Piracci, E., Galati, G., Petrochilos, N. and Fiori, F. (2009) 1090 MHz channel capacity improvement in the air traffic control context. International Journal of Microwave and Wireless Technologies, 1(3), doi: 10.1017/s1759078709000191.
26. EUROCONTROL (2006) CASCADE programme: 1090 MHz Capacity Study–Final Report, edition 2.7, July 2006.
27. Chen, Y., Lo, S., Enge, P. and Jan, S. (2014) Evaluation & comparison of ranging using Universal Access Transceiver (UAT) and 1090 MHz Mode S Extended Squitter (Mode S ES). 2014 IEEE/ION Position, Location and Navigation Symposium - PLANS 2014, doi: 10.1109/PLANS.2014.6851456.
28. Li, W. and Kamal, P. (2011) Integrated aviation security for defense-in-depth of next generation air transportation system. 2011 IEEE International Conference on Technologies for Homeland Security (HST), doi: 10.1109/thh.2011.6107860.
29. Skaves, P. (2011) Information for cyber security issues related to aircraft systems. 2011 IEEE/AIAA 30th Digital Avionics Systems Conference, doi: 10.1109/dasc.2011.6095968.
30. De Cerchio, R. and Riley, C. (2011) Aircraft systems cyber security. 2011 IEEE/AIAA 30th Digital Avionics Systems Conference, doi: 10.1109/dasc.2011.6095969.

31. El-Badawy, E., EL-Masry, W., Mokhtar, M. and Hafez, A. (2010) A secured chaos encrypted mode-S aircraft identification friend or foe (IFF) system. 2010 4th International Conference on Signal Processing and Communication Systems, doi: 10.1109/icspcs.2010.5709756.
32. Purton, L., Abbass, H. and Alam, S. (2010) Identification of ADS-B System Vulnerabilities and Threats. Australasian Transport Research Forum 2010 Proceedings 29 September – 1 October 2010, Canberra, Australia.
33. De Cerchio, R. and Riley, C. (2012) Aircraft systems cyber security. 2012 Integrated Communications, Navigation and Surveillance Conference, doi: 10.1109/icensurv.2012.6218454.
34. Globus, I. (1972). Binary coding in asynchronous systems. Moscow: Svyaz'.
35. Belov, A., Kozlov, S., Korobkov, A. and Chabdarov, S. (2018) Multi-Signal Extraction of Address Flows in Asynchronous Impulse Radio-Systems. Vestnik KGTU im. A.N. Tupoleva, 74(4).
36. Tsikin, I. and Poklonskaya, E. (2017) 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, doi: 10.18721/JCSTCS.10205.
37. Svyd, I., Obod, I., Maltsev, O., Shtykh, I., Zavolodko, G. and Maistrenko, G. (2019) Model and Method for Request Signals Processing of Secondary Surveillance Radar. 2019 IEEE 15th International Conference on the Experience of Designing and Application of CAD Systems (CADSM), doi: 10.1109/CADSM.2019.8779347.
38. Zhironkin, S., Bliznyuk, S. and Kuchin, A. (2019) Jamming Resistance of the Inbound Channel of an Identification System with Broadband Signals and Error Control Codes in the Conditions of Pulse Noise and Intra-System Jamming. Journal of Siberian Federal University. Engineering & Technologies, doi: 10.17516/1999-494X-0166.
39. Petrov, A. and Mikhalev, V. (2019) Bit-Error Rate in a Digital Data Transmitting Channel at Chaotic Impulse Noise with Random Radio-Pulse Duration Action. Systems of Control, Communication and Security, no.3, doi: 10.24411/2410-9916-2019-10303.
40. Svyd, I., Obod, I., Maltsev, O., Shtykh, I. and Zavolodko, G. (2019) 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), doi: 10.1109/CADSM.2019.8779322.
41. Malyarenko, A. (2007) Secondary Radar Systems For Air Traffic Control And State Recognition. Kharkiv: HUVS.
42. Guo, Y., Yang, J. and Guan, C. (2013) A Mode 5 signal detection method based on phase and amplitude correlation. 2013 Ninth International Conference on Natural Computation (ICNC), doi: 10.1109/ICNC.2013.6818164.
43. Huan, L., Feng, Z., Bai, L. and Jian, W. (2015) One Joint Demodulation and Despreading Algorithm for MOD5. The Open Automation and Control Systems Journal, 7(1), doi: 10.2174/1874444301507010386.
44. SBIR. (2018) Mode 5 Identification Friend Or Foe (IFF) Simulation And Subsequent RF Injection. 2nd ed. Culver City, CA: Department of Defense, Scalable Network Technologies, Inc., 12 December 2018.
45. Lenshin, A. and Lebedev, V. (2015) Characteristics of Detection of Signals of Immitostable Regimes of Identification Systems. Dynamics of Complex Systems - XXI Century, 9(1).
46. Lenshin, A. and Lebedev, V. (2016) Algorithm for detecting signals of immitostable modes of identification. Telecommunications, (7).

47. Leonardi, M. and Gerardi, F. (2020) Aircraft Mode S Transponder Fingerprinting for Intrusion Detection. *Aerospace*, 7(3), doi: 10.3390/aerospace7030030.
48. Obod, I., Svyd, I., Maltsev, O., Zanolodko, G. and Pavlova, D. (2020) Optimization of Data Processing of Primary Radar Systems. 2020 IEEE 40th International Conference on Electronics and Nanotechnology (ELNANO), doi: 10.1109/elnano50318.2020.9088842.
49. Obod, I., Svyd, I., Maltsev, O., Zanolodko, G. and Pavlova, D. (2020) 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), doi: 10.1109/TCSET49122.2020.235511.
50. Pavlova, D., Zanolodko, G., Obod, I., Svyd, I., Maltsev, O. and Saikivska, L. (2019) Optimizing Data Processing in Information Networks of Airspace Surveillance Systems. 2019 10th International Conference on Dependable Systems, Services and Technologies (DESSERT), doi: 10.1109/DESSERT.2019.8770022.
51. Borisov, V., Zinchuk, V., Limarev, A. and Shestopalov, V. (2011) Interference Immunity of Radio Communication Systems with Spectrum Spreading by Direct Modulation by a Pseudo-Random Sequence. 2nd ed. Moscow: RadioSoft.
52. Obod, I. (1999) Integrated Coordinate-and-Time Support for the Address Inquiry in the Secondary Radar Systems. *Telecommunications and Radio Engineering*, 53(3), doi: 10.1615/TelecomRadEng.v53.i3.100.
53. Pankov, V., Manezhkin, A. and Mytil, V. (2016) Evolution of Aviation Means of Identification. Chernogolovka: RIO IPHVF RAS.
54. Svyd, I., Obod, I., Maltsev, O., Shtykh, I., Maistrenko, G. and Zanolodko, G. (2019) Comparative Quality Analysis of the Air Objects Detection by the Secondary Surveillance Radar. 2019 IEEE 39th International Conference on Electronics and Nanotechnology (ELNANO), doi: 10.1109/ELNANO.2019.8783539.
55. Obod I., Svyd I., Maltsev O., Vorgul O., Maistrenko G., Zanolodko G. (2020) Optimization of the Quality of Information Support for Consumers of Cooperative Surveillance Systems. In: Radivilova T., Ageyev D., Kryvinska N. (eds) *Data-Centric Business and Applications. Lecture Notes on Data Engineering and Communications Technologies*, vol 48. Springer, Cham. [https://doi.org/10.1007/978-3-030-43070-2\\_8](https://doi.org/10.1007/978-3-030-43070-2_8).
56. Obod I., Svyd I., Maltsev O., Zanolodko G., Pavlova D., Maistrenko G. (2020) Fusion the Coordinate Data of Airborne Objects in the Networks of Surveillance Radar Observation Systems. In: Radivilova T., Ageyev D., Kryvinska N. (eds) *Data-Centric Business and Applications. Lecture Notes on Data Engineering and Communications Technologies*, vol 48. Springer, Cham. [https://doi.org/10.1007/978-3-030-43070-2\\_31](https://doi.org/10.1007/978-3-030-43070-2_31).
57. Leonardi, M., Di Gregorio, L. and Di Fausto, D. (2017) Air Traffic Security: Aircraft Classification Using ADS-B Message's Phase-Pattern. *Aerospace*, 4(4), doi: 10.3390/aerospace4040051.
58. Mantilla-Gaviria, I., Galati, G., Leonardi, M. and Balbastre-Tejedor, J. (2014) Time-difference-of-arrival regularised location estimator for multilateration systems. *IET Radar, Sonar & Navigation*, 8(5), doi: 10.1049/iet-rsn.2013.0151.