SUMMARY

OF THE SCIENTIFIC WORKS
of Col. Dr. Eng. IVAN PENCHEV IVANOV

I. MONOGRAPHIC WORKS

Software-Defined Radiocommunication Systems, published by the Defence Institute "Professor Tsvetan Lazarov," 2025, ISBN 978-619-90024-8-3.

This monograph explores the concept of Software-Defined Radio (SDR) and its practical implementation. A historical overview of the origin and evolution of the SDR paradigm is provided. The architecture of such systems is analyzed and defined. Through modeling and simulation, the fundamental blocks of a radiocommunication system based on the SDR concept are studied. Based on the obtained results, a computer model of a radiocommunication system for data exchange is synthesized. Practical implementations of radiocommunication systems based on software-defined radio have been created, implementing essential information exchange protocols applicable in the military domain. Experimental results demonstrate the convenience of using the SDR concept for rapid prototyping.

II. SCIENTIFIC ARTICLES AND PAPERS

1. **Dikov D., Ivanov I., Military Mobile Network Based on TETRA Standard – Current Status and Development Perspectives**, (CIO Journal – Information and Communication Technologies for Defence, pp. 12–16, July 2008, ISSN 1312-5605)

   Differences in operational requirements, needs, frequency spectrum management policies, and other factors have led to the development of separate standards for public commercial mobile networks and security and defense mobile networks. In the area of secure and defense communications, systems based on the TETRA standard have gained widespread popularity and advancement.

2. **Ivanov I., Cognitive Radio: Paradigm, Architecture, and Prospects**, (Scientific Conference with International Participation "Military Technologies and Defence Support Systems 2011" (MT&S 2011), pp. 188–197, Sofia, 2011, ISBN 978-619-90024-1-4)

The rapid development of information processing technologies creates conditions for the emergence of new paradigms and modernization of radio communication platforms. Cognitive radio and cognitive radio networks represent a modern approach to increasing spectrum efficiency and expanding services to users. The report presents the cognitive radio paradigm, defines key views on its architecture, and analyzes important standardization and project activities.

3. **Iliev R., Ivanov I., Unified Communications – A Tool for Increasing Management Efficiency**, (Scientific Conference with International Participation "Military Technologies and Defence Support Systems 2011" (MT&S 2011), pp. 106–112, Sofia, 2011, ISBN 978-619-90024-1-4)

   The report presents Unified Communications (UC) – their essence, leading industry solutions, applications, and business process optimization, as well as the use of UC in the Ministry of Defence and the Bulgarian Army.

4. **Ivanov I., Cognitive Wi-Fi Access Point Based on Open-Source Embedded System**, (Sixth International Scientific Conference “Solutions and Technologies for Smart Defense”, Hemus 2012, pp. II-172–II-179, Plovdiv, 2012, ISSN 1312-2916)

   The article explores the potential for integrating cognitive functionality into a Wi-Fi radio access point based on an open-source embedded system. A specific implementation of a cognitive function for channel selection is presented.

5. **Ivanov I., Kolev A., TETRA Cellular Network Coverage through the Lens of Augmented Reality**, (Sixth International Scientific Conference “Solutions and Technologies for Smart Defense”, Hemus 2012, pp. II-216–II-226, Plovdiv, 2012, ISSN 1312-2916)

   Augmented Reality (AR) is a current trend in modern electronic industries. One possible application is the superimposition of computer graphics on real-world images. The paper presents a concept and analysis of approaches for applying AR in visualizing the coverage of cellular networks.

6. **Ivanov I., Integrating the Architectural Approach into the Life Cycle Management of C4I Systems,** (Scientific Conference with International Participation "Military Technologies and Defence Support Systems 2013 (MT&S-2013)", pp. II-161–II-174, Sofia, 2013, ISSN 2367-5942)

   The introduction of the architectural approach in the Armed Forces of the Republic of Bulgaria is seen as the next immediate step towards improving the effectiveness of the military organization. However, the issue of integrating this approach into the management system for the development of the Armed Forces remains open.

7. **Ivanov I., Iliev R., Perspectives in Information and Communication Technologies for Enhancing Security and Defense**, (International Scientific Conference at National Military University "V. Levski", Faculty of Artillery, Air Defense and CIS, Proceedings, pp. 243–250, Shumen, 2015, ISSN 2367-7902)

New technologies are a critical element in achieving military superiority and ensuring high defense capabilities. This paper explores perspectives in ICT and their potential application in priority investment projects of the Ministry of Defence and the Bulgarian Army.

8. **Alexandrova K., Ivanov I., Alternatives for Research and Design of Software-Defined Radars**, (International Scientific Conference at National Military University "V. Levski", Faculty of Artillery, Air Defense and CIS, Proceedings, pp. 251–254, Shumen, 2015, ISSN 2367-7902)

   Modern radars are indispensable in many military operations such as target detection and identification, air and ground surveillance, weapon guidance, and damage assessment. The need for diverse radar capabilities has led to the development of various highly specialized radar systems. Recent years have seen increasing demands for cost-effectiveness and adaptability in radar systems, challenges that software-defined radars can address.

9. **Kolev A., Marinov S., Ivanov I., Cloud-Based Communication and Information Infrastructure for Network-Centric Operations**, (Scientific Conference with International Participation "Cloud Structures and Information Security", Proceedings, pp. 227–234, Shumen 2016, ISBN 978-954-9681-73-4)

   Given the demands of cooperative combat operations through multiple network links in a network-centric battlefield, this paper analyzes the problems and challenges in network-centric warfare. Emphasis is placed on the idea that cloud computing services should be the backbone of the communication systems in such an environment. A new system for real-time, demand-oriented battlefield communication—called the Unified Data Exchange System—is presented, based on cloud technologies. It is demonstrated that cloud technology integration significantly improves service levels in unified networks.

10. **Ivanov I., Cloud Radio Access Network Architecture for Security and Defense**, (Scientific Conference with International Participation "Cloud Structures and Information Security", Proceedings, pp. 235–240, Shumen 2016, ISBN 978-954-9681-73-4)

    Radio access networks are the foundation of mobile communication systems. The increasing demand for high-speed services and capacity necessitates new approaches and technologies. The proposed architecture is based on the paradigms of cloud computing and software-defined radio, introducing new functionality for multi-protocol support. The main advantages and drawbacks of cloud-based RAN in the context of security and defense are summarized.

11. **Ivanov I., Stoyanov N., Analysis of Cloud Service Architectures**, (Scientific Conference with International Participation “Cloud Structures and Information Security,” Proceedings, pp. 85–93, Shumen 2016, ISBN 978-954-9681-73-4)

    The classical architecture of cloud computing has become a widespread reality. The development of mobile computing and the modern demands for services necessitate the exploration and analysis of new cloud computing models. Of particular interest is the identification of suitable solutions for

military operations. Based on the analysis of classical and specialized architectures, a hybrid model of cloud computing is proposed—one that takes into account the dynamics of the modern battlefield.

12. **Kolev A., Marinov S., Ivanov I., Data Model in Objective Control Systems,** *(Eighth International Scientific Conference "Scientific Research – A Key Factor for Acquiring New Defence Capabilities Hemus 2016", Proceedings, III-12 – III-21, Plovdiv, 2016, ISSN 1312-2916)*

    Aviation instruments, sensors, indicators, and alarms are essential components of onboard aviation equipment, including flight data recording devices installed on aircraft. They play a key role in objective control, ensuring the combat readiness of air assets, flight safety, and improving the operational reliability of aviation systems in flight.This paper proposes an informational and digital model of the data structures involved in objective control, as well as an algorithm for generating an informational data frame.

13. **Iliev R., Ivanov I., Data Center Management Solutions,** *(Eighth International Scientific Conference "Scientific Research – A Key Factor for Acquiring New Defence Capabilities Hemus 2016", Proceedings, III-275 – III-282, Plovdiv, 2016, ISSN 1312-2916)*

    This report presents the management requirements for data centers in relation to their engineering, technical, and information systems. It outlines several solutions for the development of modern data centers designed for defense purposes.

14. **Alexandrova K., Ivanov I., Prospective Radars Against Electronic Threats on the Modern Battlefield,** *(Eighth International Scientific Conference "Scientific Research – A Key Factor for Acquiring New Defence Capabilities Hemus 2016", Proceedings, III-202 – III-210, Plovdiv, 2016, ISSN 1312-2916)*

    Technological advancements in physics, microelectronics, and information technologies have led to the creation of new radar technologies and promising technical solutions. This paper analyzes the capabilities of modern radars to counter various types of electronic attacks. It discusses the trends in radar technology development and their implementation in modern radar systems that provide high performance, maximum protection, and efficiency in real combat operations.

15. **Alexandrova K., Ivanov I., Architecture of a Passive Bistatic Radar System Based on DVB-T Signals and a Software-Defined Platform,** *(Eighth International Scientific Conference "Scientific Research – A Key Factor for Acquiring New Defence Capabilities Hemus 2016", Proceedings, III-193 – III-201, Plovdiv, 2016, ISSN 1312-2916)*

    This article focuses on the architecture of a passive bistatic radar system built on a software-defined platform. The DVB-T digital television standard is used as the source of radio transmissions. The paper analyzes the advantages and disadvantages of this radar type and its capabilities for detection and monitoring. Key performance indicators are evaluated for specific applications in the relevant field.

16. **Ivanov I., Architecture and Models of Cloud Software-Defined Radio Station,** *(Eighth International Scientific Conference "Scientific Research – A Key Factor for Acquiring New Defence Capabilities Hemus 2016", Proceedings, III-177 – III-185, Plovdiv, 2016, ISSN 1312-2916)*

Radiocommunications are a fundamental type of network in modern military command and control systems. Software-defined radio (SDR) is a key paradigm in the design of radio equipment. The development of cloud computing introduces a new architectural approach involving the spatial distribution of radio system components. Offloading various elements of the platform to the cloud enables the creation of new models of cloud-based software-defined radio.

17. **Ivanov I., Software-Defined Multichannel Radio Access Point,** *(INTERNATIONAL SCIENTIFIC CONFERENCE 2016, COLLECTION OF PAPERS, pp. 281–288, Shumen, Bulgaria, 2016, ISSN 2367-7902)*

Radio access points are the foundation of mobile communication systems. Software-defined radio is a core paradigm in radio equipment design, enabling new architectures and capabilities for mobile communication networks. This article analyzes a tactical radio access point and presents a new model for a software-defined multichannel radio access point, along with a developed prototype.

18. **Ivanov I., Service Models of Cloud Software-Defined Radio,** *(24th National Conference with International Participation Telecom 2016, Sofia, Proceedings on CD, pp. 80–88, ISSN: 1314-2690)*

Cloud computing and software-defined radio (SDR) are promising concepts in the development of modern radiocommunication systems. The combined use of these two technologies enables the formation of new architectures involving the spatial distribution of radio station components and the offloading of computations to the cloud. This paper presents the opportunities offered by the integration of cloud computing and SDR for the implementation of new service models in modern communication networks and systems. The proposed service architecture models will enable the development and deployment of cloud-based radiocommunication systems.

19. **Alexandrova K., Ivanov I., Architecture of a Dual-Band Bistatic Passive Radar Based on LTE and DVB-T Signals,** *(Scientific Conference "Current Trends in Aviation Training," Proceedings, pp. 140–145, Dolna Mitropoliya, 2017, ISBN 978-954-713-110-1)*

This article analyzes the possibilities for detecting LTE signals and their applicability in passive radar systems. A dual-band passive bistatic radar architecture operating with LTE and DVB-T signals is presented, based on a universal open-source software-defined radio receiver (USRP). The capabilities of the dual-band architecture for monitoring and security are examined.

20. **Marinov S., Ivanov I., Kolev A., Modeling a Managed Communication Environment,** *(Scientific Conference "Current Trends in Aviation Training," Proceedings, pp. 146–151, Dolna Mitropoliya, 2017, ISBN 978-954-713-110-1)*

    The communication and information support of the activities of the Bulgarian Air Force is directed towards ensuring stable wireless digital communication between aircraft and ground. This paper proposes a model of a managed communication environment for the Bulgarian Air Force, based on modern technological solutions such as a digital tactical data network, cloud-based tools for managing the information infrastructure, software-defined radio, and a digital model of the surrounding environment. A mathematical framework is presented, illustrating the potential to overcome existing adverse effects typical for wireless radiocommunication.

21. **Ivanov I., Information Interoperability in Automated Weapon Control Systems,** *(Ninth International Scientific Conference "Scientific Research, Innovation and Industrial Cooperation in the Interest of Common European Defence and Security – Hemus 2018", Proceedings, II-100 – II-106, Plovdiv, 2018, ISSN 1312-2916)*

    This paper addresses the issue of information interoperability in the context of weapon systems management. The structure and general requirements for a specialized information system are discussed. Functional requirements for the specialized software are defined.

22. **Ivanov I., Opportunities for Building a Multifunctional Radiotechnical System Based on a Software-Defined Radio Platform,** *(Annual University Scientific Conference, June 14–15, 2018, Proceedings, Vol. 9, Technical Sciences, pp. 91–100, Veliko Tarnovo, 2018, ISBN 978-619-7246-20-9)*

    This paper explores the possibilities of designing a multifunctional radio system based on software-defined radio (SDR). It presents the concepts of multifunctional radio, software-defined radio, and software-defined processor. A review of the current state of SDR technology is provided. The paper examines the feasibility of developing a multifunctional radio system based on existing platforms.

23. **Laso, P.M., L. Salmon, M. Bozhilova, I. Ivanov, N. Stoianov, G. Velev, C. Claramunt, Y. Yanakiev, ISOLA: An Innovative Approach to Cyber Threat Detection in Cruise Shipping,** *(Developments and Advances in Defense and Security. Smart Innovation, Systems and Technologies, vol. 255, Springer, Singapore, 2022, pp. 71–81, https://doi.org/10.1007/978-981-16-4884-7_7)*

    Today's cruise ships can carry over 5,500 passengers and 2,200 crew members, with average voyage durations of seven days. The cruise industry constitutes a large segment of the tourism market, and demand is increasing. Despite the large number of people onboard, crime reporting on cruise ships remains relatively low. While the ship itself is exposed to security threats, both onboard and shore-side activities provide multiple opportunities for security breaches and vulnerabilities.With the proliferation of onboard data activities and sensors, there is an urgent need

to develop data fusion algorithms to gain a comprehensive understanding of the information environment. This study analyzes current maritime cyber risks with a specific focus on cruise ships, as developed within the H2020 ISOLA project. Several data fusion algorithms are presented and discussed, followed by considerations on future needs for more secure cyber environments.

24. **Ivanov I., Modeling, Simulation and Implementation of π/4-DQPSK Modem on SDR,** *(XXXII International Scientific Conference Electronics (ET), Sozopol, Bulgaria, 2023, doi:10.1109/ET59121.2023.10278732)*

This paper presents the modeling, simulation, and implementation of a digital π/4 Differential Quadrature Phase Shift Keying (π/4-DQPSK) modem on a software-defined radio (SDR) platform. A system model was developed in the GNU Radio environment. Simulations yielded experimental results for bit error rate (BER) in the presence of additive white Gaussian noise (AWGN). An experimental RF DQPSK modem was implemented using a USRP radio frequency module.

III. RESEARCH AND DEVELOPMENT ACTIVITIES

(*Technical-Economic Reports, Technical Specifications, Projects, Programs for Testing, Methodologies for Testing, etc.*)

This section includes educational and methodological works related to the author's participation in the development of doctrinal documents, techno-economic reports, tactical-technical specifications, projects for the construction and development of a departmental cellular system based on the TETRA standard, communication and information systems, as well as programs and methodologies for testing and acceptance of communication systems, automated information systems and subsystems, and other source documents necessary for the acquisition of communication and information products for the needs of the Ministry of Defence, the Bulgarian Armed Forces, and their subordinate structures.A total of 20 documents were developed during the period 2011–2025.

1. **Doctrine for the Communication and Information System of the Armed Forces**, NP-06, Sofia 2012
(Ivan Ivanov – member of the authoring team)
This officially approved national publication describes how the capabilities of the C4IS system are to be used in modern operations. It presents the main principles guiding commanders and C4IS units in organizing and conducting actions to achieve their assigned objectives.
The goals of the Doctrine for the Communication and Information System of the Armed Forces are:
• To establish unified understanding and terminology;
• To summarize principles and methods for planning, building, developing, training, utilizing, managing, and protecting the communication and information system for the support of command and control under modern conditions.
2. **Development of the AIS of the MoD, Bulgarian Armed Forces, Operational and Tactical Headquarters**
Techno-Economic Report, Tactical-Technical Specification
(Ivan Ivanov – member of the authoring team)

3. **Module for Communication and Information Support of a Contingent**
Techno-Economic Report, Tactical-Technical Specification
(Ivan Ivanov – member of the authoring team)
4. **Battalion Battle Group – Subsystem "Combat Reconnaissance Vehicle"**
Techno-Economic Report, Tactical-Technical Specification
(Ivan Ivanov – lead of the authoring team)
5. **Battalion Battle Group – Subsystem "CIS"**
Techno-Economic Report
(Ivan Ivanov – member of the authoring team)
6. **Transit Access Vehicle B2**
Techno-Economic Report, Tactical-Technical Specification
(Ivan Ivanov – member of the authoring team)
7. **Refitting of Command-Staff Vehicle R-142 N**
Techno-Economic Report, Tactical-Technical Specification
(Ivan Ivanov – lead of the authoring team)
8. **System "Automated Network for Communication with Mobile Units – TETRA Standard"**
Acceptance Testing Program, Acceptance Testing Methodology
(Ivan Ivanov – developer)
9. **Mobile Module from the Mobile Segment of the System "Automated Network for Communication with Mobile Units – TETRA Standard"**
Techno-Economic Report, Tactical-Technical Specification
(Ivan Ivanov – lead of the authoring team)
10. **Automated Fire Control System for 122 mm Rocket Artillery Battalion (ASUFORS-122)**
Techno-Economic Report, Tactical-Technical Specification
(Ivan Ivanov – lead of the authoring team)
11. **System for Management of Material Supplies in Military Stores and the Logistic Support of Military Personnel**
Techno-Economic Report, Tactical-Technical Specification
(Ivan Ivanov – member of the authoring team)
12. **Communication Transmission Subsystem (Network) EKRAN M**
Techno-Economic Report, Tactical-Technical Specification
(Ivan Ivanov – member of the authoring team)
13. **Construction and Equipment of a Stationary Communication and Information Node for Military Unit 56130 – Bankya**
Techno-Economic Report, Tactical-Technical Specification
(Ivan Ivanov – member of the authoring team)

The documents have been developed in accordance with the requirements of the following standards:
• BC 40095:2014 "Development and Commissioning of Automated Systems for Military Use";
• BC 2.03:2014 "Development and Industrial Implementation of Defense-Related Products";
• BC 40069:2014 "Tactical-Technical Specification. Structure, Content, and Formatting";
• BC 40094 "Tactical-Technical Specification for Automated Control Systems for Military Use".

The documents reflect research and development activities carried out for the operational-tactical, technical, and economic justification of the requirements for newly developed or modernized objects (automated control systems or military products), as well as for determining the feasibility and rationale for their creation. The documents were developed under the leadership of, with the participation of, or independently by Ivan Ivanov.