MINIMUM SKILL REQUIREMENTS FOR OPERATORS OF X-RAY INSPECTION SYSTEMS: SCIENTIFIC AND PRACTICAL ASPECTS

Ibrahimov Ulugbek Abidjhanovich
Senior lecturer at the Customs Institute of the Customs Committee under the Ministry of Economy and Finance of the Republic of Uzbekistan
https://doi.org/10.5281/zenodo.15401120

The article examines the minimum necessary knowledge, skills, and competencies that should be possessed by operators of X-ray inspection systems used in customs control. The study addresses the scientific justification for developing minimum professional standards, taking into account the specifics of technical means of customs control (TMCC), international practices, and modern challenges. A separate focus is given to the role of training simulators in developing and assessing the competencies of operators. A comparative analysis of the capabilities of existing training systems is conducted, and proposals for improving operator training programs are formulated. The results of the research can be applied in updating the educational standards of customs services, developing certification systems, and enhancing the effectiveness of customs control through better use of technical means.

Keywords: X-ray inspection systems, customs control, operator competencies, professional standards, training simulators, personnel training.

Introduction

In the context of increasing the volume of international trade and the intensification of smuggling methods, customs authorities are placing increasing demands on the quality of customs control. One of the key elements ensuring its effectiveness is the use of technical means, especially X-ray inspection systems (XRIS), which allow the detection of prohibited items without opening containers and vehicles. However, even the most advanced technical means lose their effectiveness if operated by personnel lacking proper training. Therefore, defining the minimum skill requirements for operators of XRIS is becoming a strategically important task.

Despite the widespread use of XRIS worldwide, there is still no unified international standard regulating the competencies of their operators. Most countries develop their own training and certification systems, based on national specifics and available resources. At the same time, global practice shows the need for harmonization and unification of requirements, especially in the context of information exchange and mutual recognition of customs procedures.

This article aims to analyze current approaches to determining the minimum requirements for operators of XRIS and propose scientifically based recommendations for their standardization.

Methods and materials

This study is based on a complex methodological approach that includes the analysis of regulatory documents, educational and methodological literature, international recommendations (WCO, IAEA, ICAO), as well as empirical data obtained through the study of existing training systems and simulators. Comparative, analytical, and expert assessment methods were used. Particular attention was paid to identifying the common elements in the training of XRIS operators in different countries.

The materials for the study included:
• National and international legal and regulatory documents on the use of technical means in customs;
• Curricula and training modules of customs training centers;
• Technical documentation and user manuals for X-ray inspection equipment;

• Descriptions and functional characteristics of training simulators and systems for operator skill development.

Results and discussion

Role and Function of XRIS Operators

The effectiveness of X-ray inspection systems largely depends on the qualifications of their operators, who are required not only to operate the equipment correctly but also to interpret the obtained images, make quick and accurate decisions, and act in accordance with legal norms. In practice, the main functions of an XRIS operator include:

• Pre-inspection preparation and calibration of equipment;
• Image acquisition and interpretation of X-ray images;
• Identification of potential threats or prohibited items;
• Documentation and reporting;
• Interaction with other customs officials in the process of detailed inspection or risk assessment.

Classification of Operator Competencies

To determine the minimum requirements, it is necessary to classify the types of competencies an XRIS operator must possess. These can be divided into:

• **Technical Competencies:** Understanding the principles of X-ray inspection, radiation safety, knowledge of the system's software interface, equipment maintenance.

• **Analytical Skills:** Image analysis, object recognition, anomaly detection, application of risk profiles.

• **Legal and Procedural Knowledge:** Customs regulations, legal framework of control, permissible items, procedural actions upon detecting violations.

• **Psychological and Cognitive Skills:** Attention to detail, visual memory, stress tolerance, decision-making under time pressure.

International Approaches to Training and Certification

In many countries, customs services develop national qualification frameworks for operators. For example, the U.S. Customs and Border Protection (CBP) employs a multi-level training system that includes theoretical instruction, simulator practice, and on-the-job training. The European Union promotes a competency-based approach within the framework of the Common Customs Training Curriculum (CCTC), which highlights the importance of harmonized skills.

In Asia, the Japan Customs Training Institute and the Korean Customs Human Resource Development Institute have implemented advanced simulation technologies for skill development. The World Customs Organization (WCO) also supports the establishment of regional training centers and promotes best practices.

However, despite this progress, the absence of unified minimum standards hinders international cooperation and mutual recognition of operator qualifications.

Role of Simulators in Skill Development

One of the most effective tools for preparing XRIS operators is the use of computer-based training simulators. These systems allow users to practice image analysis in a controlled virtual environment and simulate real-life inspection situations without the need for actual cargo or radiation exposure.

Modern simulators can include:

• Libraries of X-ray images for classification and recognition exercises;
• Scenarios for identifying smuggling methods and concealment techniques;
• Testing and assessment modules with automated scoring;
• Statistical tracking of trainee performance and development.

Comparative analysis of existing simulators (e.g., Simfox, X-Ray Tutor, CargoX) shows that their effectiveness depends on the realism of the images, adaptability of training scenarios, and integration into broader learning programs.

Conclusion and recommendations

The effectiveness of customs control using X-ray inspection systems largely depends on the professional competencies of their operators. The absence of harmonized international standards leads to inconsistencies in training programs and difficulties in mutual recognition of qualifications between countries. Based on the analysis conducted, the following conclusions and proposals can be formulated:

1.   **Minimum requirements** for XRIS operators should include not only technical knowledge of the device and radiation safety, but also strong analytical and legal competencies.

2.   **International cooperation**, particularly within the WCO and ICAO, should be aimed at developing a unified competency model and training standards for XRIS operators.

3.   The use of **advanced simulators** should become an integral part of operator training and recertification systems, ensuring safety, efficiency, and cost-effectiveness.

4.   National customs administrations should invest in **standardized training programs**, based on modern pedagogical approaches and simulation technologies, to meet the challenges of high-risk cargo inspection.

5.   The establishment of a **mutual recognition framework** for certified operators at the international level will facilitate cooperation, increase efficiency, and reduce duplication of training in multinational operations and border regions.

6.   Further research is needed on **cognitive aspects** of image recognition, decision-making under pressure, and the psychological stability of operators, to refine the selection and training methodologies.

In summary, the formation of a professional profile of an XRIS operator and the definition of minimum training standards is a critical step toward improving the quality and safety of customs control. Harmonization in this area will not only ensure higher detection rates of prohibited goods but also support the professional development of customs personnel and international coordination efforts.

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