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Evaluation of Measurement Accuracy Using MOSKITO TI+ and JIM COMPACT Handheld Optoelectronic Devices Under Various Operating Conditions

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Abstract

Handheld optoelectronic devices are a key element in target acquisition in current military operations, especially for artillery reconnaissance and infantry reconnaissance units. This article focuses on a comparative evaluation of two optoelectronic devices of different performance classes, MOSKITO TI+ and JIM COMPACT, both manufactured by Safran Vectronix. The aim of the study is to assess whether the higher technical level of JIM COMPACT leads to a measurable improvement in target location accuracy under various field conditions. Measurements were performed under both ideal and deteriorated conditions (reduced visibility, adverse atmospheric effects) using standardized methodology with reference coordinates determined by geodetic methods. Preliminary results confirm a consistent difference in target localization accuracy between the two devices, with JIM COMPACT demonstrating lower dispersion and higher angular measurement stability, particularly at longer distances and in conditions where orientation accuracy becomes operationally critical.

KEY WORDS: *optoelectronic devices; target acquisition; target location accuracy; laser rangefinder; field experiment; military reconnaissance*

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1. Introduction

The accuracy of target localization plays a crucial role in modern military operations, particularly in the context of networked combat systems and the sensor-to-shooter concept, where errors in target position directly affect the effectiveness of fire support [1, 2]. The A2AD (Anti-Access/Area Denial) operational environment further intensifies demands on target acquisition accuracy [3]. Handheld optoelectronic devices represent a key element in target acquisition for artillery reconnaissance and infantry units operating in complex environments. The integration of advanced electro-optical and infrared sensors, combined with laser rangefinders and angle measurement systems, has significantly enhanced the capabilities of ground-based observation and targeting equipment [4, 5]. Integration of optoelectronic sensors on unmanned ground and aerial platforms further extends these capabilities on the digital battlefield [6, 7, 8]. This extension should be understood not only as the physical placement of sensors on unmanned platforms, but also as the integration of sensor data into wider reconnaissance and surveillance architectures. Recent studies on UAV LiDAR mapping, UGV swarm maneuver planning, UAV reconnaissance in force protection, and UAV swarm surveillance in complex environments show that sensor effectiveness depends on terrain structure, occlusions, route planning, coverage quality, and the ability to coordinate multiple platforms in dynamic operational conditions [9; 10; 11; 12]. The development of immersive and simulation-based training methods further supports the preparation of operators to work effectively with such systems under realistic conditions [13,

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14, 15]. Extended reality and immersive simulation approaches have been shown to significantly improve operator comprehension of complex military tactics and sensor employment [16].

Target localization accuracy is determined by a complex set of error factors, including inaccuracies in measuring distance, angles, orientation, and observer position. Research confirms that the dominant source of total localization error is angular measurement rather than ranging itself, and that optimized calculation methods can significantly improve accuracy [3]. Furthermore, geolocation accuracy is highly dependent on the quality of navigation data and observation geometry [1]. This dependence is particularly important for Joint Fires Observer tasks, where the suitability of target acquisition systems is determined by mission-specific requirements, orientation method, and compatibility with fire support procedures. Earlier research on artillery target acquisition systems already highlighted the operational importance of shifting from magnetic to gyroscopic orientation, while studies on topographical-geodetic data emphasize the role of geodetic connection in tactical and technical control of artillery fire. In electronically contested environments, these requirements are further reinforced by the need to preserve alternative methods for coordinate determination when GNSS signals are degraded, denied, or deceptive [17, 18, 19]. Experimental analyses of laser rangefinders demonstrate that receiver signal fluctuations can introduce systematic errors, mitigated by appropriate design and calibration methodology [20, 21, 6]. Environmental factors, including degraded GNSS availability, can cause localization accuracy to deteriorate from centimeter to meter level [7, 8, 22]. The influence of GNSS signal quality on positioning in operationally relevant terrain types such as forests has also been specifically documented [23].

From an artillery perspective, the precision of target and firing position coordinates is a fundamental prerequisite for effective indirect fire [24, 25]. Systematic evaluation of positioning accuracy across diverse measurement conditions has confirmed the sensitivity of localization systems to environmental factors [26]. Innovations in artillery weapon systems and fire control continue to raise the bar for required localization accuracy, including for target acquisition sensors [2, 27]. The use of constructive simulation and modelling tools enables evaluation of fire effectiveness under controlled conditions and supports decision-making on equipment selection and employment [28, 29]. Beyond ground-based positioning, the integration of optoelectronic sensors on unmanned platforms further expands target acquisition capabilities [4, 16].

From a military perspective, it is therefore necessary to evaluate optoelectronic devices not only against manufacturer-declared parameters, but also through experimental verification of actual accuracy under realistic operational conditions [4, 25]. This article presents a comparative evaluation of two devices of different performance classes – MOSKITO TI+ (lightweight personal observation and targeting) and JIM COMPACT (advanced multi-sensor target acquisition system) – both manufactured by Safran Vectronix [30]. The aim of the study is to assess whether the higher technical level of JIM COMPACT leads to a measurable improvement in target location accuracy under ideal and deteriorated field conditions.

2. Description of Tested Devices

Both devices under evaluation are manufactured by Safran Vectronix and represent different capability tiers within the category of handheld observation and target acquisition systems [30]. The MOSKITO TI+ is designed primarily as a lightweight personal observation and targeting device, integrating a laser rangefinder, angle measurement system, and a thermal imaging channel. It features an uncooled thermal imager (640×480 px), an optical daylight sight (6× magnification), and a low light camera. The integrated laser rangefinder operates at 1550 nm and provides range measurements with an accuracy of ±2 m (1σ) up to 10 000 m. Azimuth accuracy of the digital magnetic compass is ±10 mil (1σ), improving to ±7 mil when the device is used on a tripod with PPS calibration. Total weight including batteries is under 1.4 kg [31]. When combined with the STERNA True North Finder, MOSKITO TI+ achieves TLE CAT I accuracy at ranges up to 4.4 km [31, 32]. The JIM COMPACT is a more advanced multi-sensor system intended for precision target acquisition, combining superior optics, a high-accuracy laser rangefinder, improved orientation system, and enhanced data processing algorithms. JIM COMPACT integrates three complementary observation channels: a cooled MWIR thermal imager (640×480 px, continuous zoom up to ×28), a 14-megapixel color day camera, and a low light CMOS sensor (1280×1024 px). The eye-safe laser rangefinder provides ranges up to 12 000 m. The device uses a digital magnetic compass with azimuth accuracy of ±10 mil (1σ) and supports external military GNSS (PLGR/DAGR). Total weight is under 2 kg. Its modular design allows direct attachment of the STERNA TNF True North Finder, enabling TLE CAT I target location accuracy beyond 4 km even in GNSS-denied environments [32, 33].

Both devices are furthermore compatible with the STERNA System (Safran Vectronix), a gyroscope-based True North Finder (TNF) that serves as an external orientation module mountable directly onto these devices. STERNA uses a Hemispheric Resonating Gyro (HRG) to determine true geographic north independently of magnetic field conditions, GNSS signals, and environmental interference from body armor, vehicles, or urban structures. When combined with JIM COMPACT or MOSKITO TI+, the STERNA System enables target location accuracy of TLE CE90 CAT I at extended ranges, including in GPS-denied or GPS-spoofed environments [32]. Two variants are available: STERNA TNF 45 (optimized for latitudes up to 45° N/S and shorter target distances) and STERNA TNF 60 (for higher latitudes and extended ranges). Total system weight including payload is under 3 kg.

Table 1.

Technical parameters of tested optoelectronic devices

Parameter	MOSKITO TI+	JIM COMPACT
Manufacturer	Safran Vectronix	Safran Vectronix
Primary purpose	Personal observation & targeting	Multi-sensor target acquisition
Laser rangefinder accuracy	±2 m (1σ), 10–10 000 m [31]	up to 12 000 m [33]
Angle measurement accuracy	±10 mil (1σ); ±7 mil on tripod [31]	±10 mil (1σ) [33]
Thermal imaging channel	Uncooled, 640×480 px, FOV 12.4°/220 mil [31]	Cooled MWIR, 640×480 px, zoom ×28 [33]
Mass [kg]	<1.4 kg incl. batteries [31]	<2 kg incl. batteries [33]
Operating temperature	MIL-STD-810 [31]	MIL-STD-810 & MIL-STD-461 [33]

Fig. 1. Optoelectronic devices MOSKITO TI+ and JIM COMPACT [30]

3. Methodology

The comparison of both devices was performed through controlled field experiments focused on target localization accuracy. The experimental approach follows the methodology established in previous positioning accuracy studies conducted at the University of Defence [24, 25]. Measurements were carried out in two categories of conditions: ideal conditions (clear visibility, standard atmospheric conditions) and deteriorated conditions (reduced visibility, adverse atmospheric effects such as haze, rain, or elevated temperature gradient). The test scenarios simulated typical operational situations of artillery and infantry reconnaissance units.

Predefined targets were positioned at known reference coordinates determined independently by a more accurate geodetic method, using points of the national geodetic network as a reference baseline. For each target, a series of repeated measurements was performed with each device to determine systematic error, repeatability, and statistical characteristics of results. The experimental procedure was standardized to minimize operator influence; both devices were operated according to the same methodology, and measurements were performed in multiple series with alternating order of device use.

The following measurement components were evaluated for each device and condition: distance measurement error, azimuth measurement error, elevation angle measurement error, coordinate deviations in the east and north components (ΔE, ΔN), and the resulting total position error. Statistical parameters including Root Mean Square Error (RMSE) and Circular Error Probable (CEP) were calculated to enable objective comparison [3]. CEP is defined as the radius of a circle within which 50% of measured positions fall, approximated as $CEP \approx 0.59 \times (\sigma\mathrm{lat} + \sigma\mathrm{range})$, where the lateral standard deviation $\sigma\mathrm{lat}$ is derived from azimuth standard deviation as $\sigma\mathrm{lat} = \sigma\mathrm{mil} \times d \times \pi/6400$ [m]. Reference azimuths for both target points were independently verified against the national geodetic network, providing a traceable accuracy baseline for bias assessment. Angular and linear measurement rules for fire control have been systematically analyzed in the context of Czech artillery operations [32], and the influence of meteorological conditions on manual gunnery procedures is well documented [34, 35, 36].

All measurements were made in civilian areas without intentional interference, external manipulation of positional data, magnetic anomalies, or other artificial variables. Future experimental designs should therefore expand the current measurement framework toward more operationally complex conditions, including electronic warfare, multispectral UAV detection scenarios, and structurally degraded urban environments. Research on non-destructive counter-UAV electronic warfare, multispectral detection of commercial UAVs, and blast-induced structural deformation demonstrates that real battlefield conditions may affect not only target visibility and sensor performance, but also line of sight, background contrast, electromagnetic conditions, and the stability of reference points or observation positions [37, 38, 39]. The influences on measurement accuracy were solely those of the surrounding natural environment. This represents both a controlled experimental design and an acknowledged limitation addressed in Section 6.

4. Results

The measurement results are presented in Tables 2–3 and Fig. 2. A total of 12 repeated measurements were performed with each device at two geodetically verified target points: Point A (distance 2056 m, reference azimuth 1800 mil) and Point B (distance 3152 m, reference azimuth 2376 mil). Point A and Point B differed primarily in target distance and observation geometry; no intentional electromagnetic or GNSS interference was introduced during the measurements. Both devices recorded consistent distance measurements across all series, with MOSKITO TI+ showing one outlier measurement at Point A (2098 m in series no. 2, compared to the series mean of 2061 m). A systematic positive azimuth bias was observed in both devices at both target points; however, as noted in the methodology, this bias is attributable to the absence of magnetic declination correction during orientation setup and does not represent a sensor error. The operationally relevant parameter is therefore measurement repeatability, expressed as standard deviation (std) and the derived Circular Error Probable (CEP). Table 4 summarizes the complete set of statistical indicators for both devices and both target points.

Table 2.

Raw measurement data – Target Point A (2056 m, az. 1800 mil)

Measurement No.	MOSKITO TI+ Dist. [m]	MOSKITO TI+ Azimuth [mil]	JIM COMPACT Dist. [m]	JIM COMPACT Azimuth [mil]
1	2061	1847	2061	1868.8
2	2098	1850	2061	1869.9
3	2060	1850	2061	1876.3
4	2061	1853	2061	1881.6
5	2060	1851	2061	1879.5
6	2060	1840	2061	1867.7
7	2061	1830	2061	1864.5
8	2061	1842	2061	1861.3
9	2061	1839	2061	1870.9
10	2061	1834	2061	1864.5
11	2061	1837	2061	1866.7
12	2061	1837	2061	1868.8
Average	**2063.8**	**1842.5**	**2061.0**	**1870.0**
Reference value	**2056**	**1800**	**2056**	**1800**
Deviation (bias)	**+7.8 m**	**+42.5 mil**	**+5.0 m**	**+70.0 mil**

Note: Ref. value – geodetically determined reference azimuth. Bias – systematic deviation of the average from the reference. Elevation angle in mils. Azimuth in mils (1/6400 of a circle).

Table 3.

Raw measurement data – Target Point B (3152 m, az. 2376 mil)

Measurement No.	MOSKITO TI+ Dist. [m]	MOSKITO TI+ Azimuth [mil]	JIM COMPACT Dist. [m]	JIM COMPACT Azimuth [mil]
1	3154	2467	3154	2544.0
2	3155	2462	3154	2532.3
3	3155	2465	3154	2537.6
4	3154	2461	3154	2536.5
5	3155	2465	3154	2518.4
6	3155	2472	3154	2526.9
7	3154	2435	3154	2518.4
8	3155	2434	3154	2524.8
9	3155	2447	3154	2523.7
10	3156	2446	3154	2521.6
11	3155	2441	3154	2528.0
12	3155	2443	3154	2529.1
Average	**3154.8**	**2453.2**	**3154.0**	**2528.4**
Reference value	**3152**	**2376**	**3152**	**2376**
Deviation (bias)	**+2.8 m**	**+77.2 mil**	**+2.0 m**	**+152.4 mil**

Note: Both devices exhibit a systematic azimuth bias. This is attributable to the orientation setting (without magnetic correction), not to a sensor error. The operationally relevant parameter is repeatability (std).

Table 4.

Summary of statistical indicators – measurement repeatability and accuracy

Parameter	MOSKITO TI+ Point A	MOSKITO TI+ Point B	JIM COMPACT Point A	JIM COMPACT Point B
n (number of measurements)	12	12	12	12
Target distance [m]	2056	3152	2056	3152
Azimuth – std [mil]	7.53	13.50	6.17	7.94
Distance – std [m]	10.77	0.58	0.00	0.00
Lateral std derived from azimuth [m]	7.60	20.88	6.23	12.28
Distance – bias [m]	+7.8	+2.8	+5.0	+2.0
Azimuth – bias [mil]	+42.5	+77.2	+70.0	+152.4
Repeatability CEP [m]	**10.83**	**12.66**	**3.67**	**7.24**

Note: std – standard deviation (repeatability). Bias – mean deviation from the reference. Lat. std – lateral position uncertainty derived from azimuth std (std_mil × distance × π/6400). CEP ≈ 0.59 × (lat. std + range std) – 50% probability that the measured position falls within the given radius.

Preliminary results show a consistent difference in target localization accuracy between the two devices. JIM COMPACT demonstrated lower dispersion of measured target coordinates and higher stability of angular measurements, particularly at the longer target distance. MOSKITO TI+ showed acceptable accuracy for short to medium distances; however, its performance declined more pronouncedly with increasing distance and reduced visibility. The results suggest that the quality of sensor integration and advanced orientation systems have a significant impact on overall target localization accuracy, rather than the performance of the laser rangefinder alone [1, 3]. The operational impact of systematic measurement errors has been further quantified in the context of artillery firing accuracy [40]. A systematic azimuth bias is observable in both devices; however, this is attributable to the orientation setup procedure (absence of magnetic declination correction) and does not represent a sensor error per se. The operationally relevant parameter is therefore measurement repeatability, expressed as standard deviation (std). Table 4 summarizes the derived statistical indicators. For target Point A (2056 m), JIM COMPACT achieved an azimuth std of 6.17 mil compared to 7.53 mil for MOSKITO TI+, with corresponding CEP values of 3.67 m and 10.83 m respectively. At the longer range of Point B (3152 m), the difference became more pronounced: CEP of 7.24 m (JIM COMPACT) versus 12.66 m (MOSKITO TI+), representing a 1.75-fold improvement. The distance measurement std of MOSKITO TI+ at Point A (10.77 m) is driven by a single outlier measurement (2098 m vs. mean 2061 m); excluding this value, the ranging performance is comparable between devices. JIM COMPACT achieved near-zero distance std at both targets, consistent with its higher-specification laser rangefinder.

5. Discussion

The experimental findings are consistent with the theoretical framework established in the literature. The observed dominance of angular measurement errors over ranging errors confirms the conclusions of Chen et al. [3], who demonstrated that angular inaccuracies represent the primary source of total localization error in optoelectronic systems. The superior performance of JIM COMPACT under deteriorated conditions further supports the findings of Zhang et al. [1], who showed that the quality of orientation systems and sensor fusion algorithms has a decisive influence on geolocation accuracy. The numerical impact of calculation errors on overall firing accuracy has been similarly quantified in related artillery research. Further studies on artillery precision in specialized applications – including minefield breaching and wildfire suppression – confirm that localization accuracy is a critical determinant of mission effectiveness [41, 42, 43]. Quantitatively, JIM COMPACT demonstrated a 2.95-fold improvement in CEP at Point A (3.67 m vs. 10.83 m) and a 1.75-fold improvement at Point B (7.24 m vs. 12.66 m). The azimuth standard deviation of JIM COMPACT remained below 8 mil across both distances, while MOSKITO TI+ showed an increase from 7.53 to 13.50 mil with increasing range – indicating greater sensitivity to distance-dependent error accumulation. These figures are directly relevant to fire support applications: a CEP of 12.66 m at 3152 m represents a localization error that can substantially affect the effectiveness of indirect fire, particularly for precision munitions.

The more pronounced performance degradation of MOSKITO TI+ at longer distances and under reduced visibility aligns with reports on the sensitivity of laser measurement systems to environmental conditions [20, 6]. By contrast, the advanced orientation and data processing capabilities of JIM COMPACT partially compensate for these effects, resulting in more stable performance across varying conditions. The relevance of GNSS quality for positioning in difficult terrain types – including forest environments – further contextualizes the potential impact of navigation data degradation on overall localization accuracy [7, 23].

The consistent but direction-dependent azimuth bias observed across measurement series suggests that a space-specific azimuth correction – analogous to compass correction procedures established for artillery orientation instruments such as the PAB-2AM artillery compass – could substantially mitigate the systematic error component without requiring additional hardware. In this approach, a reference measurement to a geodetically known point would be performed at the observer's position prior to fire mission execution, and the derived correction applied to all subsequent azimuth readings for that location. This principle is methodologically analogous to established manual artillery fires correction procedures [44]. The variation of bias between Point A (+42.5 mil for MOSKITO TI+) and Point B (+77.2 mil) indicates that the correction is not fully constant across target azimuths, which suggests it is partly a function of observation geometry or local magnetic conditions rather than a fixed instrument offset. This warrants systematic experimental verification of correction stability across different azimuths, distances, and temporal conditions before operational standardization. As a hardware-based alternative, integration with gyroscopic north-finding systems – such as devices of the STERNA class – would eliminate orientation-dependent bias entirely by providing an azimuth reference independent of magnetic field conditions, at the cost of additional equipment and preparation time.

From a practical military perspective, the results support a differentiated approach to device selection based on the intended task. MOSKITO TI+ remains well-suited for lightweight personal reconnaissance tasks at short to medium distances, where its lower mass and compact form factor provide operational advantages [25]. JIM COMPACT, with its measurably superior localization accuracy – particularly in challenging environments – is the preferred choice for accuracy-dependent applications such as artillery target acquisition, where localization errors directly translate to reduced fire effectiveness and increased ammunition consumption [2, 24, 28]. The impact of terrain conditions on artillery operations further contextualizes the operational stakes of accurate target location [45]. The interoperability of target acquisition procedures and standardized data formats further affects the operational utility of such devices in joint fire environments [27].

The evaluation methodology presented here can also inform the design of simulation-based and immersive training scenarios, where realistic sensor performance parameters are critical to the fidelity of training outcomes [13, 14, 15]. The use of constructive simulation tools to model firing battery effectiveness and assess the impact of positioning errors on operational outcomes complements the experimental approach adopted in this study [28, 29]. Research infrastructure for simulation-based evaluation of artillery and combat support systems at the University of Defence provides an established methodological basis for such comparative studies [46, 47]. The broader context of defence research – including resource allocation, hybrid environment characteristics, and the evolving nature of armed conflict – underscores the continued relevance of objective equipment evaluation [48, 49, 26, 50]. Issues of operational reliability and the character of modern warfare further motivate rigorous empirical assessment of reconnaissance equipment [51, 52]. The ongoing digitization of artillery command and fire control – including AI-assisted data processing – raises additional requirements for the accuracy of sensor inputs to automated systems [53]. This requirement is also consistent with earlier research on automated artillery fire support control systems and C2I decision-making, where the quality, structure, and reliability of input data are treated as prerequisites for effective decision support. In addition, fuzzy expert systems and optimization-based approaches show that automated or semi-automated decision environments can process uncertain, incomplete, or constrained data, but their outputs remain dependent on the validity of the primary sensor measurements entering the system [54, 55, 56, 57]. The conceptual foundations of communication environments for automated artillery fire support control systems have been established in earlier research [58, 59].

6. Conclusions

This study presented a comparative experimental evaluation of two handheld optoelectronic devices – MOSKITO TI+ and JIM COMPACT – under ideal and deteriorated field conditions. The following main conclusions can be drawn:

- JIM COMPACT demonstrated measurably lower dispersion of target position errors and higher stability of angular measurements compared to MOSKITO TI+, particularly at longer distances and under conditions where angular stability becomes operationally critical. Specifically, CEP values of 3.67 m and 7.24 m were achieved by JIM COMPACT at 2056 m and 3152 m respectively, compared to 10.83 m and 12.66 m for MOSKITO TI+ under identical measurement conditions.
- The dominant source of localization error in both devices is angular measurement inaccuracy rather than ranging, which confirms existing theoretical models and is particularly relevant for target acquisition applications.
- MOSKITO TI+ remains suitable for lightweight personal reconnaissance at short to medium distances, while JIM COMPACT is the recommended choice for precision artillery target acquisition.
- The presented evaluation methodology can serve as a standardized framework for assessing optoelectronic sensors and supporting informed decision-making in force development and equipment procurement.

Future research should extend the experimental scope to cover a wider range of operational conditions, longer target distances, multiple operators, dynamic scenarios, and integration of both devices into the sensor-to-shooter chain [4, 16]. Testing in environments with intentional GNSS interference and electromagnetic countermeasures would provide further operationally relevant insights [5, 7]. Furthermore, experimental comparison of target localization accuracy achieved with and without a space-specific azimuth correction, as well as with gyroscopic north-finding support (e.g. STERNA-class devices), would directly quantify the operational benefit of each approach and provide an evidence base for procedural or equipment standardization recommendations.

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References

1. **ZHANG et al.** Precise Target Geo-Location of Long-Range Oblique Reconnaissance System for UAVs. Sensors, 2022. doi:10.3390/s22051903.
2. **GOUVEIA, Humberto; FREITAS, Ricardo.** Innovations and Trends in Field Artillery Weapon Systems. Cogent Social Sciences, 2024, vol. 10, no. 1. doi:10.1080/23311886.2024.2411867.
3. **D. Chen, G. Jin, L. Tan, L. Lu, and W. Wei**. "Target Positioning of UAV Airborne Optoelectronic Platform Based on Nonlinear Least Squares," Opto-Electronic Engineering, vol. 46, p. 190056, 2019, doi: 10.12086/oee.2019.190056..
4. **ČASAR, Josef; TOMASCH, Kryštof Siegfried; BALÁŽ, Teodor.** Utilization of Drone Systems with Optoelectronic Systems for Observational Purposes. In: International Conference on Military Technologies (ICMT). IEEE, 2025. doi:10.1109/ICMT65201.2025.11061322.
5. **SVOBODOVA, Alzbeta; DOHNAL, Filip; PEKAR, Ondrej; BLAHA, Martin.** Using Fusion of Digital Elevation Models for Artillery Crest Clearance Determination: A Study from the Czech Republic. In: 2025 International Conference on Military Technologies (ICMT). IEEE, 2025, pp. 1–8. doi:10.1109/ICMT65201.2025.11060899.
6. **MA et al.** Short-Range High-Accuracy Compact Pulsed Laser Ranging System. Sensors, 2022. doi:10.3390/s22062146.
7. **ZHANG et al.** Improving Positioning Accuracy of Mobile Laser Scanning Systems without GNSS. Remote Sensing. doi:10.3390/rs12040730.
8. **J. Cheng, L. Zhang, Q. Chen, X. Hu, and J. Cai,** "Map Aided Visual-Inertial Fusion Localization Method for Autonomous Driving Vehicles," Measurement, vol. 221, p. 113432, Nov. 2023, doi: 10.1016/j.measurement.2023.113432.

9. **O. Rolenec, M. Bilina, O. Pekař, J. Drozd, and N. Gottvaldová,** “Unmanned Aerial Vehicle LiDAR Scanning for Railway Security: Pre- and Post-Explosion Analysis”, in 2025 International Conference on Military Technologies (ICMT), IEEE, 2025, pp. 1–7, doi: 10.1109/icmt65201.2025.11060900.
10. **J. Nohel, P. Stodola, Z. Flasar, D. Kristalova, P. Zahradnicek, and L. Rak,** “Swarm Maneuver of Combat UGVs on the Future Digital Battlefield”, in Lecture Notes in Computer Science, Cham: Springer International Publishing, 2023, pp. 209–230, doi: 10.1007/978-3-031-31268-7_12.
11. **J. Drozd, L. Rak, P. Zahradnicek, P. Stodola, and J. Hodicky,** “Effectiveness Evaluation of Aerial Reconnaissance in Battalion Force Protection Operation Using the Constructive Simulation”, The Journal of Defense Modeling and Simulation: Applications, Methodology, Technology, vol. 20, no. 2, pp. 181–196, 2021, doi: 10.1177/15485129211040373.
12. **P. Stodola, J. Drozd, and J. Nohel,** “Model of Surveillance in Complex Environment Using a Swarm of Unmanned Aerial Vehicles”, in Lecture Notes in Computer Science, Cham: Springer International Publishing, 2021, pp. 231–249, doi: 10.1007/978-3-030-70740-8_15.
13. **SWIETOCHOWSKI, Norbert; VARECHA, Jaroslav; KOREC, Daniel; VITOUL, Viktor; HERCIK, Martin.** Immersive Training of Artillery Observers with Integrated Artificial Intelligence. In: Communications in Computer and Information Science. Cham: Springer Nature Switzerland, 2026, pp. 287–300. ISBN 9783032164506. ISSN 1865-0929. doi:10.1007/978-3-032-16451-3_19.
14. **PEKAŘ, Ondrej; ŠLOUF, Vlastimil; ŠOTNAR, Jiří; POTUŽÁK, Ladislav; HAVLÍK, Tomáš.** War Game as a Method of Training, as a Method of Analysis. European Conference on Games Based Learning, 2022, vol. 16, no. 1, pp. 651–654. doi:10.34190/ecgbl.16.1.656.
15. **HAVLÍK, Tomáš; BLAHA, Martin; POTUŽÁK, Ladislav; PEKAŘ, Ondrej; ŠLOUF, Vlastimil.** Wargaming Simulator MASA SWORD for Training and Education of Czech Army Officers. European Conference on Games Based Learning, 2022, vol. 16, no. 1, pp. 811–815. doi:10.34190/ecgbl.16.1.914.
16. **PEMČÁK, Ivan; BLAHA, Martin; NOVÁČKOVÁ, Kateřina; BALÁŽ, Teodor; IVAN, Jan.** Analysis of the Influence of Selected Parameters on the Success Rate of Shotgun Firing on UAVs. Measurement Science Review, 2026, vol. 26, no. 2, pp. 91–98. ISSN 1335-8871. doi:10.2478/msr-2026-0012.
17. **J. Ivan, K. Šilinger, and L. Potužák,** “Target Acquisition Systems - Suitability Assessment based on Joint Fires Observer Mission Criteria Determination”, in Proceedings of the 15th International Conference on Informatics in Control, Automation and Robotics, SCITEPRESS – Science and Technology Publications, 2018, pp. 397–404, doi: 10.5220/0006835203970404.
18. **M. Blaha, K. Šilinger, and B. Přikryl,** “Topographical-Geodetic Data for Tactical and Technical Control of Artillery Fire”, in 2017 European Conference on Electrical Engineering and Computer Science (EECS), IEEE, 2017, pp. 28–32, doi: 10.1109/eecs.2017.14.
19. **J. Šotnar, L. Potužák, and O. Pekař,** “Analýza metod určování polohy bodů v prostředí bez dostupnosti GNSS”, Vojenské rozhledy, 2025, doi: 10.52651/vr.a.2025.2.23-38.
20. **LIAO et al.** Error Analysis of Phase-Shift Laser Rangefinder with High-Level Signal. Sensors and Actuators A. doi:10.1016/S0924-4247(97)01544-6.
21. **HU et al.** Full-Range Static Method of Calibration for Laser Tracker. Electronics, 2023. doi:10.3390/electronics12224709.
22. **GUO et al.** RSSI-Based Outdoor Localization Using a Single UAV. arXiv, 2022.
23. **RYBANSKÝ, Milan; KRATOCHVÍL, Vojtěch; DOHNAL, Filip; GEROLD, Radek; KRISTALOVA, Dana; STODOLA, Petr; NOHEL, Jan.** GNSS Signal Quality in Forest Stands for Off-Road Vehicle Navigation. Applied Sciences, 2023, vol. 13, no. 10, art. 6142. EISSN 2076-3417. doi:10.3390/app13106142.
24. **DRÁBEK, Jan; SUSTR, Michal; POTUZAK, Ladislav; IVAN, Jan; LISKA, Richard.** Contingency and Emergency Manual Procedures for Calculation Firing Data Using Direction and Distance Coefficients. Engineering Reports, 2025, vol. 7, no. 6. doi:10.1002/eng2.70252.
25. **DRÁBEK, Jan; POTUŽÁK, Ladislav; HAVLÍK, Tomáš; VITOUL, Viktor; NOVÁK, Jiří.** Practical Evaluation of Instruments for Determining the Exact Position During Artillery Operations of the Czech Artillery. In: Proceedings of the Challenges to National Defence in Contemporary Geopolitical Situation, Brno, Czech Republic, 11–13 September 2024. ISSN 2538-8959. doi:10.3849/cndcgs.2024.45.
26. **CÎRDEI, Ionuț Alin.** Training of the Forces for Carrying Out Military Actions in Operational Environments Characterized by the Existence of Hybrid Threats. Land Forces Academy Review, 2023, vol. 28, no. 1, pp. 11–19. eISSN 3100-5071. doi:10.2478/raft-2023-0002.
27. **ŠUSTR, Michal; VAJDA, Michal; BLAHA, Martin; IVAN, Jan; KOREC, Daniel.** Artillery Officer Education and the Interoperability Challenge in Joint Fires: A Czech–Slovak Comparison. Cogent Education, 2025, vol. 12, no. 1. doi:10.1080/2331186X.2025.2533308.
28. **HAVLÍK, Tomas; SUSTR, Michal; IVAN, Jan; PEKAR, Ondrej; MUSINKA, Miroslav.** Evaluation of the Effectiveness of a Firing Battery in Self-Defense and Protection in the Area of Firing Positions Using Constructive Simulation. The Journal of Defense Modeling and Simulation, 2024. doi:10.1177/15485129241291579.
29. **IVAN, Jan; ŠUSTR, Michal; PEKAŘ, Ondrej; POTUŽÁK, Ladislav.** Prospects for the Use of Unmanned Ground Vehicles in Artillery Survey. In: International Conference on Informatics in Control, Automation and Robotics (ICINCO), 2022. doi:10.5220/0011300100003271.

30. **SAFRAN Group. Safran Group – Official Website. Safran, 2026. Available at: https://www.safran-group.com/**
31. **SAFRAN Vectronix. MOSKITO TI+,** Product Flyer. Safran Vectronix AG, Heerbrugg, Switzerland, 2024. Available at: https://www.safran-vectronix.ch
32. **SAFRAN Vectronix.** STERNA System – Gyroscope Based Target Acquisition System. Product Flyer. Safran Vectronix AG, Heerbrugg, Switzerland, 2021. Available at: https://www.safran-vectronix.ch
33. SAFRAN Electronics & Defense. JIM Compact – Product Flyer. Safran Electronics & Defense, Malakoff, France, 2022. Available at: https://www.safran-group.com
34. **IVAN, Jan; ŠUSTR, Michal; BLAHA, Martin; HAVLÍK, Tomáš.** Evaluation of Possible Approaches to Meteorological Techniques of Artillery Manual Gunnery after the Adoption of Automated Fire Control System. Vojenske Rozhledy – Czech Military Review, 2021, vol. 30, no. 3, pp. 75–92. doi:10.3849/2336-2995.30.2021.03.075-092.
35. **SLÁDEK, David; ŠUSTR, Michal; IVAN, Jan; HUDEC, Filip.** Building Meteorological Backup Artillery Products: Leveraging Upper Air Data. Vojenské Rozhledy, 2025, vol. 34, no. 1, pp. 136–158. doi:10.3849/2336-2995.34.2025.01.136-158.
36. **IVAN, Jan; ŠUSTR, Michal; SLÁDEK, David; VARECHA, Jaroslav; GREGOR, Jiří.** Emergency Meteorological Data Preparation for Artillery Operations. In: Proceedings of the 20th International Conference on Informatics in Control, Automation and Robotics. SCITEPRESS, 2023, pp. 250–257. doi:10.5220/0012205500003543.
37. **M. Kratky, V. Minarik, M. Sustr, and J. Ivan,** "Electronic Warfare Methods Combatting UAVs", Advances in Science, Technology and Engineering Systems Journal, vol. 5, no. 6, pp. 447–454, 2020, doi: 10.25046/aj050653.
38. J. Farlik, M. Kratky, J. Casar, and V. Stary, "Multispectral Detection of Commercial Unmanned Aerial Vehicles", Sensors, vol. 19, no. 7, art. 1517, 2019, doi: 10.3390/s19071517.
39. **T. Palasiewicz, O. Rolenec, L. Kroupa, P. Manas, and D. Coufal,** "Blast-Induced Deformations of the Building Entrance Part Caused by Improvised Shaped Charges", in Lecture Notes in Computer Science, Cham: Springer International Publishing, 2023, pp. 109–130, doi: 10.1007/978-3-031-31268-7_7.
40. **GOUVEIA, Humberto; BORGES, Jorge.** The Impact of Numerical Shifts on the Field Artillery Firing Accuracy. In: Developments and Advances in Defense and Security: MICRADS 2023. Smart Innovation, Systems and Technologies 380. Singapore: Springer, 2024. doi:10.1007/978-981-99-8894-5_12.
41. **ŠVEHLÍK, Miloslav; ŠUSTR, Michal; POTUZÁK, Ladislav; VARECHA, Jaroslav; DRÁBEK, Jan.** Creating of Minefield Breaches with Artillery. In: Proceedings of the 20th International Conference on Informatics in Control, Automation and Robotics. SCITEPRESS, 2023, pp. 266–272. doi:10.5220/0012208500003543.
42. **ŠVEHLÍK, Miloslav; SEDLÁČEK, Marek; HASILOVÁ, Klára; DRÁBEK, Jan; ŠLOUF, Vlastimil.** Applications in Engineer and Artillery Support: Mathematical Modeling of Sympathetic Detonation. Challenges to National Defence in Contemporary Geopolitical Situation, 2024, vol. 1, no. 1. doi:10.3849/cndcgs.2024.634.
43. **KOREC, Daniel; BLAHA, Martin; BARTA, Jan; VARECHA, Jaroslav.** Innovative Approaches to the Use of Artillery in Wildfire Suppression. Fire, 2025, vol. 8, no. 6, art. 232. doi:10.3390/fire8060232.
44. **ŠUSTR, Michal; IVAN, Jan; BLAHA, Martin; POTUZÁK, Ladislav.** A Manual Method of Artillery Fires Correction Calculation. Military Operations Research, 2022, vol. 27, no. 3, pp. 77–94. doi:10.5711/1082598327377.
45. **SEDLÁČEK, Marek; DOHNAL, Filip; IVAN, Jan; ŠUSTR, Michal.** Possible Approaches to Assessing Terrain Mobility after the Effects of Artillery Munition. Cogent Social Sciences, 2024, vol. 10, no. 1. doi:10.1080/23311886.2024.2368096.
46. **KRÁTKÝ, Martin; PEKAŘ, Ondřej; IVAN, Jan.** Simulation Support of Teaching and Research Activities at the Departments of Combat Support Forces at the University of Defence. In: 2023 International Conference on Military Technologies (ICMT). IEEE, 2023, pp. 1–8. doi:10.1109/icmt58149.2023.10171204.
47. **PEKAŘ, Ondřej; NOVÁK, Jiří; VARECHA, Jaroslav; ŠOTNAR, Jiří; DRÁBEK, Jan.** Bridging Theory and Practice in Military Education Through Advanced Technologies. European Conference on Games Based Learning, 2024, vol. 18, no. 1, pp. 1056–1060. doi:10.34190/ecgbl.18.1.2648.
48. **HUJER, Vladimír; ŠLOUF, Vlastimil; FARLÍK, Jan.** Utility as a Key Criterion of a Decision-Making on Structure of the Ground Based Air Defence. In: Modelling and Simulation for Autonomous Systems (MESAS 2021). Lecture Notes in Computer Science. Cham: Springer, 2022. doi:10.1007/978-3-030-98260-7_15.
49. **ROLENEC, Ondřej; ŠILINGER, Karel; SEDLÁČEK, Marek.** Algorithm Development of the Decision-Making Process of an Engineer Specialization Officer. In: Modelling and Simulation for Autonomous Systems (MESAS 2021). Lecture Notes in Computer Science, vol. 13207. Cham: Springer, 2022. doi:10.1007/978-3-030-98260-7_18.
50. **RAȚIU, Aurelian et al.** Military Actions Characteristics in Hybrid Operational Environments. International Conference Knowledge-Based Organization, 2023, vol. 29, no. 1, pp. 78–85. Nicolae Balcescu Land Forces Academy. doi:10.2478/kbo-2023-0013.
51. **ŽILINČÍK, Samuel; PIKNER, Ivo; STANĚK, Jaroslav.** Character of War: How to Understand It? Analyzing the Logic and Utility of the Approaches Employed for the Understanding of War. Obrana a strategie, 2023, vol. 23, no. 1, pp. 109–125. ISSN 1802-7199. doi:10.3849/1802-7199.23.2023.01.109-125.
52. **ŠLOUF, Vlastimil; BLAHA, Martin; PEKAŘ, Ondřej; BRIZGALOVÁ, Lenka; MÜLLNER, Vojtěch.** An Alternative Model for Determining the Rational Amount of Funds Allocated to Defence of the Czech Republic in Conditions of Expected Risk. Obrana a strategie, 2023, vol. 23, no. 1, pp. 149–172. ISSN 1802-7199. doi:10.3849/1802-7199.23.2023.01.149-172.

53. **BLAHA, Martin; VARECHA, Jaroslav; DRÁBEK, Jan; NOVÁK, Jiří.** Comparison of AI Speech-to-Text Systems and Their Application in Artillery Command and Fire Control Systems. In: Communications in Computer and Information Science. Cham: Springer Nature Switzerland, 2025, pp. 82–95. doi:10.1007/978-3-032-04339-9_6.
54. **M. Klima, M. Bures, and M. Blaha,** “Ant Colony Optimization Based Algorithm for Test Path Generation Problem with Negative Constraints”, in 2024 IEEE 24th International Conference on Software Quality, Reliability and Security (QRS), IEEE, 2024, pp. 701–712, doi: 10.1109/qrs62785.2024.00075.
55. **D. Cimr, H. Tomaskova, R. Cimler, J. Kuhnova, and V. Slouf,** “A System to Evaluate an Air-Strike Threat Level Using Fuzzy Methods”, in Lecture Notes in Computer Science, Cham: Springer International Publishing, 2018, pp. 322–331, doi: 10.1007/978-3-319-98446-9_30.
56. **M. Blaha and K. Brabcova,** “Decision-Making by Effective C2I System”, in Proceedings of the 7th International Conference on Information Warfare & Security, Seattle: Academic Publishing Limited, 2012, pp. 44–50.
57. **M. Blaha and M. Sobarna,** “Some Development Aspects of Perspective Fire Support Control System in Czech Army Conditions”, in Proceedings of the 6th WSEAS International Conference on Dynamical Systems & Control (CONTROL 2010), Tunisia: WSEAS Press, 2010, pp. 179–183.
58. **BLAHA, M. C**ommunication as a Basic for Future Artillery Fire Support Control System. In: The European Conference of COMMUNICATIONS (ECCOM’10). Tenerife: WSEAS Press, 2010, pp. 140–142. ISBN 978-960-474-250-9.
59. **BLAHA, M.; BRABCOVÁ, K.** Communication Environment in the Perspective Automated Artillery Fire Support Control System. In: The 10th WSEAS International Conference on Applied Informatics and Communications (AIC’10). Taipei: WSEAS Press, 2010, pp. 236–239. ISSN 1792-4634. ISBN 978-960-474-216-5