Serbian Mine Action Center

UAS application in NTS

Training experience

"The practical demonstration of how UAV-derived geospatial products are used in NTS includes the overlay of risk indicators, spatial analysis, and evidence-based decision-making."

Training period: 09.-12.02.2026
Duration: 36 hours
Venue: Serbian Mine Action Centre (SMAC)
Velika Moštanica, Republic of Serbia

UAV TEAM Serbia

Key Connections of the training program and IMAS

IMAS 08.10 – Non-Technical Survey (NTS)

- UAS provide aerial imagery and terrain analysis
- Identification of indicators of mine/UXO contamination
- Support for mapping suspected hazardous areas (SHA)

IMAS 09.10 – Clearance Requirements

- High-resolution orthophotos and terrain models support planning of clearance operations
- Better prioritization of hazardous areas

IMAS 07.31 – Occupational Safety and Health

- UAS reduce the need for personnel to enter hazardous areas during early survey stages
- Improves safety of mine action personnel

IMAS 04.10 – Accreditation of Demining Organizations

- Integration of UAS requires accredited procedures, trained operators, and validated methodologies

IMAS 01.10 – Guide for the Application of IMAS

- Provides the framework for integrating new technologies such as UAS in mine action operations

Content:

- IMAS-aligned NTS methodology
- UAVs structrue
- Sensors- (RGB)
- UAVs mission planning and flight operations
- Photogrammetric processing (orthophoto, DSM, DTM…)
- GIS analysis in QGIS
- Benefits for NTS
- Safety and SOP implementation

Humanitarian demining = risk management, not just reconnaissance.

UAVs are not a “silver bullet.”

UAVs are a **decision-support tool**, not a replacement for field operations.

4. COURSE STRUCTURE

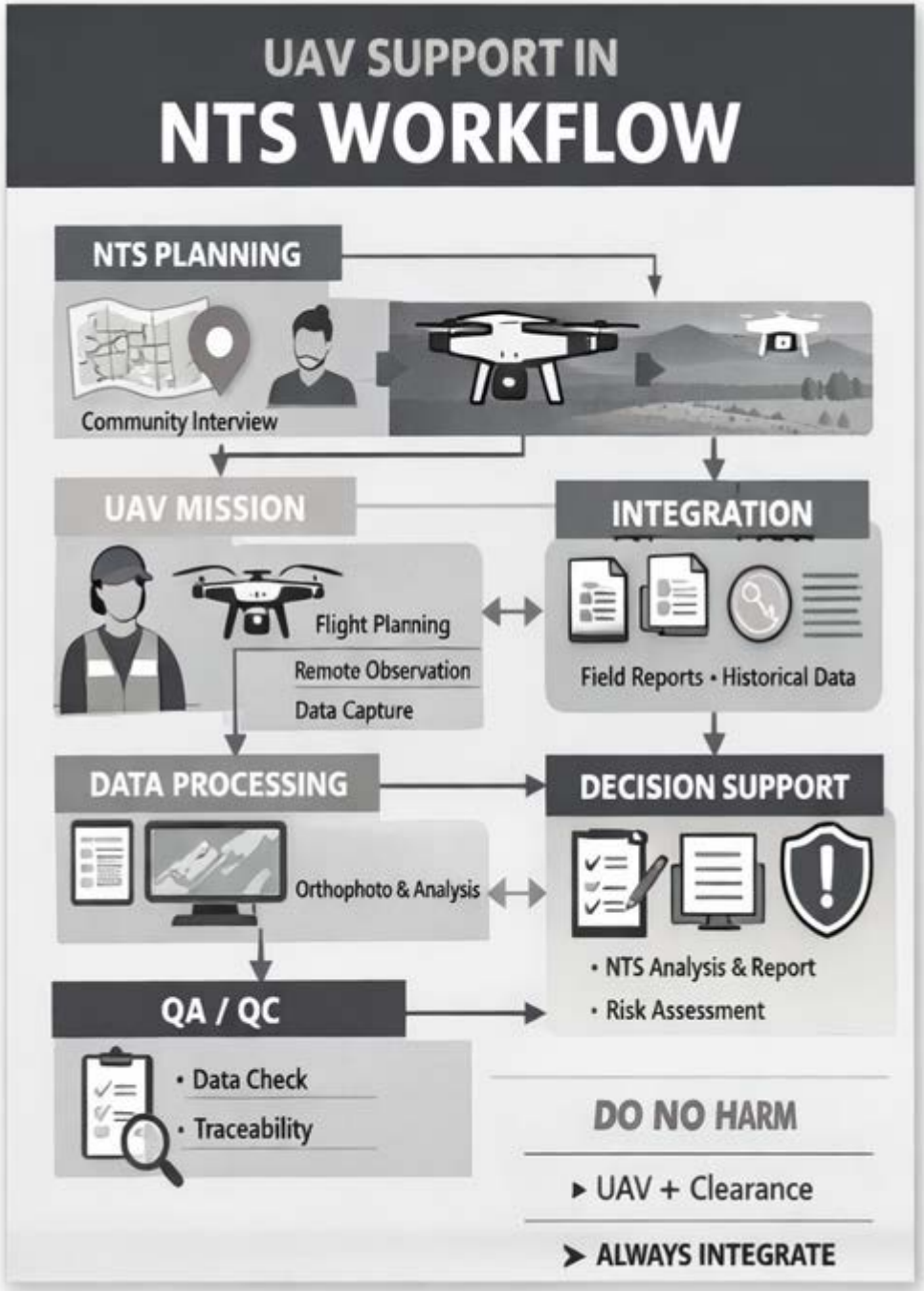
Duration: 4 days

Training ratio:

- 30% theoretical&demo instructions
- 70% practical exercises

Resources

- UAVs –DJI products
- Software packages PIX4D mapp, Q Gis
- Polygons
- Classroom
- Didactic materials
- Interactive apporoach -



Participants

Total Number of Participants

- 9 participants

Country Distribution

- Serbia – 6
- Bosnia and Herzegovina – 2
- Montenegro – 1

Institutional Representation

- Armed Forces of Serbia
- Ministry of Interior
- Serbian demining companies – 2 person
- SMAC – 2 person
- BiH demining companies – 2 person
- Montenegro demining companie - person

- 5 participants had no prior UAV experience
- 3 participants had basic UAV experience
- 3 participants had more than 5 years of demining experience
- 1 participant had 3–5 years of experience
- 2 participants had 1–3 years of experience
- 2 participants had less than 1 year of experience
- 1 participant had no demining experience

The participant group represented a balanced mix of operational and institutional expertise.

KEY POINTS for Flight operations

1. Takeoff and Landing
•Controlled vertical takeoff and landing (VTOL)
•Safety checks: clear area, battery, GNSS/RTK, payload readiness
•Smooth transitions to avoid damage to the UAV or surroundings

2. Circular / Focus-Point Flight
•Orbiting a fixed point of interest for **high-detail imagery**
•Maintain **constant altitude and camera orientation**
•Capture **360° coverage** of target (e.g., suspected UXO feature, trench, or structure)

3. Obstacle Avoidance
•Visual and sensor-based detection of obstacles
•Automatic or manual avoidance to maintain safe flight

4. Line-of-Sight (LOS) / Visual Line-of-Sight (VLOS)
•Maintain continuous **LOS or VLOS** to UAV per regulations
•Ensures immediate response to emergencies
•Critical for safe navigation in complex or vegetated areas

5. Flight Execution Best Practices
•Maintain **planned flight path and speed**
•Keep **camera nadir or specified angle**
•Monitor telemetry and adjust for wind, drift, or GNSS errors

SELFCHECK LIST FOR ATENDENCES

1. Flight plan defined (altitude, overlap, speed)

☐ Forward overlap ≥ 75%
☐ Side overlap ≥ 65%
☐ Batteries fully charged (drone + controller)
☐ SD card empty / sufficient storage available
☐ Camera lens clean
☐ RTK status (if available) → **FIX**
☐ GNSS signal stable
☐ Weather conditions suitable (wind or rain, visib.)
☐ Sun position: avoid strong shadows

2. In-flight

☐ Constant flight altitude
☐ Constant speed
☐ No abrupt direction changes
☐ Camera set to nadir (90°)
☐ Continuous image capture (no interruptions)
☐ Full area coverage (no gaps)
☐ Visual check: no motion blur

3. Image Quality Check (on-site quick review)

☐ Images are sharp (no motion blur)
☐ Proper exposure (not too dark/bright)
☐ No strong shadows or reflections
☐ Overlap visible between images
☐ No coverage gaps

4. Georeferencing

☐ GPS/RTK data present in EXIF
☐ GCPs (if used):
    ☐ visible in images
    ☐ properly distributed
    ☐ accurately surveyed

5. Post-flight (on-site)

☐ Data backup completed (laptop / external drive)
☐ All images verified and saved
☐ No corrupted files
☐ Number of images matches flight plan

QUALITY ASSURANCE (QA) OF NTS DATA PROCESSING RESULTS

Pix4D QA Outputs

- **Point Cloud and DTM/DSM**
  - Dense and continuous; minimal noise or artifacts
  - DTM accurately represents bare earth; vegetation/building filtered
- **Orthomosaic**
  - Seamless, no ghosting, consistent radiometry
- **Reprojection and GCP Accuracy**
  - Reprojection error ≤ 1 px
  - GCP RMS error ≤ 5 cm (if used)
- **Visual Validation**
  - Terrain features match field-observed conditions
  - Cross-check anomalies (trenches, craters) against UAV imagery

2. QA of QGIS Analysis Results

- **Input Layer Integrity**
  - CRS, resolution, and extent are consistent across layers
- **Terrain Derivatives (Slope, TRI, TPI, Roughness, SVF)**
  - Logical terrain patterns; no edge artifacts
- **Raster Calculations**
  - Correct formulas, no NULL propagation, aligned outputs
- **Validation**
  - Compare raster outputs with orthophotos and field observations
  - Ensure reproducibility and consistency across analyses

5. EVALUATION RESULTS

5.1 Course Content
67% rated clarity of objectives as Excellent (5)
78% rated course content as Excellent (5)
74% rated alignment with IMAS standards as Excellent (5)
74% rated relevance to real NTS operations as Excellent (5)
100% rated the balance of theory and practice as Excellent (5)

5.3 Instructor Performance
100% rated professional expertise as Excellent (5)
100% rated opportunity to ask questions as Excellent (5)
100% rated practical UAV demonstrations as Excellent (5)
100% rated practical data processing demonstrations as Excellent (5)

5.2 Organization and Delivery
78% rated overall organization as Excellent (5)
89% rated practical exercises as Excellent (5)
89% rated fieldwork organization as Excellent (5)
76% rated course tempo as Excellent (5)

5.4 Safety and Operational Applicability
100% rated clarity of safety procedures as Excellent (5)
89% rated understanding of UAV role in NTS as Excellent (5)
77% rated practical applicability of knowledge as Excellent (5)

QUALITATIVE FEEDBACK

Participants identified the following as the most valuable aspects of the course:

- Practical UAV flight training
- Hands-on GIS and data processing
- Application of processed outputs in NTS reporting

Final Test – UAV Flight Operations and NTS Workflow

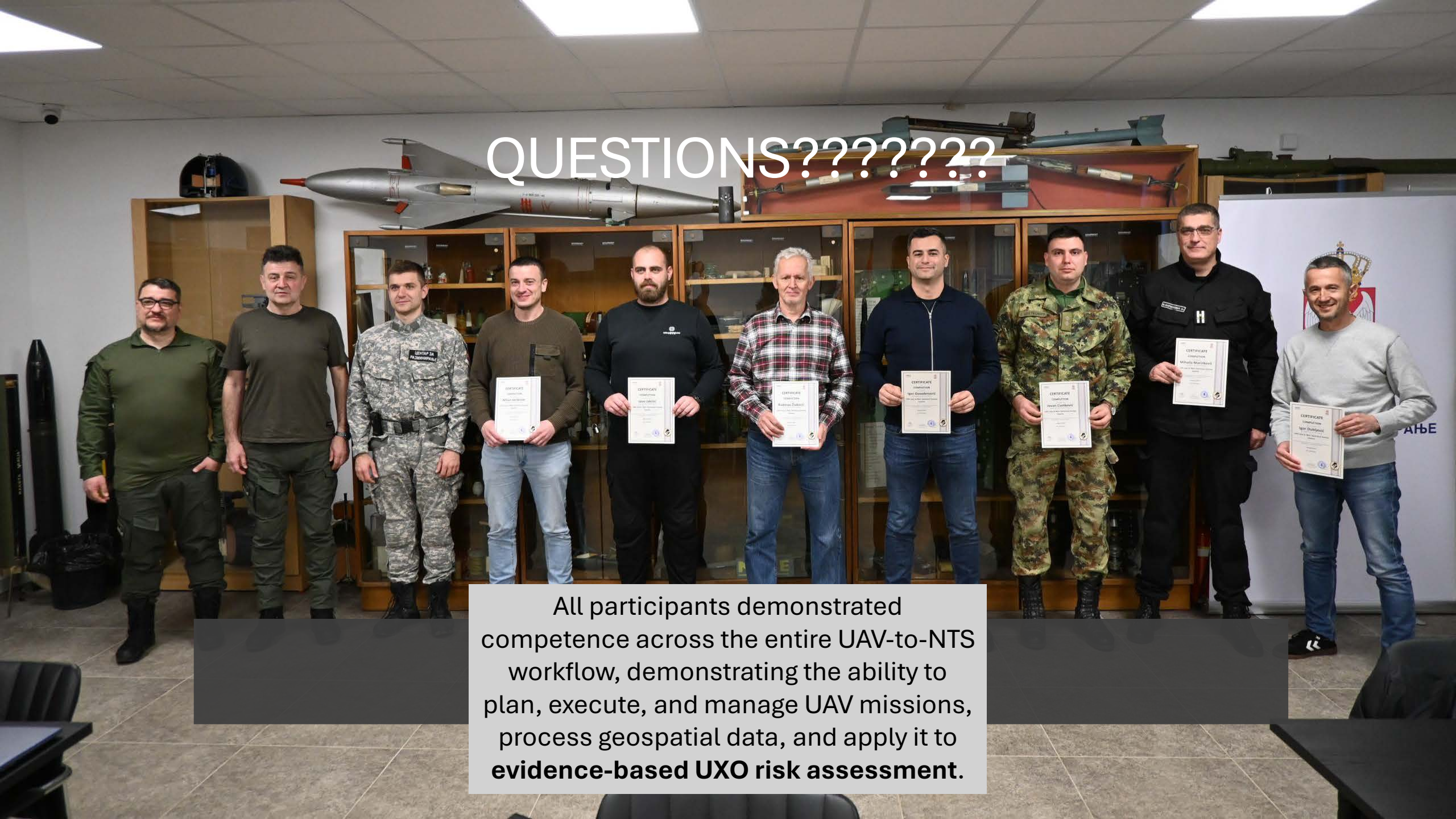
During the final exam, each participant was assigned a specific task as part of the evaluation process, which included

1. Mission Planning and Execution
•Planning M300 RTK missions and defining the **AOI**
•Performing **safe takeoffs and landings**
•Conducting **obstacle-aware flight maneuvers**
•**Surface mapping**
•Ensuring **complete and high-quality data acquisition**

2. Data Acquisition and Processing
•Collecting geospatial imagery according to **planned flight parameters**
•Processing raw UAV data in **Pix4D** to generate **orthomosaics, DSM,DTM**
•Importing **Pix4D outputs into QGIS** for further spatial analysis

3. NTS Application and Analysis
•Using processed geospatial data to **identify high-risk zones**
•Integrating QGIS outputs into the **NTS investigation workflow**
•Applying the learned methodology for **SHA/CHA classification and risk assessment**

QUESTIONS???????



All participants demonstrated competence across the entire UAV-to-NTS workflow, demonstrating the ability to plan, execute, and manage UAV missions, process geospatial data, and apply it to **evidence-based UXO risk assessment**.