

## Military Bridge Classification – The Role of BRASSCO NG in NATO’s Capability Profile

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### Abstract:

Military bridge classification is essential for operational planning in national and collective defence. It is based on NATO STANAG 2021, defining Military Load Classification (MLC) for vehicle-bridge compatibility. NATO partners use tools like BRASSCO NG to assess bridge usability efficiently. It enables rapid evaluation via manual and semi-automated methods such as drone surveys and laser scanning. These methods gather precise data for structural analysis and MLC determination. The results integrate with military command systems to support planning and decisions. Automation reduces effort and enhances assessment speed and consistency. Future development aims at damage detection and battlefield usability assessment. BRASSCO NG will support repair estimation and infrastructure resilience. Thus, it strengthens mobility and critical infrastructure reliability in military contexts.

**Keywords: Military Bridge Assessment, Bridge Classification, STANAG 2021, Infrastructure Resilience, Bridge Load Capacity**

### 1 Introduction:

The ability to move troops and military equipment fast and safe is one of the most important parts of NATO’s readiness. In big multinational exercises like Defender Europe [1] or in the case of the NATO Response Force (NRF) [2]. Military mobility plays a key role. It makes sure that forces can arrive in the right place at the right time, also across borders and different countries. The war in Ukraine has shown very clearly how important good infrastructure is, especially in the rear areas, for the flexibility and strength of NATO forces. Because of that, the EU Military Mobility Action Plan [3] and the strengthening of NATO’s forward presence [4] in the eastern member states have become more important again. These projects want to make military transport easier and faster and also help to bring the different systems and rules of the NATO and EU countries closer together.

Bridges are a very important part of this military transport system, but they can also be a weak point. A bridge that is too weak or not well known can stop a whole unit or delay operations. This is true for normal (civilian) bridges, but also for military bridges that are built during a mission. That’s why it is necessary to know exactly what load a bridge can carry, and if it is strong enough for certain vehicles.

Today, many military vehicles are very heavy, especially tanks, engineering vehicles or supply trucks. Some of them have special axle loads, and that can be a problem for older or smaller bridges. Because of this, NATO uses standard rules and systems to check and classify bridges. These systems must be fast, reliable and compatible with the planning tools of the alliance, so that commanders can make good decisions during training or in real missions.

This paper wants to show how bridge classification works inside the NATO framework, and how it is used in practice with the help of the digital tool BRASSCO NG (Bridge Assessment Code – New Generation) [5]. The main focus is on how this tool supports the evaluation of bridges during military missions and exercises. The classification follows the Military Load Classification (MLC) concept, which defines how much load a bridge can safely carry when crossed by military vehicles. This concept is officially established in STANAG 2021 (Standardization Agreement 2021) [6], and the technical details are provided in the Allied Engineering Publication AEP-3.12.1.5 [7].

This AEP gives all the necessary formulas, factors and procedures to calculate a bridge’s MLC value in a harmonised way. It considers different bridge types, loading conditions, vehicle types and operational factors. BRASSCO NG uses this standard to calculate MLC values directly from the bridge data input and the relevant NATO vehicle classes.

In today’s multinational operations, it is essential to perform fast, standardised and interoperable bridge assessments, especially when moving across several NATO countries. The BRASSCO NG software enables military engineers and even other personnel to perform these assessments quickly and reliably, with full digital support. It helps to reduce errors, improve reaction time and increase coordination between partner nations.

By doing so, BRASSCO NG plays an important role in standardisation, digitalisation and operational effectiveness of NATO’s engineering forces. It is already implemented at the German military, used during exercises and in real deployment scenarios. It is being continuously updated, for example to support UAV-based bridge inspections or 3D geometry input systems. With this, BRASSCO NG contributes directly to NATO’s mobility and readiness goals.

## 2 Classification Logic and Load Models in NATO's MLC System

The core idea of the Military Load Classification (MLC) system is to provide a numerical value that allows military planners to compare the load capacity of a bridge with the load demand of a vehicle. This matching process ensures that only vehicles of suitable class are routed across a given structure. The MLC system is defined in STANAG 2021 Edition 9 [6], which forms the basis for its use in NATO operations.

The framework described in STANAG 2021 introduces a set of hypothetical standard vehicles, also called load models, which simulate typical wheeled and tracked military vehicles. These models are not real vehicles, but simplified patterns that serve as a reference for structural analysis and classification. For each MLC level, there is one model for wheeled and one for tracked vehicles, reflecting their different load distributions. The following Figure 1 shows some examples (MLC 90 and MLC 100) from the AEP. The technical implementation, including axle schemes, dimensions, and loading rules, is detailed in AEP-3.12.1.5 [7].

1	2	3	4	5	6
MLC	Tracked Vehicles	Wheeled Vehicles			
		Axle Load [Tonnes] and Spacing [m]	Axle Load and Nominal Ground Contact Length [m]	Tyre Load and Nominal Ground Contact Width [m]	Axle Wheel Spacing and Nominal Ground Contact Width [m] *
90					
100					

Figure 1: Example hypothetical vehicles MLC 90 and 100 [7]

The load from tracked vehicles is represented either as a surface load or a line load, applied over the length or area of the track contact surface. In contrast, the load from wheeled vehicles is simplified as a uniform surface load over the tyre footprint or as a single concentrated load acting at the centre of the contact area.

For all standardised model vehicles, a reference table provides the corresponding unit bending moments (UBMs) [kN/m] and shear forces [kN] for simply supported single-span bridges with spans ranging from 1 m to 100 m. The unit bending moment (UBM) is defined as the maximum bending moment divided by the span length of the bridge. (These span lengths correspond to the values highlighted in green in Figure 2)

	MLC															
	4	8	12	16	20	24	30	40	50	60	70	80	90	100	120	150
1	5.57	12.24	17.81	21.14	24.48	26.71	32.25	37.82	44.49	51.16	56.73	62.29	66.73	71.20	80.10	93.44
1.5	5.57	12.24	17.81	21.14	24.48	26.71	32.25	37.82	44.49	51.16	56.73	62.29	66.73	71.20	80.10	93.44
2	5.57	12.24	17.81	21.14	24.48	26.71	32.25	37.82	44.49	51.16	56.73	62.29	66.73	71.20	80.10	93.44
2.5	5.57	12.24	17.81	21.14	24.48	26.71	32.25	37.82	44.49	51.16	56.73	62.29	66.73	71.20	80.10	93.44
3	5.57	12.24	17.81	21.14	24.48	28.24	32.25	37.82	44.49	51.16	56.73	62.29	66.97	71.20	80.10	93.44

Figure 2: Example data UBM [7]

The classification process compares the bending moment and shear force caused by these standard load models to the calculated or estimated structural resistance of the bridge. Based on the maximum admissible internal force, the bridge is assigned a corresponding MLC value. If the load effect falls between two discrete MLC levels, linear interpolation is permitted, allowing for intermediate MLC numbers that are not directly covered by the model vehicles [7].

Depending on the width and structure of the bridge, two values can be assigned: one for single-lane traffic and one for two-lane traffic, with the latter typically allowing for lower load classes due to the simultaneous loading effects.

The theoretical basis of MLC load models has been thoroughly described by [8], while [9] extended the concept through a practical application using machine learning for data-based bridge classification.

In many real-world cases, detailed static calculations or structural models are not available, especially in field or deployment conditions. In such situations, the attribution of an MLC value to a specific bridge is often based on observable

physical characteristics, such as span length, number of supports, material type, and structural configuration. This requires the use of engineering judgement or simplified assessment methods. To support this process, data-driven approaches have also been explored. For example, [9] proposed the use of machine learning to predict MLC values based on bridge attributes in the absence of full calculation data.

In addition to BRASSCO, there are other recognised approaches to bridge classification within NATO and partner nations. One example is the Canadian MLC-Suite, a Windows-based application developed by the Canadian Armed Forces [10]. It integrates the outputs of three subordinate modules and provides a Go/No-Go recommendation for bridges and routes based on simplified or analytical methods [10].

Another alternative is the Belgian method, which uses national empirical models and correlation tables to estimate MLC values based on limited structural information [11]. These methods are especially useful in expeditionary contexts, where rapid assessments are required but full structural data may not be available. The Belgian method is currently taught as part of the NATO Bridge Assessment Course and relies on correlation tables for simplified classification [12].

Together, these tools reflect the variety of operational needs and methodological preferences across NATO and demonstrate the ongoing effort to harmonise engineer support through interoperable software and shared standards.

### 3 The BRASSCO NG Assessment System

BRASSCO NG (Bridge Assessment Code – New Generation) is a software-based platform developed to support the assessment, classification, and documentation of military bridge infrastructure. This tool was designed to provide engineers with a standardised digital tool for evaluating the load-carrying capacity of existing and temporary bridges in accordance with NATO standards. Figure 3 shows the landing page of the software with the bridge types on the left and the start

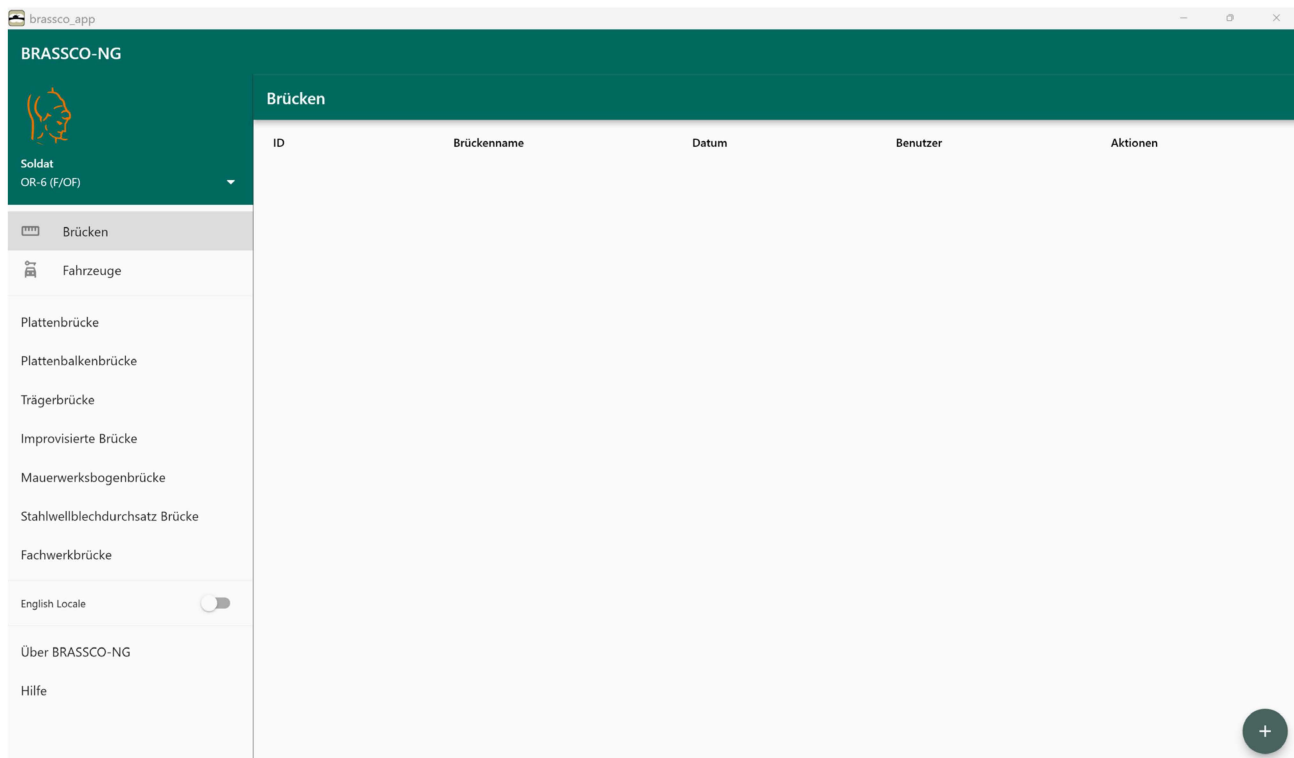


Figure 3: BRASSCO-NG GUI Landing page

Over the last years, the BRASSCO NG tool has undergone significant further development, especially regarding its usability and flexibility. Today, the system supports different user categories, allowing not only trained engineers but also non-specialist personnel to perform a rapid initial classification of bridges, which can be seen in the following Figure 4 from [12]. This makes the tool suitable for field use by military staff who may not have a civil engineering background.

Level	Description of the expertise
A	personnel WITHOUT any specific experience in bridge engineering
B	personnel TRAINED in bridge engineering and military bridge assessment, like (warrant) officers engineers
C	personnel with a BACHELOR DEGREE in civil engineering and <u>trained</u> in bridge engineering and military bridge assessment
D	personnel with at least a MASTER DEGREE in civil engineering and <u>experienced</u> in military bridge assessment
HN	Assessment by local authorities (host nation)

Table 1 : Levels of expertise of the leader of the assessment team or its counselor

Figure 4: Level of expertise of the reconnaissance and assessment team [12]

At the same time, advanced numerical modules have been integrated into the software, enabling qualified structural engineers and technicians to carry out more precise and detailed assessments. These modules include calculation routines for internal forces, influence lines, and structural checks based on input geometry and material assumptions. In this way, BRASSCO NG can be used both for quick tactical decisions and for technically sound classifications according to established engineering standards.

The system has been developed through multinational cooperation under the coordination of the NATO Military Engineering Centre of Excellence (MILENG COE), with essential contributions from partner nations and the Team of Experts Military Bridging and Assessment (ToE MBA). This expert group, composed of military engineers, civil infrastructure specialists, and software developers from several NATO countries, played a central role in the design, specification, and validation of the BRASSCO NG system. Their combined efforts ensured that the tool meets both the technical standards defined in NATO doctrine and the operational requirements of field units. As a result, BRASSCO NG can be used effectively for bridge assessments in tactical scenarios and for mobility planning in multinational operations.

BRASSCO NG provides a wide range of technical functions to enable fast and reliable classification of bridges. The main functionalities include:

Data input for structural and geometrical information: span lengths, number of spans, type of supports, construction materials, bridge width, and condition state. An example of a slab bridge input in BRASSCO can be seen in Figure 5. Integration of military vehicle data in the so called “vehicle creator”, including Military Load Classification (MLC) values and vehicle geometry. This allows for precise comparison between bridge capacity and vehicle requirements. Automated calculation of the bridge’s MLC according to the technical procedures defined in AEP-3.12.1.5 [7]. The software applies load models for wheeled and tracked vehicles and considers relevant safety factors. Other data from the reconnaissance necessary for bridge survey or notes can be put into the files, too.

Figure 5: BRASSCO-NG GUI slab bridge input

BRASSCO NG is suitable for tactical-level assessments, including under time pressure or in areas with limited technical infrastructure. Its design allows mobile use on ruggedised devices, cause of the use via tablet. The system also includes a reporting function that generates standardised MLC evaluation sheets, which can be stored, exported, and transferred to other platforms. By doing so, BRASSCO NG supports interoperability and enables seamless data exchange between nations during joint operations.

This capability ensures that bridge assessment data can be integrated into larger command and control (C2) environments, making it available for operational decision-making in real time. As a result, BRASSCO NG contributes to the digitalisation and standardisation of NATO's engineering forces and enhances the overall responsiveness in deployment and mobility scenarios.

BRASSCO is not only compatible with Windows-based computers but can also be used on mobile Android devices running SDK version 2.1 or higher [13]. The software applies the Finite Element Method (FEM) to calculate the Military Load Classification (MLC) of bridge structures.

In its current version (v1.2.6), the program can classify seven different bridge types, including:

- Slab bridges
- Slab-and-beam bridges
- Improvised/makeshift bridges
- Masonry arch bridges [14]
- Corrugated steel culvert bridges
- Truss bridges
- Composite girder bridges (steel–concrete or steel–timber)

To perform a classification, the user must enter the relevant geometric parameters specific to the selected bridge type. The system currently supports the assessment of bridges with up to six individual spans.

#### 4 Digital Bridge Survey Using UAV and Laser Scanning

In recent years, unmanned aerial vehicles (UAVs) equipped with LiDAR sensors have been successfully used for the digital acquisition of bridge structures in various test and operational environments. These UAV-based systems enable a fast and contact-free recording of geometric bridge data, even in locations that are difficult to access, such as deep valleys or damaged structures and most important under bridges.

Some examples of this approach were carried out during a joint demonstration project of the Bundeswehr University Munich with the German military, where different existing bridge structures were scanned with UAVs using LiDAR and photogrammetry. The collected data was processed into high-resolution 3D models that could be used for structural analysis and military load classification. One example can be seen in

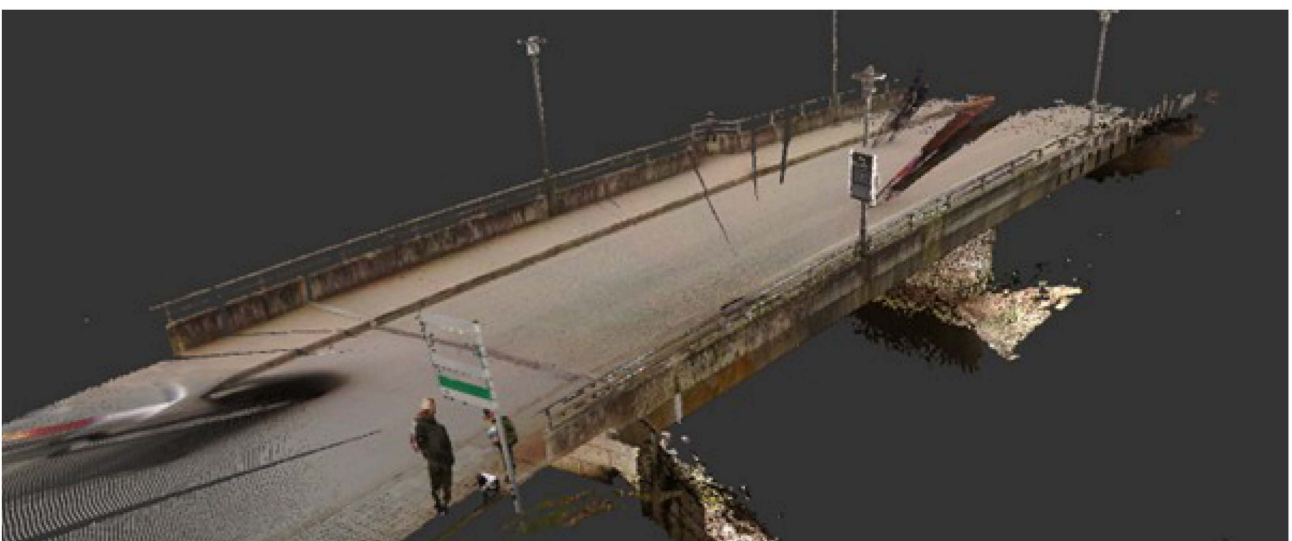


Figure 6: point cloud of a bridge of the joined demonstration of the German military Bundeswehr and the University of the Bundeswehr Munich^

From the generated point clouds, it was possible to automatically extract key structural parameters like in the examples Figure 7 and Figure 8 below, including:

- Span lengths and support distances,
- Cross-section geometry,
- Support and bearing locations,
- And in some cases, surface material types, estimated from textures and reflectivity values.



Figure 7: point cloud with extracted parameters of the cross section

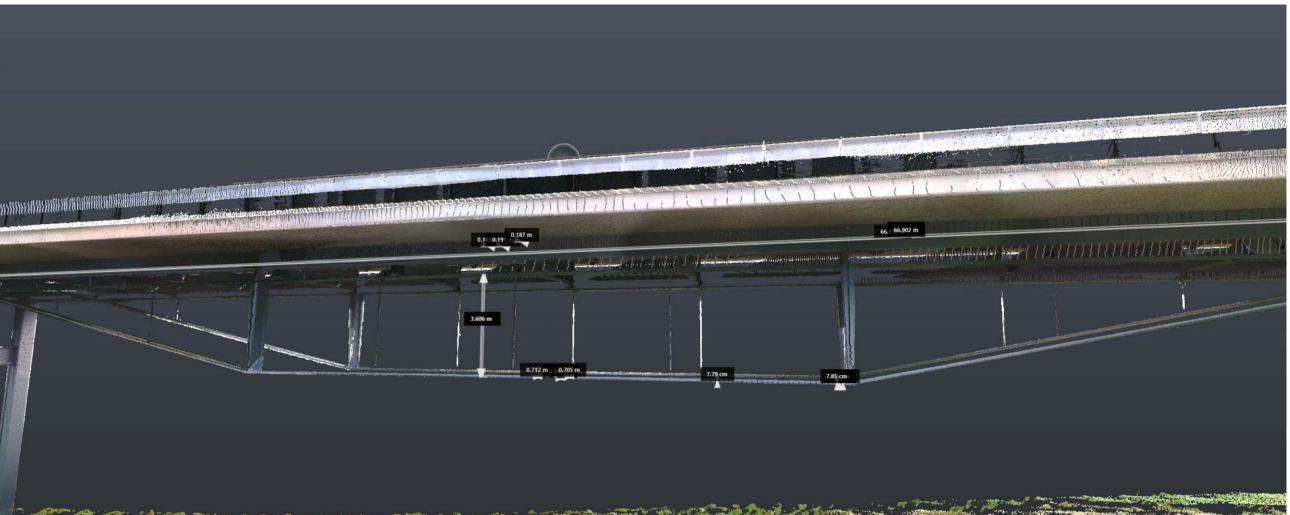


Figure 8: point cloud with extracted parameters of the side view

These 3D models serve as a valuable digital basis for further evaluation, either by engineers using conventional static analysis or within digital tools such as BRASSCO NG. While full integration is still under development, the current data formats can already be adapted to different interfaces, making future use in interoperable NATO environments feasible.

This method has proven to be especially useful in time-critical or tactical situations, where no construction plans or inspection documents are available or in critical areas, where the typical reconnaissance is not possible. In such cases, the combination of UAV, LiDAR, and automated data processing allows a rapid initial classification, which can later be refined by expert evaluation. These workflows are currently being tested and refined in research projects and have already been applied in pilot assessments of infrastructure objects relevant for military mobility planning.

The following Figure 9 and Figure 10 show the input in the BRASSCO Interface and the rough MLC classification of one of the examples, shown in Figure 6.

Figure 9: Input of data of the example bridge into BRASSCO GUI

111 MLC Rad-Einspurig      50 MLC Rad-Zweispurig      98 MLC Kette-Einspurig      20 MLC Kette-Zweispurig

Rad      Kette

(WR) : Die (gesamte) Fahrzeugbreite überschreitet die Fahrbahnbreite der Brücke.  
(ST-WR) : Das Befahren der Brücke ist nach STANAG für diese Fahrzeugklasse nicht empfohlen.

Tag: MLC

Einspurig				Zweispurig			
Fahrzeug	Erlaubt	Auslastung M	Auslastung Q	Fahrzeug	Erlaubt	Auslastung M	Auslastung Q
MLC-4	✓	0.26	0.26	MLC-4	✓	0.28 (ST-WR)	0.28 (ST-WR)
MLC-8	✓	0.29	0.29	MLC-8	✓	0.33 (ST-WR)	0.33 (ST-WR)
MLC-12	✓	0.33	0.33	MLC-12	✓	0.40 (ST-WR)	0.40 (ST-WR)
MLC-16	✓	0.35	0.35	MLC-16	✓	0.45 (ST-WR)	0.45 (ST-WR)
MLC-20	✓	0.38	0.38	MLC-20	✓	0.52 (ST-WR)	0.52 (ST-WR)
MLC-24	✓	0.41	0.41	MLC-24	✓	0.57 (ST-WR)	0.57 (ST-WR)
MLC-30	✓	0.44	0.44	MLC-30	✓	0.63 (ST-WR)	0.63 (ST-WR)
MLC-40	✓	0.51	0.51	MLC-40	✓	0.76 (ST-WR)	0.76 (ST-WR)
MLC-50	✓	0.57	0.57	MLC-50	✓	0.88 (ST-WR)	0.88 (ST-WR)
MLC-60	✓	0.66	0.66	MLC-60	☐	(WR)	(WR)
MLC-70	✓	0.73	0.73	MLC-70	☐	(WR)	(WR)
MLC-80	✓	0.78	0.78	MLC-80	☐	(WR)	(WR)
MLC-90	✓	0.85	0.85	MLC-90	☐	(WR)	(WR)
MLC-100	✓	0.92	0.92	MLC-100	☐	(WR)	(WR)
MLC-120	☐	1.06	1.06	MLC-120	☐	(WR)	(WR)
MLC-150	☐	1.16	1.16	MLC-150	☐	(WR)	(WR)

Figure 10: Results in rough MLC classification of example bridge in BRASSCO

## 5 Future Developments and Functional Expansion

In summary, the classification of bridges within the NATO framework faces several technical and structural challenges, including national differences in data availability, a wide range of bridge types, and the ongoing evolution of military vehicles with new load characteristics. Nevertheless, digital tools like BRASSCO NG offer great potential to improve the efficiency, consistency, and speed of military bridge assessments. The integration of UAV-based data collection, automated analysis, and machine learning represents a major step toward more dynamic and data-driven decision-making.

In the future, BRASSCO NG is expected to support even more advanced functions. These may include the detection and classification of structural damage, the assessment of bridge usability under battlefield conditions, and the estimation of required repair measures. By incorporating these features, the tool can contribute to operational infrastructure resilience and help to maintain or restore critical movement routes under stress or during conflict. This way, BRASSCO NG not only strengthens tactical mobility but also supports long-term mission assurance and logistical continuity within NATO and allied operations.

## 6 Acknowledgement

We would like to sincerely thank the Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support (BAAINBw) for its support during the development of this work. We are especially grateful to the Team of Experts for Bridge Engineering for their valuable technical input and constructive discussions. Furthermore, we would like to thank the colleagues at the NATO Military Engineering Centre of Excellence (MILENG COE) for their continued cooperation, for providing relevant reference materials, and for their ongoing contribution to the development of military bridge classification standards.

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