



Volume 132

2026

p-ISSN: 0209-3324

e-ISSN: 2450-1549

DOI: <https://doi.org/10.20858/sjsutst.2026.132.8>

Journal homepage: <http://sjsutst.polsl.pl>



Article citation information:

Ilkström Kravcov, A., Kotisa, J., Vlkovský, M., Heinzova, R., Backhaus, H. Comparative transport capability of T-72 and Leopard 2 main battle tanks in Central Europe: implications for military mobility. *Scientific Journal of Silesian University of Technology. Series Transport*. 2026, **132**, 145-164. ISSN: 0209-3324.
DOI: <https://doi.org/10.20858/sjsutst.2026.132.8>

**Alexander ILKSTRÖM KRAVCOV¹, Jan KOTISA², Martin VLKOVSKÝ³,
Romana HEINZOVA⁴, Holger BACKHAUS⁵**

COMPARATIVE TRANSPORT CAPABILITY OF T-72 AND LEOPARD 2 MAIN BATTLE TANKS IN CENTRAL EUROPE: IMPLICATIONS FOR MILITARY MOBILITY

Summary. Military mobility is a strategic sustainment and movement-control problem rather than a purely technical transport issue. It links infrastructure capacity, regulatory coordination, transport assets and the ability to generate and sustain deployable combat power. Within NATO and the European Union, rapid movement of personnel, armoured vehicles and materiel is therefore treated as an enabling condition for reinforcement and deterrence [1-4]. Europe combines a dense civilian transport network with route, loading-gauge, axle-load and administrative constraints that were not designed around the mass and dimensions of modern heavy tracked systems. This study examines those constraints at

¹ University of Defence, Department of Logistics, Kounicova 65 Street, 662 10 Brno, Czech Republic. Email: alexander.ilksromkravcov@unob.cz. ORCID: <https://orcid.org/0009-0002-3036-2670>

² University of Defence, Department of Logistics, Kounicova 65 Street, 662 10 Brno, Czech Republic. Email: jan.kotisa@unob.cz. ORCID: <https://orcid.org/0000-0002-9223-2946>

³ University of Defence, Department of Logistics, Kounicova 65 Street, 662 10 Brno, Czech Republic. Email: martin.vlkovsky@unob.cz. ORCID: <https://orcid.org/0000-0002-0568-7687>

⁴ Tomas Bata University in Zlín Faculty of Logistics and Crisis Management Department of Logistics. Email: rheinzova@utb.cz. ORCID: <https://orcid.org/0000-0002-6616-6252>

⁵ Multinational Logistics Coordination Centre, Bundeswehr, Germany. Email: olgererwinbackhaus@bundeswehr.org. ORCID: <https://orcid.org/0009-0007-5396-2560>

European and Central European levels and then compares selected T-72 and Leopard 2 transport cases, with particular attention to the Czech and Hungarian contexts. The technical comparison distinguishes vehicle mass from transport-system payload, axle-load distribution, securing requirements and route acceptance, while also considering maintenance and recovery implications for sustained operational readiness.

Keywords: military mobility, heavy equipment transport, main battle tank, sustainment, transportability, recovery

1. INTRODUCTION – THEORETICAL BACKGROUND

The modern development of military mobility is inseparable from the mechanisation of logistics. The transition from animal-drawn transport to motor vehicles increased operational tempo, but it also deepened dependence on transport infrastructure, maintenance capacity and reliable lines of communication. Eccles framed logistics as the link between the national economy and forces in operation and stressed that strategic flexibility and mobility rest on a sound logistical foundation [5].

The First World War exposed this relationship clearly. Early armoured vehicles, including the British Mark I, created transport and maintenance demands well beyond those associated with horse-drawn forces. Railways remained indispensable for strategic movement, but loading capacity, clearances, terminal facilities and the handling of heavy tracked equipment became increasingly important constraints.

By the Second World War, rail transport had become a principal means of strategic movement for heavy land forces, while maritime transport connected theatres across global distances. Air transport also began to assume an operational role. The result was an increasingly integrated transport system in which movement planning, modal transfer and infrastructure availability directly conditioned the speed with which combat power could be concentrated.

The Cold War brought a further increase in platform mass with main battle tanks such as the Leopard 2, M1 Abrams and Challenger 2, while strategic airlift expanded the reach of military logistics. NATO movement doctrine and rail-transport standards codified many of the procedures required for such movements [1,2]. Maintenance doctrine likewise distinguishes operational transport from recovery and evacuation: recovery concerns the extrication and return of disabled equipment to friendly control or repair, while maintenance support seeks to restore equipment serviceability and operational readiness as far forward as practicable [6-8].

In the contemporary security environment, military mobility is an integral component of broader transport and logistics systems and is closely connected with critical infrastructure. Critical infrastructure comprises assets whose disruption can generate severe societal and economic consequences [9]. For military mobility, the relevant question is whether transport nodes, corridors and support infrastructure remain available under crisis conditions. Digital dependence introduces an additional vulnerability because attacks on infrastructure control and energy systems can affect physical mobility as well as information flows [10].

Military mobility is therefore a function not only of transport capacity but also of route condition, resilience and engineering support. Research on bridges and host-nation mobility support shows that the technical state of roads, bridges and related infrastructure can constrain both strategic and operational movement [11,12]. Engineering adaptation and mobility-support measures consequently act as enabling functions when existing infrastructure does not meet the mass, dimensional or route requirements of modern military equipment [13].

Transport infrastructure also forms part of national resilience. Its disruption can reduce the ability of the state to support both civilian activity and military reinforcement, which supports continued investment, protection and modernisation [14]. Comparative work on contested logistics indicates that highways and railways may display different vulnerability and recovery characteristics under attack, making modal redundancy and prioritisation important planning considerations [15]. Such investment choices are also affected by the public acceptability of infrastructure-financing mechanisms [16].

Military mobility increasingly relies on dual-use infrastructure that serves civilian commerce and military deployment. Studies of infrastructure competition and geoeconomic connectivity illustrate how transport systems acquire strategic significance beyond their commercial function [17,18]. At the operational level, civil-military logistics cooperation can improve access to transport capacity, infrastructure and services [19]. Integrated national logistics initiatives, such as India's GatiShakti programme, demonstrate the potential value of coordinating infrastructure and logistics planning across sectors [20], while historical research continues to show the operational importance of logistics networks in shaping military outcomes [21].

Recent crises have also demonstrated that armed forces operate within interdependent civilian supply and transport networks. Military organisations supported procurement, distribution and continuity of essential services during the COVID-19 pandemic [22,23], reinforcing the need to integrate military and civilian logistics planning rather than treat them as separate systems [24].

Within military supply-chain logistics, resilience is increasingly treated as a design requirement for operations under disruption, uncertainty and hybrid threats [25]. Performance-based support arrangements seek to improve availability and cost efficiency by allocating selected support responsibilities to external partners [26]. Digital technologies, including IoT-enabled monitoring and data-driven lifecycle management, can improve visibility and traceability [27], while current literature links these capabilities to the dynamic adaptation of military supply chains [28].

2. MATERIALS AND METHODS

2.1. Europe's mobility deficit

Despite extensive civilian infrastructure, Europe's capacity for rapid movement of heavy military forces remains constrained by the suitability of individual routes, terminals and transport systems for military loads. The problem is therefore one of usable military capacity and movement control, not simply the total amount of infrastructure available [29,30].

Bridges may lack the required load capacity, rail tunnels and structures may constrain the loading gauge, suitable heavy flat wagons are limited, and national technical rules remain uneven. For road movement, axle loads, overall dimensions and vehicle-combination limits must be considered together with permits and route acceptance [2,31].

The operational consequence is increased deployment time and reduced freedom of movement. European analyses of military mobility have repeatedly identified border procedures, infrastructure bottlenecks and limited heavy-transport capacity as factors that can delay reinforcement [29,30]. In high-tempo operations, such delays directly reduce the commander's ability to build and sustain combat power where it is required.

Administrative barriers compound physical constraints. Cross-border military movement may require advance coordination, while national road-weight and dimension rules can restrict particular combinations unless exemptions are authorised [30,31]. Movement control therefore requires timely information on what must move, when and where it must move, and which transport mode and route can accept the load – a relationship consistent with classical logistics theory [5].

2.2. Policy responses: towards a “military Schengen”

European institutions have responded by treating military mobility as a cross-border enabling capability. The policy objective is to reduce administrative friction and ensure that transport corridors can support rapid military reinforcement, consistent with the broader security objectives of the EU Strategic Compass [4,30].

This approach effectively treats military mobility as a dual civil-military infrastructure problem. It links defence planning to transport policy and recognises that the same corridors, terminals and networks must often support both economic activity and military movement.

The scale of adaptation is considerable. European planning documents identify a large number of infrastructure points requiring improvement and have linked military-mobility investment to the Trans-European Transport Network and the Connecting Europe Facility [32,33]. The practical effect will depend on whether projects remove specific route, bridge, rail and terminal constraints rather than merely increase nominal spending.

NATO’s renewed emphasis on reinforcement and readiness complements these EU measures. The key requirement is implementation: movement plans, transport assets, infrastructure works and national permissions must be coordinated so that forces can move within operational timelines [1,3].

2.3. Infrastructure as strategy: the Iron Rhine

Few projects illustrate the dual civilian-military character of European mobility as clearly as proposals to revive the Iron Rhine railway linking the Antwerp area with Germany’s Ruhr region. Recent reporting has presented the line as both a commercial corridor and a potential contributor to NATO military mobility [34-36].

Additional rail capacity can reduce dependence on congested nodes and provide modal redundancy for heavy equipment movements. The same investment can strengthen civilian supply chains, illustrating how dual-use transport infrastructure can contribute simultaneously to economic resilience and defence readiness.

Comparable logic underpins wider TEN-T and Rail Baltica development. Harmonised loading-gauge, axle-load and terminal parameters do not remove the need for military movement planning, but they expand the number of routes that can be considered during reinforcement [30,32].

The Leopard 2 main battle tank is operated by numerous NATO members and partner countries, creating a geographically dispersed fleet with substantial variation in configuration and modernisation level [37,38]. This diversity has direct consequences for transportability, maintenance support, spare-parts planning and multinational interoperability.

Germany remains the original developer and principal technological reference for the platform, fielding or developing variants including Leopard 2A5, 2A6, 2A7V and 2A8 [37,38]. German developments therefore influence upgrade pathways, technical support and lifecycle-management arrangements across the wider user community.

Poland and Finland operate comparatively large fleets with mixed-generation configurations. Poland combines Leopard 2A4-family vehicles with the Leopard 2PL modernisation, while Finland operates both 2A4 and 2A6 variants. Such mixed fleets preserve capability during transition but increase the number of variant-specific maintenance, training and transport requirements that must be managed [38,39].

Denmark and Norway represent smaller but highly modernised fleets, while Hungary has introduced the Leopard 2A7HU as part of a wider force-modernisation programme. Although these national solutions differ, they are developed within a NATO framework that places a premium on interoperability, reinforcement and deploy ability [3,37,40].

Other users retain limited fleets or mixed capability models. The Netherlands operates Leopard 2 capability within a binational German-Dutch structure, while Portugal, Spain and Greece maintain national fleets of differing size and configuration. The resulting diversity means that common platform heritage does not eliminate national differences in support equipment, maintenance policy, ammunition, transport interfaces or training [37,38].

The Czech Republic and Slovakia are transitional users of Leopard 2A4-family vehicles replacing or supplementing Soviet-designed platforms. In the Czech case, this transition forms part of longer-term force-development planning and additional Leopard acquisition [41,42]. Austria remains a non-NATO Leopard 2 operator, while the United States relies on the M1 Abrams rather than the Leopard 2 family.

From a logistics perspective, fleet heterogeneity has implications for interoperability, maintenance workload and military mobility. Variations in combat mass, external dimensions and support architecture complicate the standardisation of transport procedures and increase the importance of route classification and cross-border movement coordination [2,3,11].

A structured overview of selected operators, their Leopard 2 variants and operational status is presented in Table 1. The table illustrates the diversity of the platform family and the resulting requirement to plan transport and support against the specific vehicle configuration rather than against the generic designation “Leopard 2”.

Tab. 1

Distribution of Leopard 2 variants across selected NATO member states

Country	Leopard 2 Variants	Status / Notes
Germany	2A5, 2A6, 2A7V, 2A8	Main developer, most advanced operator
Poland	2A4, 2A5, 2PL	One of the largest Leopard 2 fleets in NATO
Norway	2A4NO → 2A7 / 2A8	Transition to latest generation
Denmark	2A5DK, 2A7	Highly modernized fleet
Netherlands	2A6 (within joint German-Dutch units)	No independent tank battalions
Canada	2A4M CAN, 2A6M CA	Modernized export variants
Czech Republic	2A4, planned 2A8	Transition from Soviet-era T-72
Slovakia	2A4	Limited number (compensation deliveries)
Hungary	2A4, 2A7HU	One of the most modern new Leopard operators
Portugal	2A6	Limited operational availability

Spain	2A4 (inactive), 2E (2A6-based)	Large fleet with domestic modifications
Greece	2A4, 2A6HEL	One of the largest Leopard 2 fleets in NATO
Austria	2A4	Planned modernization program
United States	x	Does not operate Leopard 2 (uses M1 Abrams)

Table 1 shows that the Leopard 2 user community combines homogeneous modern fleets, mixed-generation inventories and transitional fleets. For movement and sustainment planners, this means that vehicle mass, dimensions, recovery interfaces and maintenance requirements must be verified at variant level rather than assumed to be common across all Leopard 2 operators.

The platform therefore provides a common architectural baseline without creating complete logistical standardisation. Interoperability benefits coexist with national differences in configuration, upgrade level and fleet composition, which affect spare-parts support, maintenance training and transport planning.

Despite widespread adoption, the Leopard 2 should therefore be treated as a family of nationally configured systems rather than as one fully standardised platform [37,38]. This distinction is particularly important when transport clearances, payload margins or recovery arrangements are calculated for a specific variant.

The common platform architecture supports coalition training and doctrinal interoperability, but variant divergence increases the complexity of maintenance ecosystems and supply chains. For forces undergoing incremental modernisation, this can create temporary parallel requirements for legacy and new equipment, including transporters, recovery assets and technical training [3,39,41].

Accordingly, Leopard 2 interoperability is strongest at the system-family level, while implementation remains nationally differentiated. Operational standardisation must therefore be supported by technical data exchange, compatible transport and securing procedures, and infrastructure capable of accepting the relevant mass and dimensional envelope [2,11,37].

2.4. National adaptation: the Czech case

At national level, these broader mobility and sustainment requirements are visible in the modernisation of the Czech Armed Forces. The transition to heavier tracked platforms changes not only the combat fleet but also the transport, recovery, maintenance and infrastructure requirements that support operational readiness [41].

The introduction of Leopard 2A4 vehicles and the planned transition to heavier Leopard 2 variants require transport systems that can accept higher payloads and axle loads than many legacy combinations. Legacy rail and road procedures remain relevant, but vehicle-specific movement planning and technical acceptance must be updated for the new platforms [2,43,44].

The Czech military has therefore begun modernising its heavy road-transport fleet. The acquisition of Scania R660 tractor units with Goldhofer low-bed semi-trailers represents a significant increase in road-transport capacity (Figure 1) [45]. Reported capacities are sufficient for current Leopard 2A4 movement, but each transport condition still depends on the approved tractor-trailer configuration, loading position, axle-load distribution and route permits.



Fig. 1. Rear securing of the Leopard 2A4 tank on a Goldhofer low-bed semi-trailer
Photo by the authors

Further increases in platform mass, including the planned Leopard 2A8, reduce the margin available within existing transport and infrastructure limits. Road movement must therefore be assessed against vehicle-combination dimensions, axle loads, bridge capacity and the applicable national permitting framework [31,46].

This is not merely a vehicle-selection problem. It is a movement-control problem in which the transported platform, transporter, route, infrastructure and administrative permissions must be treated as one system. Without coordination, nationally valid solutions may still be unsuitable for cross-border reinforcement.

2.5. The wider regional context: the Hungarian case

Across Central Europe, armed forces face the same structural challenge: the growing mass of heavy combat systems must be matched by transport, recovery and maintenance capabilities able to keep those systems deployable.

Hungary's Leopard programme emerged from a broader reassessment of heavy land forces under the Zrínyi 2026 modernisation effort. By the late 2010s, procurement shifted from replacing individual vehicles to rebuilding an integrated armoured capability with Western equipment, training and support arrangements [47].

The objective was therefore broader than tank acquisition. It encompassed mobility support, dedicated recovery vehicles, bridging, training infrastructure and logistics, creating a force package intended to generate sustainable and deployable combat power rather than a stand-alone platform fleet.

2.5.1. Programme structure and acquisition framework

This intent was formalised in December 2018 through a comprehensive agreement with KNDS Deutschland [40,48]. The scope of the programme included:

- 44 × Leopard 2A7HU
- 24 × PzH 2000
- 3 × Leguan bridge-layer

- 5 × WiSENT recovery vehicle
- Dedicated simulation and training infrastructure
- Integrated logistics and support framework

Deliveries were phased between 2023 and 2025, allowing force generation, crew conversion, maintenance preparation and doctrinal adaptation to proceed in parallel with equipment fielding.

To bridge the transition, Hungary introduced 12 Leopard 2A4 vehicles in December 2020. These served as a conversion fleet for crews moving from the T-72M1 to Western systems before Leopard 2A7HU deliveries began in 2023, reducing the training and sustainment discontinuity associated with an abrupt platform change [48].

2.5.2. Technical characteristics of the Leopard 2A7HU

The Leopard 2A7HU is the principal modern main battle tank in Hungarian service. Derived from the Leopard 2A7 family, it incorporates configuration-specific systems and protection features [37,40].

Key systems and features:

- FN Herstal Remote Weapon Station (RWS)
- Enhanced roof protection
- Upgraded fire control system (FCS) with automatic target tracking
- PERI RTWL stabilised commander's sight

The platform retains a four-person crew (commander, gunner, loader, driver), with the driver positioned on the right side of the hull.

Dimensions:

- Hull length: 7.7 m
- Overall length (gun forward): 10.97 m
- Width: 3.76 m (without add-on armour)
- Height: 3.03 m

Armament:

- Rheinmetall 120 mm L55A1 main gun
- Capable of firing high-pressure, extended-range kinetic energy rounds
- Effective range: up to ~5,000 m
- 7.62 mm coaxial machine gun
- 12.7 mm remote weapon station
- 2 × 8 smoke grenade launchers (76 mm), enabling both obscuration and high-explosive deployment

2.5.3. Mobility and survivability parameters

Despite a combat weight of approximately 67.5 tonnes, the Leopard 2A7HU maintains high mobility through a well-established propulsion system:

- Engine: MTU MB 873 Ka-501 V12 diesel
- Output: 1,500 hp
- Transmission: Renk HSWL 354
- Maximum speed: 68-72 km/h

Obstacle-crossing capability:

- Unprepared water crossing: up to 1.2 m
- Prepared fording: up to 2.25 m
- Deep wading (with preparation): up to 4 m

These vehicle capabilities are complemented by engineer support, including the Leguan bridge-layer, which expands the formation's ability to maintain mobility across terrain and water obstacles.

Protection is based on a composite armour architecture supplemented by modular add-on elements, including wedge-shaped self-limiting explosive reactive armour. An optional 360-degree urban operations kit can be installed to enhance survivability in built-up environments, alongside additional external protection elements such as rubber side skirts.

Hungarian force development also recognises that technical protection must be accompanied by doctrinal and training adaptation, including responses to emerging threats such as unmanned aerial systems.

2.5.4. Sustainment, training and industrial integration

What distinguishes the programme is the support architecture built around the combat platform. The objective is sustained operational availability rather than a one-time equipment acquisition.

Maintenance and lifecycle support are anchored domestically through KNDS Hungary Kft. This reduces dependence on external support chains and can shorten the time required to restore equipment serviceability, while higher-level repair and industrial support remain part of the broader sustainment system.

Ammunition procurement follows a similar logic, linking combat-system support with domestic industrial capacity, including the Várpálotá ammunition plant developed with Rheinmetall Waffe Munition GmbH. This connects force sustainment with national defence-industrial policy.

Training is centred in Tata, where simulation supports continuous crew qualification and is complemented by live-fire training and system calibration. The combination of training, maintenance support and supply is essential to convert equipment ownership into operational readiness.

2.5.5. A system, not a platform

The Leopard 2A7HU should therefore be assessed as one element of an integrated capability that includes transporters, recovery assets, bridging, maintenance, ammunition, training and infrastructure. The coherence of these functions is more important to deployability than the nominal performance of the tank alone.

Hungary's approach reflects a shift from procurement as a discrete transaction toward lifecycle capability management. Its effectiveness will ultimately be measured by the ability of the overall system to generate, deploy and sustain combat power [47,48].

Investment in high-capacity road transport, including MAN TGS 40.540 tractor units and low-bed trailers, illustrates this system approach. Military capability is determined not only by what a force possesses, but also by how reliably and quickly it can move, recover and sustain that equipment.

2.5.6. Force structure and heavy-equipment baseline

The Hungarian approach to military mobility is inseparable from the composition of its heavy forces under the Zrínyi 2026 programme [47]. The principal armoured, artillery and mobility-support systems include:

Armoured and artillery fleet:

- 44 × Leopard 2A7HU (deliveries completed in 2025)
- 12 × Leopard 2A4
- 24 × PzH 2000
- 3 × Leguan bridge-layer (Figure 2)
- 5 × WiSENT recovery vehicle



Fig. 2. Transport of the Leguan 2HU bridge-layer to the MH Klapka György unit

Photos: Ákos Pintér, honvedelem.hu

Taken together, these systems form a substantial concentration of heavy tracked equipment in the Tata-based formation, generating a corresponding requirement for heavy transport, recovery and maintenance support.

From a transport-engineering perspective, the implications are direct:

- Leopard 2A7HU: ~67-70 tonnes combat weight
- PzH 2000: ~55-60 tonnes
- Most of the principal tracked systems fall within roughly the 55-70+ t class. This mass range exceeds the payload and infrastructure assumptions associated with many legacy transport solutions and creates a sustained requirement for purpose-built heavy equipment transporters.

2.5.7. Heavy transport fleet: structure and inferred numbers

Unlike the combat-system fleet, the exact number of Hungarian heavy transport combinations is not publicly established in the source set used for this paper. The following discussion therefore separates confirmed equipment types from an analytical estimate of fleet scale.

Confirmed equipment:

- MAN TGS 40.540 (6×6 configuration with BBS-MIL winch)
- Goldhofer STZ-P7

Technical characteristics:

- Payload capacity: ~85 tonnes

- Configuration: multi-axle low-bed transport system
- Role: transport of Leopard 2A7HU and PzH 2000 platforms

Deliveries of these transport systems began in 2022 to the MH 25th Klapka György Rifle Brigade in Tata, where they were assigned to the Logistics Battalion (Figure 3) [49]. Their arrival before full Leopard 2A7HU fielding indicates deliberate sequencing of enabling capability.



Fig. 3. Delivery of MAN TGS 40.540 heavy transport vehicles to the Logistics Battalion of the MH 25th Klapka György Rifle Brigade
Photos: Alexandra Bodnár and Zoltán Vasadi, honvedelem.hu

Analytical fleet-size estimate:

- Tank battalion: 44 MBTs
- For the estimate used in this paper, a working ratio of approximately one heavy equipment transporter per two to three heavy tracked vehicles is applied. This is an analytical planning assumption for the present comparison and is not presented as a formal NATO standard
- Applied to the tank battalion and associated heavy systems, this assumption suggests an order of magnitude of approximately 15-25 tractor-trailer combinations at brigade level
- This estimate is consistent with the scale of the force package and observed use of dedicated heavy transport systems, but it should not be interpreted as an official fleet count
- The emphasis appears to be on payload margin and transport flexibility rather than on replicating larger fleets of lower-capacity legacy transporters
- Observed convoy structures in Hungarian exercises

Notably, Hungary appears to have prioritised capacity over numerical volume. Rather than replicating the larger but lower-capacity fleets characteristic of the Warsaw Pact, it has opted for fewer systems with significantly higher payload margins.

3. RESULTS AND DISCUSSION

3.1. Operational concept: mobility doctrine

The Hungarian approach is technically differentiated in three respects.

(1) Full-spectrum mobility integration

Transport assets are treated as integral elements of the force package alongside tanks, artillery, dedicated recovery systems, bridging assets, logistics and training infrastructure. This supports a brigade-level system-of-systems approach consistent with NATO emphasis on deployability and interoperability [3].

(2) Emphasis on operational redeployment

The selection of high-capacity tractor units and multi-axle low-bed trailers indicates optimisation for operational and theatre-level road redeployment of heavy tracked systems:

- Medium-distance theatre-level redeployment
- Rapid road-based manoeuvre
- This reduces exclusive dependence on rail transport and increases route and timing flexibility, particularly when forces must disperse or redeploy under contested conditions [3,15]
- Dispersed force posture
- Mobility under contested conditions

(3) Overmatch capacity (85 t threshold)

The adoption of an approximately 85 t transport capacity provides deliberate payload margin.

Tab. 2

Leopard 2A7HU/PzH 2000 transport values

Platform	Weight	Transport margin
Leopard 2A7HU	~67.5 t	+17 t
PzH 2000	~55-60 t	+25 t

This deliberate overcapacity yields several advantages:

- Compatibility with future, heavier platforms
- Accommodation of additional armour or mission-specific loads
- Improved axle load distribution, reducing infrastructure stress

By contrast, transport capacity that is closely matched to the present platform mass leaves less allowance for future armour growth, mission equipment or configuration changes and can increase regulatory and operational friction.

3.2. Technical assessment

From a military-transport perspective, the Hungarian model demonstrates a high degree of internal alignment between combat-platform mass and available heavy-transport capacity.

Capability alignment

Transport systems are dimensioned against anticipated heavy loads rather than the minimum requirement of a single current platform and are introduced in parallel with the combat systems they support.

Brigade-level sufficiency

If the heavy-transporter fleet lies within the analytical range discussed above, it would support phased deployment and rotation cycles rather than simultaneous road lift of the entire heavy fleet.

- Phased deployment cycles
- Integration within NATO reinforcement frameworks

Reduced infrastructure dependency

High-capacity road transport provides:

- Lower reliance on constrained rail networks
- Increased flexibility in route selection and timing

Residual constraints

Despite these advances:

- National road regulations, particularly axle load limits, remain binding
- Cross-border movement continues to depend on EU-level harmonisation

The Hungarian case illustrates a broader point: military mobility is a determinant of operational credibility. Aligning transporter payload with the upper range of platform mass, while integrating recovery, engineering and sustainment functions, increases the ability to translate nominal force structure into deployable combat power.

The Czech transition from the T-72M4 CZ to Leopard 2A4 and the planned Leopard 2A8 raises the same issue directly. A reported 48 t T-72M4 CZ is close to the nominal payload of a 50 t P-50 N low-loader, whereas a 63 t Leopard 2A6M exceeds that nominal payload. Heavier Leopard 2 variants increase the requirement further. The relevant question is therefore not whether a tractor and trailer can physically move a tank, but whether the full combination satisfies payload, axle-load, dimensional, braking, securing and route requirements.

The following cases compare reported T-72 and Leopard 2 masses with selected road and rail transport systems in Central Europe. The analysis brings together the technical data already incorporated in the source article, the Czech Scania R650-Goldhofer weighing case and the Leopard 2A6M / Scania / DOLL S8E assessment. A Hungarian high-capacity transporter is retained as a regional reference for the design margin available from a purpose-built heavy equipment transporter.

3.3. Comparative engineering data and method

The study applies a comparative engineering case-study method. Vehicle and transporter values are taken from the technical and transport documentation incorporated in the source article; measured axle loads are reported as recorded and are not treated as fleet-wide performance data. Platform mass is compared with stated payload, followed by review of axle loads, dimensions, securing arrangements and rail-wagon payloads. Arithmetic payload margins are indicative only and do not replace approved load charts, route surveys, movement permits or vehicle-specific acceptance [2,31,50].

One case concerns the Leopard 2A6M on a four-axle Scania tractor and an eight-axle DOLL S8E semi-trailer. The weighing record and the associated assessment contain distinct mass records; both are retained as reported and are not treated as interchangeable.

The second case concerns the Scania R650-Goldhofer trial, for which two axle-load datasets with different axle numbering and values appear in the source material. The ten-axle dataset is reproduced as one reported measurement set. The datasets are not averaged because the source material does not establish that they describe the same loaded configuration. The study does not independently calculate route capacity, bridge acceptance or deployment time.

3.4. Vehicle mass and road-transporter capacity

Table 3 compares selected vehicle masses with nominal road-transporter capacities. The T-72M4 CZ retains only 2 t of nominal margin on a 50 t P-50 N. A 63 t Leopard 2A6M is 13 t above that payload. In the DOLL S8E case, 63 t is the stated cargo mass for the assessed combination, so the 2A6M uses the full stated cargo allowance. Higher technical payload values for the trailer at particular axle-load regimes do not override the cargo limit established for the assessed tractor-trailer combination.

Tab. 3

Reported tank masses and selected road-transport capacities

Vehicle or transporter	Reported mass / payload	Indicative margin or implication
T-72M4 CZ	48 t vehicle mass	2 t below a 50 t P-50 N payload
Leopard 2A6M	63 t reference load	13 t above a 50 t P-50 N payload
Leopard 2A7HU	about 67.5 t	Heavier than the 63 t DOLL case cargo limit
Tatra T-815 8×8 with P-50 N	about 50 t nominal payload	Legacy solution; limited margin for a 48 t tank
Scania R660 A6×4 with Goldhofer	up to about 66 t reported capacity	Stated capacity is configuration-specific and requires validation
Scania tractor with DOLL S8E	63 t cargo in the loading instruction	Matches the Leopard 2A6M reference load; no nominal cargo margin
MAN TGS 40.540 with Goldhofer STZ-P7	about 85 t reported payload	Provides a larger nominal payload margin for heavy tracked vehicles

Nominal payload alone does not establish operational suitability. Tank preparation, fuel and equipment state, loading position, trailer configuration, axle loads and permits can change the accepted transport condition. This is analogous to the maintenance principle that equipment status must be assessed against the actual mission and operating condition rather than a generic platform label [8].

3.5. Road transport cases

3.5.1. Czech Scania R650 and Goldhofer trial

The Czech case concerns a Leopard 2A4 transported by a Scania R650 tractor and Goldhofer low-bed semi-trailer, with axle loads measured using a PW-10 mobile weighing system [50]. In the ten-axle dataset reproduced as Table 4, the loads on axles 7-10 are 12.40-12.50 t. The comparison in the source material applies a 10 t driven-axle limit; on that basis, the measured configuration did not meet that limit. This is a configuration-specific result and should not be generalised to every Scania-Goldhofer combination or to every authorised exceptional movement.

Tab. 4

Reported axle loads for the Scania R650-Goldhofer transport trial

Axle	Load (t)	Axle	Load (t)
1	7.90	6	10.46
2	6.20	7	12.50
3	9.76	8	12.42
4	9.54	9	12.40
5	10.46	10	12.46

The companion study also contains a six-axle dataset for axles 5-10 with different values. Because the supplied material does not reconcile the datasets by vehicle configuration, loading state or measurement point, they are not combined. This preserves the distinction between measured evidence and analytical inference.

3.5.2. Scania and DOLL S8E Leopard 2A6M case

The Leopard 2A6M case uses a four-axle Scania tractor and an eight-axle DOLL S8E semi-trailer. The combination is listed at approximately 21.90-21.95 m overall length, 3.50 m width without track skirts and 3.80 m with skirts, and 4.00 m height. The associated assessment therefore treats the complete loaded combination, rather than the trailer payload alone, as the relevant object for transport acceptance.

The loading analysis fixes the tank position relative to the front edge of the loading deck. The left and right wedge positions are reported as 2.125 m and 1.950 m, and the right front road wheel is positioned relative to the loading platform. These details illustrate the importance of load placement for axle-load distribution and securing.

The weighing record reports a gross combination mass of 102.450 t, an empty combination mass of 23.860 t and a measured cargo mass of 60.590 t. The recorded axle loads are reproduced in Table 5. The expert assessment records 63.00 t cargo and a gross combination mass of 104.86 t, against listed tractor and trailer tare masses of 14.38 t and 27.40 t. Those three values sum to 104.78 t, 0.08 t below the stated total. The 2.41 t difference between the weighing-record and assessment totals corresponds to the difference between the reported cargo values.

In the weighing record, axle loads range from 5.425 t to 9.775 t. This differs materially from the Czech Scania-Goldhofer dataset, in which several reported axle loads exceed 12 t. The two cases should not be treated as controlled comparative tests because they use different tractors, trailers, vehicle variants and loading arrangements.

Tab. 5

Axle loads in the Leopard 2A6M / four-axle Scania / eight-axle DOLL S8E weighing record

Axle	Load (t)	Axle	Load (t)	Axle	Load (t)
1	7.425	5	8.525	9	9.725
2	5.425	6	8.500	10	9.725
3	7.650	7	8.525	11	9.725
4	7.750	8	9.775	12	9.725

3.6. Rail transport and securing

The technical comparison uses an approximate 54 t maximum payload for the Smmps 54 wagon, with a 14.0 m loading length and 3.10 m loading width. This provides only a limited nominal margin for a 48 t T-72M4 CZ and is below the 63 t Leopard 2A6M reference load. Rail-wagon capability must therefore be assessed at the level of the specific wagon and loaded vehicle, not by wagon family name alone [43,51,52].

The 3.10 m deck width is not itself the railway loading gauge. A tracked vehicle may overhang the deck, but the loaded profile, axle loads, route gauge and securing arrangement must all be accepted. AMovP-4(A) provides standardised technical requirements for military rail transport and securing [2].

Tab. 6

Selected AMovP-4(A) securing values reported for tracked vehicles

Tracked vehicle mass category	Individual/group: devices + chocks (daN)	Individual/group: devices only (daN)	Complete train: devices only (daN)
52 t	8,000	10,000	6,250
60 t	10,000	16,000	10,000
65 t	12,500	20,000	12,500

4. CONCLUSION

Military mobility has become a practical test of whether European armed forces can convert force structure into deployable and sustainable combat power. It is not solely a transport-engineering problem: it combines movement control, infrastructure capacity, maintenance readiness, recovery support and cross-border coordination.

Historical experience shows that increases in platform mass and complexity repeatedly expose limitations in the infrastructure and support systems around them. The current generation of heavy armoured vehicles is no exception. Europe possesses dense transport networks, but civilian connectivity does not automatically provide military load capacity, route clearance or administrative readiness.

The Czech and Hungarian cases illustrate two aspects of the same requirement. Introducing Leopard 2-family vehicles creates a need for transporters with sufficient payload and axle-load margin, but it also increases demand for compatible recovery assets, maintenance support, bridging, route planning and regulatory coordination. A modern combat platform that cannot

be moved or restored to service within operational timelines provides less usable combat power than its nominal performance suggests.

EU military-mobility initiatives and NATO reinforcement planning provide the framework for addressing these constraints, but implementation depends on specific infrastructure upgrades, transport assets, technical standards and national procedures [3,4,30,32].

The engineering comparison confirms that payload margin is only one part of transport suitability. For heavy tracked vehicles, the decisive assessment concerns the complete transport system: vehicle mass and dimensions, tractor and trailer configuration, axle-load distribution, securing, braking, route limitations and permits. In doctrinal terms, this transport function must also be integrated with maintenance and recovery planning if operational readiness is to be sustained [6,8].

Acknowledgements

This research was funded by the Ministry of Defence of the Czech Republic, grant DZRO-FVL22-INTAL “Implementation of new technologies and procedures into the logistic support of the Army of the Czech Republic”.

References

1. NATO. 1998. *AMovP-1: Regulations and Procedures for Road Movements, Designation of Authorities and Units Responsible for the Organization and Management of Movements*. Brussels: NATO.
2. NATO. 2011. *STANAG 2468 / AMovP-4(A): Technical Aspects of the Transport of Military Materiel by Rail*. Brussels: NATO.
3. NATO. 2022. *NATO Strategic Concept*. Brussels: NATO.
4. European Union. 2022. *A Strategic Compass for Security and Defence*. Brussels: European Union.
5. Eccles Henry E. 1997. *Logistics in the National Defense*. Newport, RI: Naval War College Press. ISBN 0-313-22716-0. Originally published in 1959.
6. U.S. Department of the Army. 2000. *FM 4-30.3 (FM 9-43-1): Maintenance Operations and Procedures*. Washington, DC: Headquarters, Department of the Army.
7. U.S. Department of the Army, U.S. Marine Corps. 2006. *FM 4-30.31 / MCRP 4-11.4A: Recovery and Battle Damage Assessment and Repair*. Washington, DC: Headquarters, Department of the Army.
8. U.S. Department of the Army, U.S. Marine Corps. 2025. *ATP 4-31 / MCRP 3-40E.1: Ground Equipment Battle Damage Assessment, Repair, and Recovery*. Washington, DC / Twentynine Palms, CA.
9. Pavlov Georgi, Teodora Gechkova, Tiana Kaleeva. 2025. “Critical Infrastructure Protection – Strategic Opportunities”. *International Journal for Quality Research* 19(1): 281-296.
10. Aljohani Tawfiq M. 2024. “Cyberattacks on Energy Infrastructures as Modern War Weapons – Part I: Analysis and Motives”. *IEEE Technology and Society Magazine* 43(2): 59-69.

11. Jančo Ján, Jaroslav Kompan. 2023. "Influence of the Bridge's Status on Military Mobility in the Slovak Republic". In: *TRANSBALTICA XIII: Transportation Science and Technology. Lecture Notes in Intelligent Transportation and Infrastructure*: 470-478. Cham: Springer. DOI: 10.1007/978-3-031-25863-3_44.
12. Dologa Jindřich, Ota Rolenc, Natálie Hanáková. 2023. "Engineer Mobility Support on the Territory of the Czech Republic as One of the Host Nation Support Tasks". In: *TRANSBALTICA XIII: Transportation Science and Technology. Lecture Notes in Intelligent Transportation and Infrastructure*: 491-501. Cham: Springer. DOI: 10.1007/978-3-031-25863-3_46.
13. Kompan Jaroslav, Michal Hrnčiar, Daniel Brezina. 2025. "Technological Aspects of Military Mobility Support". In: *TRANSBALTICA XIII: Transportation Science and Technology. Lecture Notes in Intelligent Transportation and Infrastructure*: 157-166. Cham: Springer. DOI: 10.1007/978-3-031-85390-6_16.
14. Boratyńska-Karpiej Edyta, Paweł Engel. 2024. "Modern Transport Infrastructure as Part of Critical Infrastructures". *Lecture Notes in Networks and Systems* 907: 102-113.
15. Chung Sukhwan, Daniel Sardak, Maksim Kitsak, Andrew Jin, Igor Linkov. 2025. "Contested logistics: Resilience of strategic highways and railways". *Transportation Research Interdisciplinary Perspectives* 32: 101507.
16. Andersson Matts, Lina Jonsson, Karin Brundell-Freij, Katja Berdica. 2022. "Who should pay? Public acceptance of different means for funding transport infrastructure". *Transportation* 50(4): 1425-1448. DOI: 10.1007/s11116-022-10282-z.
17. Lajtman Tamara, Silvina Romano. 2026. "The United States and the manufacturing of geopolitical consent on Chinese infrastructure in Latin America". *URVIO. Revista Latinoamericana de Estudios de Seguridad* 44: 70-89.
18. Kumar Dharmendra, Angela Z. Gapa, Bibek Chand. 2025. "China's Maritime Geoeconomic Strategy in the Western Indian Ocean Region". *Journal of Asian and African Studies* 61(3): 2482-2498.
19. Jałowiec Tomasz, Dariusz Grala, Piotr Masloch. 2022. "Development of military-civilian logistics cooperation". *Business Logistics in Modern Management*: 3-15. 22nd International Scientific Conference Business Logistics in Modern Management. October 6-7, 2022 - Osijek, Croatia.
20. Chadha Mukesh. 2026. "Transforming Military Logistics in India: The Strategic Impact of National Logistics Policy and GatiShakti Yojna". *Strategic Analysis* 50(1): 93-105.
21. Cui Feng. 2025. "Logistics behind revolution: Mengla and the Laos-Thailand connection in the Cold War". *Modern Asian Studies* 59(2): 487-506.
22. Bundy George, Martin Bricknell. 2025. Assessing the responses of the armed forces of NATO member states to the COVID-19 pandemic. *BMJ Military Health* 172(4): 342-347.
23. Tsagarliotis Ioannis, Nikolaos P. Rachaniotis. 2025. "Assessing the Role of Military Units in Epidemic Response: A Scoping Review of Key Issues". *Military Medicine* 191(7-8): e1421-e1428.
24. Reis João. 2021. "Civil-Military Cooperation: Integrated Logistics in Response to the COVID-19 Crisis". *Logistics* 5(4): 79.
25. Sani Sehu, D. Schaefer, Jelena Milisavljevic-Syed. 2022. "Strategies for Achieving Pre-emptive Resilience in Military Supply Chains". *Procedia CIRP* 107: 1526-1532.
26. Alqahtani Faris, Kostas Selviaridis, Mark Stevenson. 2023. "The effectiveness of performance-based contracting in the defence sector: A systematic literature review". *Journal of Purchasing and Supply Management* 29(5): 100877.

27. Parathyras Konstantinos, Christiana Papapostolou, Zoe Kanetaki. 2026. "Prospects and Challenges of Integrating Digital Technologies in the Military Supply Chain". *Lecture Notes in Networks and Systems* 1707: 284-298.
28. Loska David, Benjamin Hazen, Nicholas Rich, Stefan Genchev, Tegwen Malik. 2025. "Military Supply Chain Logistics and Dynamic Capabilities: A Literature Review and Synthesis". *Transportation Journal* 64(2): e70002.
29. Majchút Ivan, Lubomír Belan, Jaroslav Varecha. 2026. "Military Mobility as a Challenge for Europe". *Transportation Research Procedia* 93: 1041-1048. DOI: 10.1016/j.trpro.2025.12.040.
30. European Parliament. 2025. *Military Mobility Briefing*. Brussels: European Parliament.
31. Ministry of the Interior of the Czech Republic. 2018. *Decree No. 209/2018 Coll., on Vehicle Weights, Dimensions and Vehicle Combinations*. Prague.
32. European Commission. 2024. *Trans-European Transport Network (TEN-T)*. Brussels: European Commission.
33. European Commission. 2025. *Connecting Europe Facility*. Available on: https://commission.europa.eu/funding-tenders/find-funding/eu-funding-programmes/connecting-europe-facility_en.
34. Financial Times. "Iron Rhine railway revival gains support for NATO mobility". Available at: <https://www.ft.com/content/0a07238e-3657-4d1b-8460-35cfc6f8cd66>.
35. UNITED24 Media. 2025. "Belgium, Germany and Netherlands push to reopen historic Iron Rhine railway for NATO mobility". Available at: <https://united24media.com/latest-news/belgium-germany-and-netherlands-push-to-reopen-historic-iron-rhine-railway-for-nato-mobility-10773>.
36. Politico. "Iron Rhine railway military mobility plans move forward amid Russia concerns". Available at: <https://www.politico.eu/article/iron-rhine-railway-military-mobility-russia-belgium-germany-netherlands/>.
37. KNDS. 2026. "Leopard 2 Main Battle Tank". Available at: <https://www.knweg.com>.
38. Grummitt David. 2020. *Leopard 2: NATO's First Line of Defence, 1979-2020*. Oxford: Casemate Publishers.
39. Wolski Jarosław. 2017. "Od Leoparda 2A4 do Leoparda 2PL" [In Polish: „From Leopard 2A4 to Leopard 2PL"]. *Wozy Bojowe Świata* [In Polish: *Combat Vehicles of the World*] Special Issue No. 2: 32-71. Warszawa: Wydawnictwo Militaria.
40. Singsit Jangoulun. 2025. "KNDS delivers final Leopard 2A7HU MBTs to Hungarian Army". *Army Technology*, 15 December 2025. Available at: <https://www.army-technology.com/news/knds-hungary-army-leopard-2a7hu>.
41. Ministry of Defence of the Czech Republic. 2024. *Concept of the Development of the Armed Forces of the Czech Republic 2035*. Prague: Ministry of Defence.
42. CZ Defence. 2022. "The Armed Forces are procuring 14 additional Leopard main battle tanks". Available at: <https://czdefence.com>.
43. Czech Armed Forces. 2018. *Dopr-I-1: Military Rail Transport*. Prague: Ministry of Defence.
44. University of Defence. 2011. *Military Rail Transport: Freight and Passenger Railcars Used by the Czech Armed Forces*. Brno: University of Defence.
45. Scania. 2024. "The Czech Army continues its modernization – new Scania trucks for logistics units". Available at: <https://www.scania.com/cz/cs/home/about-scania/newsroom/news/2024/ArmadaCR-pokracuje-v-modernizaci-tahace-Scania-pro-logisticke-utvary.html>.

46. Czech Armed Forces. 2018. *Order of the Minister of Defence No. 4/2018: Rules for the Use of Vehicles within the Ministry of Defence and the Management of Vehicle Traffic on Public Roads During the Movement of Armed Forces Vehicles on Public Roads*. Prague: Ministry of Defence.
47. Balogh O. 2019. "The Importance of the Zrínyi 2026 Defence and Military Development Program". *Czech Military Review* 100(3): 55-70. DOI: 10.3849/2336-2995.28.2019.03.055-070.
48. Brahy Jérôme. 2025. "Hungary's Leopard 2A7HU tank fleet reaches full strength after final delivery from Germany". *Army Recognition*, 13 December 2025. Available at: <https://www.armyrecognition.com/news/army-news/2025/hungarys-leopard-2a7hu-tank-fleet-reaches-full-strength-after-final-delivery-from-germany>.
49. Hungary Today. "Military power grows with new Leopard 2A7HU tanks". Available at: <https://hungarytoday.hu/military-power-grows-with-new-leopard-2a7hu-tanks>.
50. Novax. "PW-10 Mobile Axle Scales – Technical Product Sheet". Dubí, Czech Republic. Available at: <https://www.novax.cz>.
51. ČD Cargo. 2023. *D33: Provision of Military Rail Transport*. Edition 002.
52. ČD Cargo. 2022. *Catalogue of Freight Wagons*. Prague: ČD Cargo. Available at: <https://www.cdcargo.cz>.

Received 11.05.2026; accepted in revised form 30.09.2026



Scientific Journal of Silesian University of Technology. Series Transport is licensed under a Creative Commons Attribution 4.0 International License