RAND EUROPE

Opportunities for European collaboration in armoured vehicles

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Project objectives and approach

RAND Europe was commissioned by the European Defence Agency (EDA) in October 2017 to conduct a study on collaborative opportunities relating to armoured vehicles among participating Member States (pMS) of the EDA and partner countries.[1] The overarching goal was to support the EDA's work in identifying new collaboration opportunities throughout the full life-cycle of armoured vehicles (excluding main battle tanks – MBTs). This study constitutes part of a wider EDA effort to develop European defence capabilities and promote armaments cooperation.

The study considered three categories of armoured vehicles:

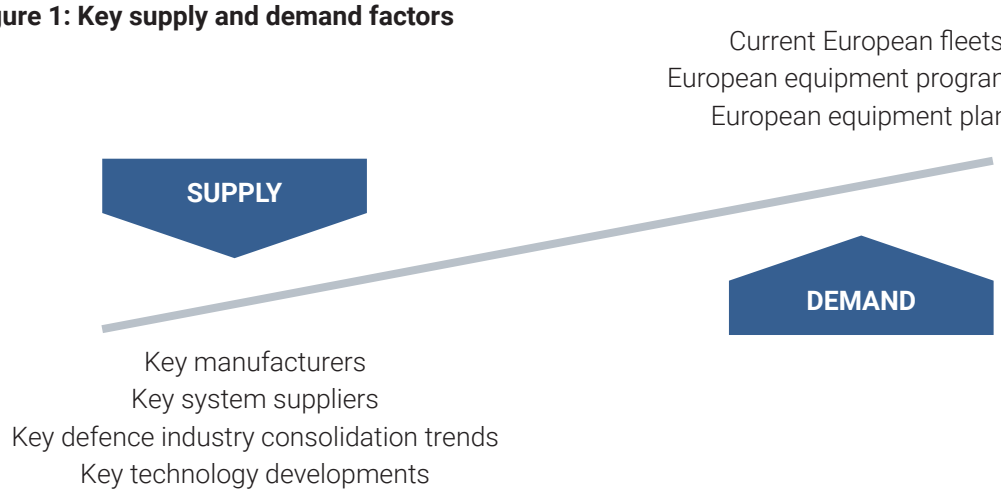
- Armoured tracked vehicles: Tracked vehicles (excluding MBTs) configured for any mission module.
- Armoured wheeled vehicles: Wheeled 6x6 and 8x8 vehicles configured for any mission module.
- Protected transport vehicles: A combination of lighter 4x4 armoured vehicles as well as mine-resistant and ambush-protected armoured vehicles (MRAPs).

In order to identify the potential collaboration opportunities, RAND Europe performed a high-level overview of supply and demand elements related to current and future trends in armoured vehicle servicing, research and development (R&D) and procurement (see Figure 1), while respecting the fact that armoured vehicle choice is impacted by such factors as the potential adversary profile, intended mission set, deployability and terrain, as well as other political and strategic factors.

Overview of the methodologies used

During the study, RAND Europe employed a selection of methodologies that included literature review, questionnaire design, an expert workshop with the participation of the EDA pMS representatives and the development of cost models, as shown in Figure 2.

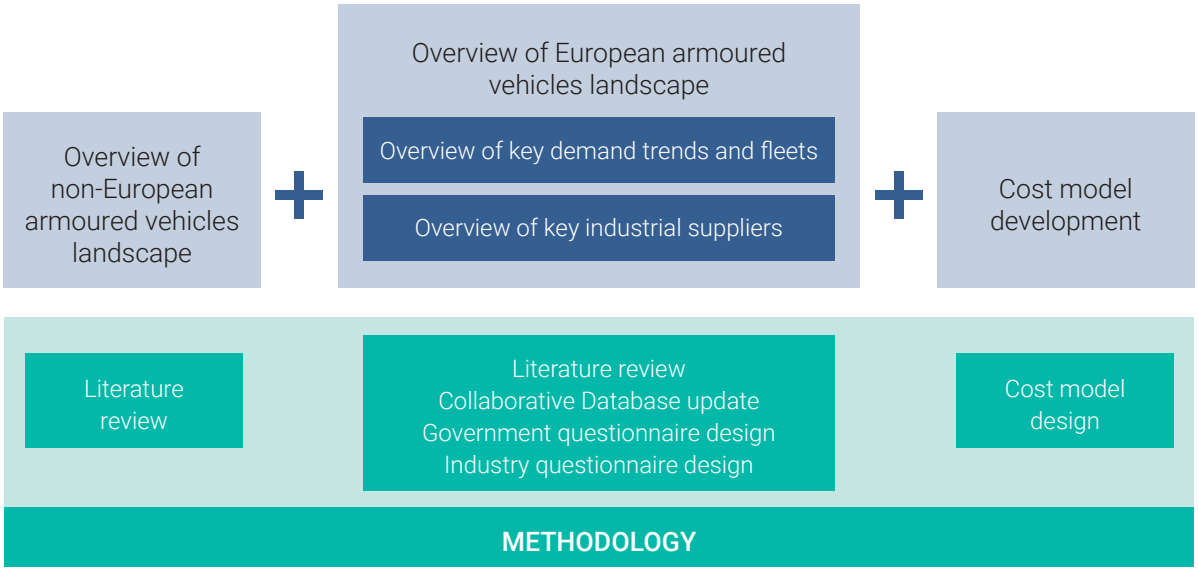
Figure 1: Key supply and demand factors



SOURCE: RAND Europe

1 The study considered EDA partner countries Norway, Serbia and Switzerland, following the EDA's recommendation.

Figure 2: Overview of methodologies used during the study



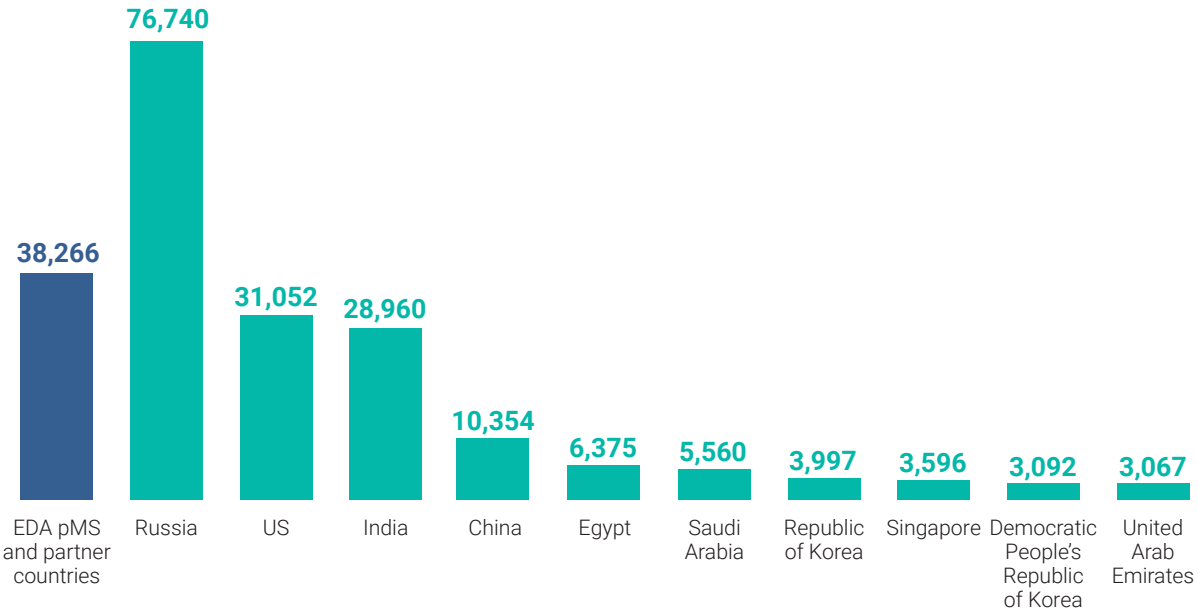
SOURCE: RAND Europe

Study context

Europe is experiencing an increase in investment in land capabilities after more than a decade of limited spending in this area. The overall growth in defence spending in Europe has been influenced by economic and security factors. The economic situation in Europe and globally has been improving since the 2008 Eurozone crisis. At the same time, the rise of immediate security threats to the east and south of Europe, involvement in conflicts in the Middle East, the increasing blurring of the divide between internal and external security threats – which have been exacerbated by terrorist attacks and migration – as well as a decrease in global stability has resulted in the perception that there is a need to strengthen European security. Furthermore, increasing uncertainty about the ability to rely on non-European allies for security guarantees and assistance, along with concerns about the political cohesiveness of the EU and NATO, incentivise investing in national capabilities. Lastly the change in defence-budget trends comes at a time when the military capabilities of many European countries have been reduced. This resulted from force posture trends in post-Cold War Europe that predominantly focused on out-of-area operations rather than territorial defence. Force readiness and the number of personnel was reduced and capabilities downscaled due to the perception of peace dividend, while reallocating some of the defence funding to other areas of the economy was inspired by the potentially resulting economic benefits.

The EU Global Strategy stipulates the continued need to develop full-spectrum land capabilities, reiterating the importance of defence collaboration through the development of the Permanent Structured Cooperation

Figure 3: Comparison of EDA pMS and partner countries' armoured vehicle fleets with top ten global armoured vehicle fleet holders (# of vehicles)



SOURCE: RAND Europe analysis of IISS data

on security and defence (PESCO).[2] PESCO provides a mechanism for the EU member states to develop and deploy defence capabilities jointly. On 6 March 2018, the European Council approved the first set of 17 projects under PESCO, with Italy-led collaborative development of an armoured vehicle family amongst them.[3] Although the results of this endeavour remain to be seen, this development provides an encouraging indication of member states' intent and interest to cooperate in the area of land capabilities.

Main findings

The EDA member states and partner countries hold a significant part of global armoured vehicle fleets

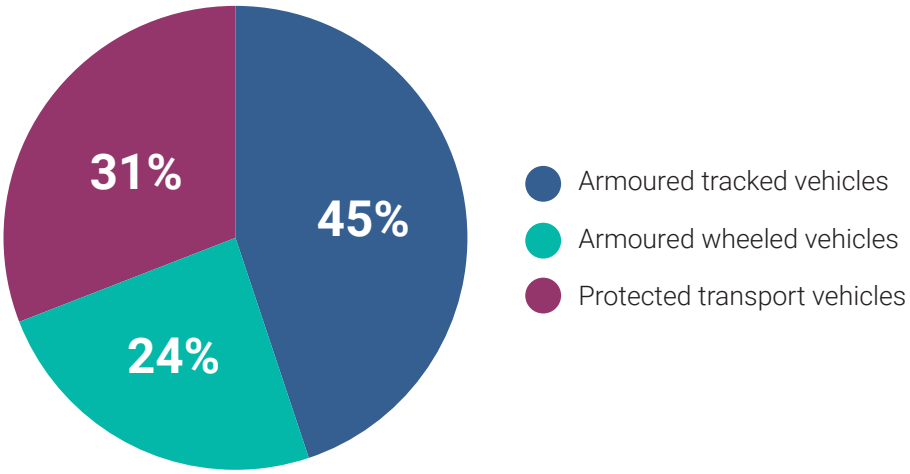
The EDA participating member states (pMS) and partner countries' combined fleet of armoured vehicles is second in quantity only to that of Russia and slightly exceeds the combined US fleet (see Figure 3). At the same time, the EDA pMS and partner countries form a substantial region in terms of the overall defence expenditure, accounting for approximately 16 per cent of the overall defence spending in 2017.[4]

2 Council of the EU. 2018. Council Decision Establishing the List of Projects to be Developed under PESCO. 1 March. As of 6 May 2018: http://data.consilium.europa.eu/doc/document/ST-6393-2018-INIT/en/pdf

3 This project has been joined by Greece and Slovakia.

4 IISS. 2018. The Military Balance. International Institute for Strategic Studies.

Figure 4: EDA pMS and partner countries' armoured vehicle fleet, by vehicle type



SOURCE: RAND Europe analysis of open-source data

The current landscape of European armoured vehicle fleets reveals a large number of vehicle families, while also illustrating considerable degree of overlap

Against the background of increasing defence spending in Europe (3.6 per cent in real terms in 2017[5]), the last five years have seen a number of EDA pMS focus on enhancing their land capabilities, investing in armoured vehicle procurement, upgrade, and, to a lesser extent, development. According to the open-source analysis performed as part of this study, the timelines and requirements of a number of these initiatives are broadly aligned.

Despite this, there is a considerable degree of fragmentation in the armoured vehicle holdings of EDA pMS – of approximately 37,000 vehicles in total, there are up to 47 different families of tracked vehicles[6] and over 35 different families of wheeled vehicles. At the same time, there is also a considerable degree of overlap among countries that own the same vehicle families in all three vehicle categories. These broad parameters coincide with an overcapacity within the European defence industry relative to the size of the European market and the lack of industrial cooperation, consolidation and supply-chain integration.

The European armoured vehicle supply landscape is characterised by fragmentation and overcapacity

The study team has identified a total of 18 armoured vehicle manufacturers in the reviewed European countries (see Table 1), although only 16 have vehicles in serial production or have preserved serial production capabilities.[7] Among these, eight companies export to international markets (outside of the EDA pMS and partner countries), meaning that the majority of the manufacturers are focused on domestic and to a lesser extent, regional,

5 IISS. 2018. The Military Balance. International Institute for Strategic Studies.

6 Includes tracked vehicles in roles that include bridge-laying, engineering and other specialist roles.

7 Despite their merger, Krauss-Maffei Wegmann and Nexter are presented separately for greater granularity.

Table 1: Examples of armoured vehicle manufacturers in EDA pMS and partner countries

Manufacturer	Category of vehicles	Manufacturer	Category of vehicles
AMZ Kutno	Wheeled, protected	Nexter (KNDS)	Tracked, wheeled, protected
BAE Systems	Tracked, wheeled, protected	Rheinmetall Defence	Tracked, wheeled
Bumar Labedy	Tracked	Patria	Wheeled
Gamma Tech. Corp	Wheeled, protected	Romarm	Tracked, wheeled, protected
GDELS	Tracked, wheeled, protected	Rosomak SA	Wheeled, protected
Huta Stalowa Wola	Tracked, wheeled	Supacat	Wheeled, protected
Iveco	Tracked, wheeled, protected	VGGS (ACMAT, Panhard, Renault Trucks)	Wheeled, protected
KMW (KNDS)	Tracked, wheeled, protected	Yugoimport-SDPR	Tracked, wheeled, protected
MSM Group	Wheeled	Zetor Engineering	Tracked, wheeled, protected

SOURCE: RAND Europe analysis

markets. It is also important to highlight the transatlantic industrial links of the European armoured vehicle suppliers. Specifically, while General Dynamics European Land Systems (GDELS) has its production in Europe, it is in fact the result of the US-based General Dynamics acquisition of a series of European armoured vehicle manufacturers. Similarly, while BAE Systems is a UK-headquartered original equipment manufacturer (OEM), its production line for the M113 is in the United States, and it was created as a result of BAE's acquisition of the US-based FMC Corporation in 2005, which designed and originally produced the vehicle.

Thus, EDA pMS have twice the number of armoured vehicle manufacturers than the US, and face the need to focus on export markets in order to sustain their revenue, which is a difficult undertaking considering Europe's relatively limited defence budget size. This saturation has already led to a major step towards industrial consolidation (e.g. the merger of KMW and Nexter in 2016). Although the planned divestiture of the Volvo Governmental Sales was aborted in late 2017, it illustrated the existence of a rationale and an appetite for further consolidation among manufacturers. European manufacturers already cooperate on the design and manufacture of vehicles, although cooperation between national players remains more widespread. At the same time, while nationally based supplier links are dominant, there is some cross-border supply-chain integration.

There is a balanced interest in all three vehicle types, with slightly higher level of interest in tracked armoured vehicles

The overview of European demand-and-supply programmes and plans shows that there is currently a balanced interest in the procurement of the three vehicle categories considered in the study, with 19 current procurement programmes and future procurement plans identified for wheeled armoured vehicles and 17 each for the categories of tracked armoured vehicles and protected transport vehicles. The trend of replacing tracked vehicle fleets with wheeled vehicles, which started in the late 1990s, is no longer clear-cut, as the change in the strategic environment in Europe has heightened governments' demand for the superior level of protection combined with firepower that tracked vehicles offer in comparison to wheeled vehicles. Industry has reacted to this demand signal.

Significant modernisation, upgrade and procurement activities may be observed in the tracked and wheeled vehicle categories, while the ongoing and planned activities in protected transport vehicles are focused on procurement. In particular:

Armoured tracked vehicles: Considering the large European holdings of armoured tracked vehicles (42 per cent of the total European armoured vehicle fleet), and the fact that this category of vehicles has the highest number of different vehicle families (approx. 47) and a large number of aged vehicles (e.g. BMP and M113), a number of European countries are implementing programmes aimed at modernising and upgrading older platforms (e.g. BV-206, CV-90, M113 and BMP-1). Furthermore, at least eight European countries have current plans for the procurement of armoured tracked personnel carriers, six countries are to procure armoured recovery vehicles and five countries have plans to buy infantry fighting vehicles (IFVs) and armoured engineering vehicles.8

Notable development activity may be observed in this vehicle category aimed at both the European and the export market. Examples include the development of the ASCOD 2 by GDELS in 2013, the Puma IFV by the German-based PSM Group in 2014, the Lynx IFV by Rheinmetall in 2016, the Borsuk amphibious tracked vehicle by Poland's Huta Stalowa Wola and the DCL Renove armoured recovery vehicle by Nexter (initial operational capability planned in 2020).

Armoured wheeled vehicles: This is the second-largest category of vehicles present in Europe (see Figure 4) and the focus of the most activity with regard to current and planned procurement plans. Fifteen countries have programmes or plans to buy armoured personnel carriers (APCs), six to buy IFVs, five to buy armoured recovery vehicles and four to buy armoured engineering vehicles. Although some R&D activities have also been identified, this category shows fewer modernisation and upgrade plans and programmes, possibly because some of the most widely used vehicles in this category are either relatively new or belong to the Russian/Soviet-made BTR vehicle family that may be up for replacement with Western platforms, or whose modernisation and upgrade by the original manufacturer would not be feasible due to political concerns.

While there has been notable export activity in this vehicle category, both within and beyond Europe, some R&D activity has also been highlighted. Examples include the development

8 Here and elsewhere in the document: RAND Europe analysis of CODABA and open-source information.

of the Rosomak 2 (Poland's version of the Patria) and GDELS' recently completed development of the Piranha V as the future 8x8 AIFV[9] of the Spanish Army. Although this vehicle segment is characterised by a relatively higher level of industrial fragmentation, some industrial integration is occurring. For example, Rheinmetall is collaborating with the Romanian ROMARM in order to jointly develop and produce an 8x8 wheeled vehicle, which will incorporate elements of both the Rheinmetall-KMW Boxer and the Romanian Saur.

Protected transport vehicles: This category is smaller in terms of share of the overall European fleet (24 per cent), and has fewer identified current and planned activities in upgrade, modernisation, procurement and development. In addition, this category is characterised by one very dominant fleet owner – France. Furthermore, the vehicles in this category are comparatively newer than those in the other categories.[10] At the same time, there appears to be increasing interest in the procurement of these vehicles. Seventeen European countries have current programmes or future plans for the procurement of protected transport vehicles: eight countries have programmes or plans to buy armoured utility vehicles, and seven are interested in the procurement of protected patrol vehicles and reconnaissance vehicles. Although overlapping R&D programmes were not identified, it was observed that both the UK and Italy are interested in vehicle development in this category.

Table 2 shows a summary of the identified indicative levels of current and planned activity in each vehicle category.

Table 2: Summary of European armoured vehicle landscape

Factors	Tracked armoured vehicles	Wheeled armoured vehicles	Protected transport vehicles
Modernisation and upgrade	**Significant** current and planned activity	**Some** current and planned activity	N/A
Procurement	**Significant** current and planned activity	**Significant** current and planned activity	**Significant** current and planned activity
R&D	**Significant** R&D activity present	**Some** R&D activities identified	**Low** level of R&D activities
Additional collaboration possibilities (to those identified in the study)	Potential for cooperation in divestment of aged/ obsolete platforms	Potential for cooperation in divestment of aged/ obsolete platforms	Potential for cooperation in storage of unused mine-resistant vehicles
Overall trend in Europe	Heightened government interest in last five years, future investment expected	Continued government interest, significant expert activity expected	Continued government interest, competitive supplier landscape

SOURCE: RAND Europe analysis

9 Armoured infantry fighting vehicle.

10 However, vehicles in this family – particularly mine-resistant vehicles – generally have a shorter lifespan.

A number of demand and supply factors may lead to increased collaboration in armoured vehicles in Europe

European tracked, armoured and protected transport vehicle fleets are fragmented, with numerous vehicle families observable for each vehicle category. However, EDA pMS and partner nations also have a number of vehicle types in common, including ageing platforms that are being, or are soon to be, replaced.

Notwithstanding these observations, any future collaborative activities on joint procurement, R&D and upgrade would need to consider the potentially differing views of each participating country on factors shaping the armoured vehicle requirement, such as the potential adversary, mission set, deployability and terrain, as well as any political and economic considerations. Collaborative approaches to maintenance, repair and overhaul (MRO) would need to take account of differences in maintenance and repair philosophies and timelines.

The project team identified a non-exhaustive list of factors that may be relevant to the potential for future collaboration in armoured vehicle maintenance, repair, overhaul and upgrades, as well as R&D and procurement. They are listed in Table 3.

Table 3: High-level summary of key factors that may influence potential collaboration in armoured vehicles

Demand factors	Supply factors
Shared overall defence and security threats that fall into two groups: concern about conventional conflict and concern about hybrid and domestic security threats	18 armoured vehicle manufacturers currently exist in Europe, with 16 of them having vehicles in serial production, indicating over-capacity in the supplier base
Most of the armoured vehicle families are currently present in the fleets of two or more European countries	Some industrial consolidation has occurred, paving the way for further industrial integration, although cross-border mergers remain challenging
Groups of countries with broadly aligned vehicle procurement plans and programmes have emerged	European armoured vehicle manufacturers have experience in collaboration and cross-border supply-chain integration, although nationally-based suppliers links remain dominant
A number of European countries own large fleets of older generation vehicles that will need upgrade/replacement	European original equipment manufacturers (OEMs) have shown flexibility in responding to the evolving requirements of European (and global) armed forces
Some collaboration formats (e.g. via the EDA, NATO and OCCAR (Organisation for Joint Armament Cooperation), as well as bilateral cooperation) are in place	

SOURCE: RAND Europe analysis

The study identified five potential collaboration models that may lead to cost savings, provided that key challenges are addressed

Based on the analysis of the current European armoured vehicle fleets, upgrade and modernisation programmes and future plans, as well as procurement and R&D programmes and plans, five potential models* for collaboration were identified and analysed.

While each of the collaboration opportunities may provide substantial cost savings compared to non-cooperation, they may also provide operational and strategic benefits, such as harmonised maintenance, repair and overhaul and procurement processes, and increased vehicle standardisation that may lead to better interoperability. However, all of these models also require a certain level of closer armoured vehicle capability integration or an acceptance of at least some level of strategic dependence of the collaboration partners. The models and the related potential high-level cost savings are summarised below.

Model 1	**Pooling and sharing of spare parts**
An armoured vehicle may contain around 5,000 individual spare parts, and the use of an armoured vehicle places these components under strain. Throughout the operational lifetime of a vehicle, any of these components may fail either through long-term wear ('wear-out' failures), unforeseen high-stress events (chance failures), or initial faults that are not identified at the manufacturing stage ('burn-in' failures). In order to maintain the operational capabilities of their armoured vehicle fleets, countries must establish and maintain a store of spare parts from which they can source replacement components when required. The cost of this spare-parts pool includes an initial provisioning and on-going replenishment of spare parts, together with the management actions required to acquire, catalogue, receive, store, transfer, issue and dispose of spare parts.	
Potential estimated savings range across the considered vehicle categories	21%–63%

Model 2	**Joint Level 4 MRO**
To maintain operational capabilities, militaries are required to carry out regular maintenance of their armoured vehicles, and repair or replace any components that are broken or worn out. Level 4 maintenance, repair and overhaul (MRO) refers to the complete overhaul of armoured vehicles that is typically carried out at a fixed facility located in a country's national territory. Level 4 MRO is required on a periodic basis for armoured vehicles and is typically carried out by specialist non-military personnel from either the public or private sectors in a tailored Level 4 MRO facility.	
Potential estimated savings range across the considered vehicle categories	19%–63%

Model 3	**Joint modular upgrade**
Modular upgrade is understood as the integration of new components into an armoured vehicle that either adds to or replaces existing modules. These components may be integrated either in response to a particular environment or threat, or more generally to increase the capability of the vehicle. Examples of modular upgrades include the integration of more powerful engines, improved mine-resistant protection, improved radar technology, or the installation of a remote weapons system.	
Potential estimated savings range across the considered vehicle categories	52%–59%

Model 4	Joint off-the-shelf procurement
There are a number of ways in which a country can add to or replace an inventory of armoured vehicles, including purchase of surplus second-hand vehicles, development and production of a new platform, or purchasing an existing platform from industry in a so-called 'off-the-shelf' procurement. 'Off-the-shelf' procurement refers to the purchase of commercially available armoured vehicles that require little or no modification to meet national-level requirements. There are a number of advantages associated with this type of procurement, including lower acquisition costs that result from higher volumes of production and greater distribution of R&D costs, accelerated procurement timelines, greater certainty of performance as read-across can be assumed from other in-service platforms, and improved logistics support that results from the higher customer base of the vehicle.	
Potential estimated savings range across the considered vehicle categories	20%–25%

Model 5	Joint platform development
The development of a new platform refers to the design and production of a new type of armoured vehicle. This includes initial R&D costs consisting of advanced technology development, system design and integration, initial fabrication of prototypes, and testing and evaluation of performance, followed by production costs beginning at low-rate initial production (LRIP) through to completion of the final vehicle.	
Potential estimated savings range across the considered vehicle categories	26%–36%

The study also considered the potential cost savings related to the recently launched PESCO project on armoured vehicles

Based on the information and formulae used in the five collaboration models mentioned above, the project team was able to make assumptions about the potential range of cost savings if the PESCO project on armoured infantry fighting vehicles / amphibious assault vehicles and light armoured vehicles encompasses models 1 (pooling and sharing of spare parts), 2 (Joint Level 4 MRO) and 5 (joint platform development).

PESCO model: scenario A		PESCO model: scenario B	
Participating countries include current PESCO armoured vehicle project participating and observer countries, with the assumption of replacing 30% of current armoured vehicle fleets.		Participating countries include all EDA pMS and three partner countries, with the assumption of replacing 30% of current armoured vehicle fleets.	
Potential estimated savings range across the considered vehicle categories	34%–49%	Potential estimated savings range across the considered vehicle categories	52%–70%

** The modelling is subject to a number of caveats described in full in Chapter 4 of the full report on the study. While the study applies practical methodological steps towards this task, it is important to note some of the caveats: Given the challenge of obtaining reliable and detailed publically available cost data, the cost analysis relies on a number of assumptions that underpin the scenarios used in the modelling effort. The models are based on publically available cost information and the operational knowledge of the study team and our experts. Where no cost or benefit data is available, the study team uses a parametric cost estimate by drawing comparisons with historic data or a comparable capability. Furthermore caveats include: (1) Although relatively detailed breakdowns of life cycle cost*

(LLC) structures are available in open- source literature, few precise cost figures are available. This lack of precise open- source cost data places significant limitations on the complexity of economic models that may be developed, as in most cases, there is insufficient data available to support anything more than basic order of magnitude estimates. (2) The majority of data that is available in open- source literature appears to relate to American vehicles and/or sectors other than armoured vehicles, with a particular emphasis on commercial and military aircraft. Throughout the development of the cost-saving models, it is assumed that the same cost structures and absolute costs apply to the European context, albeit adjusted for both inflation and currency. (3) The cost-saving calculations typically assume a best-case collaboration scenario where additional costs from inefficiencies of collaboration are minimised. Existing studies that examine cost savings from real-world examples of collaboration, however, often find that cost savings are counterbalanced to some degree by additional costs that arise from challenges of collaboration. (4) The economies of scale calculations used to calculate cost savings in each collaboration model are simplistic and assumed to apply uniformly across several different processes.