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THE COST OF EUROPEAN MILITARY PROCUREMENT FRAGMENTATION EXEMPLIFIED BY MAIN BATTLE TANKS

Lieutenant-Colonel Thorsten Quendt

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Exercise *Solo Flight*

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THE COST OF EUROPEAN MILITARY PROCUREMENT FRAGMENTATION EXEMPLIFIED BY MAIN BATTLE TANKS

> *The idea was to conceive the military build-up so that all effort be directed in the best possible way and to the best possible place. Duplication and overlapping were to be avoided; a government should not be wasting its money on building, say ships, if it could do more important work, equally useful to North Atlantic defence, in some other field.*
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> .
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> - Lord Ismay, *NATO- The first 5 years 1949-1954*

INTRODUCTION

The European ability to be a competent and reliable security actor is at risk. The widening gap between the European defence requirements caused by rising security challenges and the limited national budgets make productivity improvements imperative.[1] "Everybody knows that the buck-to-bang ratio in Europe today is unacceptable."[2] The inefficiencies are mainly due to the non-integration of the European armed forces and the lack of an EU-wide defence market. These missing elements cause the duplication of weapon systems as well as industrial and organizational structures resulting in lost economies of scale and market inefficiencies.[3] A rough top down estimate of the European commission puts the total cost of the lack of cooperation between the EU states in the field of security and defence between $27.5bn and $110bn per year.[4] The non-integration of the European defence procurement is solely estimated to amount to 30% of the total annual spending for equipment and research & development, respectively $14.5bn in 2012. A comparison with the US armed forces illustrates the inefficiencies and redundancies in Europe in real terms. The US fields a

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[1] McKinsey & Company, *The Future of European Defence, Tackling the Productivity Challenge*, 8.
[2] Wolfang Ischingerr, President of the Munich Security Conference, in McKinsey & Company, *The Future of European Defence, Tackling the Productivity Challenge*, 4.
[3] Valerio Briani, *The Costs of non-Europe in the Defence Field*. (Mancalierie/ Rome: Centre for Studies in Federalism/ Istituto Affari Internazionali , 2013).
[4] European Commission, *Defending Europe. The Case for greater EU Cooperation on Security and Defense*, (Brussels: European Commission, 2017).

total of 30 separate weapon systems versus 178 for the EU while the EU spends less than half of they US budget on weapons.[5]

This paper will show that the fragmentation of the European defense industry is a major burden for the European nations because of their inefficiency and the resulting suboptimal use of the national defence budgets. It will develop a bottom-up estimate for the costs of one weapon system, main battle tanks (MBTs), to contrast it with the rough top-down estimate for the total annual cost of the fragmented European defense procurement. In a first step the economic background of the analysis and the actual situation for MBTs in Europe will be described. The limitations and hypotheses for the applied approach will be enumerated. Finally, possible savings by MBT life phase will be derived and aggregated to estimate the overall cost of fragmentation for the European MBT procurement.

THE ANALYTICAL FRAMEWORK

MBTs have been chosen for this analysis because those weapons are crucial for defending European territory given the tense security environment, particularly along the Eastern European borders.[6] Since the annexation of the Crimea in 2014 land forces have regained importance with MBTs being considered their backbones.[7] Most European nations dispose of MBTs and several European manufacturers entertain production lines, resulting is a large number and variety of types in use. Finally, MBTs cost several

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[5] European Commission, *Reflection Paper on the future of European Defense* (Brussels: European Commission, 2017), 9.

[6] European Defence Agency, "*Optimising Europe's Main Battle Tank Capabilities*". *European Defence Matters* (Issue 14, 2017): 38.

[6] Jürgen Schnell, *Militärökonomie und Ausformungen des Wirtschaftlichkeitsprinzips in Streitkräften* (Munich: Universität der Bundeswehr, 2017).

[7] Björn Müller, „EU Tank Arsenal with Leopard-2: An useful and realizable defense project for Europe?", https://www.offiziere.ch/?p=33701

million $ per piece and therefore represent a noteworthy share in the total military procurement budget.

The economic Background

In general, economic efficiency can be attained either by implementing the *maximization principle* of reaching a maximum output with given inputs ("value for money") or the *minimization principle* of producing a given output with a minimum input. A third possibility is the *extremum principle* defining the most favorable ratio of output to input, for example the lowest unit costs.[8] However, the application of the maximization principle and the extremum principle in military economics is difficult. Since the output depends on variables such as the added value to peace or national interest, the enemy's threats, and the capabilities of allies it is difficult to measure.[9] Hence, the minimization principle with a cost optimization of the inputs is frequently chosen to measure military efficiency.

The *experience curve concept* indicates that the real unit costs decrease while the productivity increases if the total production output is augmented. In engineering literature there is a wide acceptance of a 20% experience curve, which means that the production input requirements reduce by 20% for every doubling of the cumulative past production. This effect is limited to costs which are subject to added value, like production labor time. Other costs, for instance direct material costs, will allow only for minor savings if the output is increased. The experience curve effect is caused by static and dynamic economies of scale. *Dynamic economies of scale* arise from learning effects caused by repeated and continuous work processes, improvements of the employed production process, and technical progress over time. In more capital intensive industries

[8] Jürgen Schnell, *Das Wirtschaftlichkeitsprinzip als Grundlage für Rationalisierung in Streitkräften* (Munich: Universität der Bundeswehr, 2017), 2.
[9] Katharina Wolf, "*Putting Numbers on Capabilities: Defence Inflation vs. Cost Escalation"* (Paris: European Union Institute for Security Studies. 2015), 2.

the effect primarily results from the optimization of production processes. In labor-intensive industries the effect is driven primarily by work becoming more efficient through repetition. *Static economies of scale* base upon fixed cost regression by imputing fixed costs to an increasing number of units. Other static economies are based on the change to less costly production technologies dependent on the output.[10]

The Market for MBTs in Europe

The non-integration of European forces was a conscious decision. In 1954 the European Defence Community failed, because the states wanted to preserve their sovereignty in this domain. This political choice caused the duplication of military facilities, development and acquisition programs, and national standards, which remains a major cost driver. Furthermore, the inexistent European defence market induces the protection of national defence industries at the expense of European competition.[11] This is permitted by the law of the European Union which allows derogations from the European procurement laws if essential national security interests are concerned.[12]

On the supplier side most of the European defence industries remain fragmented and operate small and inefficient entities. On a common European defence market those entities could be consolidated into more efficient companies.[13] As far as MBTs are concerned an important step was made by merging French Nexter Defense Systems and German Krauss-Maffei-Wegmann (KMW) into KNDS in 2015. Consequently, there remain four European manufacturers with "warm" MBT-production lines: KNDS, Italian IVECO-Oto Melara, British BAE Systems, and German Rheinmetall. This group of

[10] A.G. Coenenberg. *Kostenrechnung und Kostenanalyse*." (Landsberg: 1999). 203.
[11] Valerio Briani, *The Costs…* , 7.
[12] Art. 346 Treaty on the Functioning of the European Union
[13] Willy Herteleer, *Defragmentation in the Field of European Defence Industries*, http://www.eurodefense-belgium.eu/32-Jepense/jp09 Defragmentation/Defragmentation_in_the_field_of_European_Defence_Industries.pdf

manufacturers might be further reduced since Rheinmetall announced its interest to acquire 50% of KNDS in 2018.

On the product side European nations excluding Turkey and Ukraine fielded 5, 356 MBTs of 14 types and various versions as of June 2018, which compares to 15,000 MBTs in the year 2000.[14] A number of 300 T-55 and TR-580 (Romanian T-55 derivative) used by Latvia and Romania are obsolescent and due for replacement. Further 2, 570 MBTs will become due for replacement during the next 20 years, embracing M48, M60, AMX 30, Leopard 1, T-72, and PT91 Twardy (Polish development based on the T-72). Finally, 2, 480 MBTs require replacement even later, like the Leopard 2, Leclerc, Ariete, Challenger 2, and T-80.[15] In general, the number of MBTs in Europe is expected to remain stable until the year 2030.[16] The recent years were characterized by an incremental logic of MBT development.[17] The current trend is to upgrade MBTs for example with new fire control systems instead of developing new MBTs. This situation is up to change, since in 2018 KNDS has presented the European Main Battle Tank (EMBT), a concept based on the turret of the Leclerc and the chassis of the Leopard 2A7. The new EMBT will not be available until at least 2035.

Limitations and general Hypotheses

In general, only limited public information about MBTs and their economic properties and data is available. Therefore, the analysis is based on analogies with other weapon systems and general industry information.

It is assumed that the total number of MBTs in Europe will remain constant at 5, 300 over their expected life cycle of 30 years. Furthermore, it is assumed that the

[14] European Defence Agency, *optimizing Europe's*…., 38.
[15] Michel, Yohann. "France and Germany: on the right Tracks?" https://www.iiss.org/blogs/military-balance/2018/07/france-and-germany-tank-tracks
[16] European Defence Agency, *optimizing Europe's*…., 39.
[17] Yohann Michel. "France and Germany….."

replacement will be uniformly distributed over the life cycle, which results in a stable and predictable procurement of about 175 MBTs to be replaced per year in Europe. Product replacement cycles are currently not aligned among the European nations. A multinational synchronization of MBT replacement cycles will be necessary to align the replacement and upgrade cycles. Variability in procurement can increase the unit cost. First, by overestimating the actual quantity that will be produced, the production facilities may be overdimensioned and do not operate at the most economic point. Second, year-to-year variability is causing problems to manage the staff and the suppliers.[18] Furthermore, it is assumed that there are no exports of new MBTs to countries outside of Europe during the life cycle and no imports into Europe. It is supposed that the platforms are used for MBTs only, excluding use for armed personnel carriers and special vehicles such as recovery vehicles, combat engineering, and bridge layers.[19] It is assumed that no components are jointly used in European MBTs. The use of components of one platform for other vehicles would increase the experience curve effects for those elements. In fact, for example the 120mm smoothbore Rheinmetall gun, motors, gearboxes, and chains are used in various MBTs. It is further assumed that there are no negative impacts from reducing the number of manufacturers. A reduction would restrain the competition on the market by increasing the market power of the manufacturers. Moreover, a reduction of the number of manufacturers would reduce the contest for engineering solutions. The additional costs encountered for multinational projects as compared to purely national procurements are not taken into account. Possibly limited industrial capacities of the manufacturers are not regarded. A no-inflation hypothesis has been taken. In reality the cost increases for defense goods exceed the average inflation for civil products. The cost increases for some weapon systems have been calculated to be between 5% and 10% per

[18] Arena, Mark V. et al., *Why has the Cost of fixed-wing Aircraft risen?*. (Santa Monica: RAND Cooperation, 2008).
[19] European Defence Agency, *optimizing Europe's….*, 39.

year in real terms.[20] The factors contributing to this development are the imperfect competitive structure of the defence market, the relative value of defence equipment which has to be superior to the enemy's weapons, and the necessity to purchase expensive cutting edge technology. For MBTs the annual cost increase is believed to be in the range of 1 to 4% in real terms.[21] Full specification alignment and standardization are necessary to realize the potential that lies in European procurement and reduction of the industry's fragmentation. In reality, for other European projects the alignment was incomplete at best, resulting for example in two distinct French and German versions of the AH Tiger and more than 25 versions of the NH90 helicopter.

MBT LIFE CYCLE COST ANALYSIS

The typical life cycle of weapon systems can be described in four phases: development, production, in-service, and disposal.[22]

Development Phase

There are six decisive factors which have to balanced for the MBT development: the Iron Triangle incorporating firepower, protection, and mobility, as well as connectivity (collect data and share with other vehicles), sustainability (ease of supportability and logistical footprint), and adaptability (ease to reconfigure a platform to different missions).[23] The share of development costs in total acquisition costs varies largely depending on the weapon system from 5% to 90%. A value of 25% is considered as a good average indicator for weapons. Furthermore, an according figure can be

[20] European Commission. *Proposal for a Regulation of the European Parliament and of the Council establishing the European Defence Industrial Development Programme*, (Brussels: European Commission, 2017).
[21] Katharina Wolf. *Putting Numbers… .*
[22] Jürgen Schnell, *Militärökonomie und …*
[23] Nicolas Drummond, "The Challenger 2 Life Extension Programme –is it worth it?" https://uklandpower.com/2018/06/23/the-challenger-2-life-extension-programme-is-it-worth-it/

derived for MBTs based on an analogy with Armored fighting vehicles.[24] The development costs for the Leopard 2 until the production start in 1984 have been specified ex-post to be $1.1bn. The R&D costs for the M1 Abrams have been estimated ex-ante at $1.2bn.[25] In general the increasing complexity of future MBTs will further drive the R&D cost for new designs. Therefore development costs of $1.2bn are assumed to be the lowest estimate for a completely new MBT.

The development costs are subject to fixed cost regressions and thus static regression. In case of an optimized European procurement these costs can be affected to one MBT design only and 5, 300 produced units, which is $0.2m per unit. In the worst case scenario with all four active MBT producers developing their own design the development cost will be quadrupled to about $0.9m per unit.

Production Phase

The production costs for MBTs are not publicly communicated. Therefore the analysis has to be based on the market prices, which include for instance the development costs and the profit margin of the manufacturer. The price of various MBTs is estimated to be $8.5m for the AMX 56 Leclerc 2, $6.8m for the Challenger 2, $6.7m for the Leopard 2A6, $8.8 to 10m for the Leopard 2A7, $6.0m for the M1 Abrams, $5.0m for the Merkava MK4, $2.5m for the T-90S, and $1.5m for the T-72.[26] A rough estimate for the T-14 Armata is between $3.5 and $6.5m. The prices largely depend on exchange rates, the number of MBTs purchased by contract, and if services and spare parts are included. The aforementioned MBTs have been produced in very different quantities and

[24] Frédéric Mauro, *Etude préparatoire pour la Commission Européenne sur le budget du "Programme de développement pour l'industrie de défense",* (Brussels: European Commission, 2017)
[25] General Accounting Office. *Comparative Life Cycle Cost: A Case Study.* (Washington: General Accounting Office, 1978), 5.
[26] "Mass production T-14 main battle tank" Accessed 01 May 2019 https://www.nextbigfuture.com/2015/10/mass-production-t-14-main-battle-tank.html

according economies of scale are already included in the market prices. While the total production of the Challenger 2 and the AMX 56 Leclerc 2 is less than 1, 000 units, about 10, 000 units of the M1 Abrams, and more than 25,000 T-72s have entered into service.

For the analysis a basis price of $ 8 m per unit is assumed for a new MBT model with 500 scheduled units and excluding R&D cost. The share of materials and labor cost is assumed to be at 50% each, thus $4.0m each. Analysts estimate that the labor costs of production are reduced by 20% and the material costs by 10% if the output for a certain weapon system is doubled. [27] For the optimum case of one MBT manufacturer the labor part of the productions cost will decrease by 20% for every doubling of the production output from 500 units to a total of 5,000 units. This is equivalent to a decrease of the labor cost by $2.1m from $4.0m to $1.9m per unit. The material costs will be reduced by $1.2m per unit from $4.0m to $2.8m. In the worst case of four manufacturers and 1,500 units per factory labor cost will decrease by $0.9m per unit from $4.0m to $3.1m and material costs will be reduced by $0.4m per unit from $4.0m to $3.6m.

In-service Phase

During the utilization phase training and logistics support increase in importance. For instance, in 2018 less than 50% of the 244 German MBTs were operational due to badly filled spare part depots.[28] Frequently, costly life extension programs are run to increase the expected useful time of the MBTs. The latest enhancements include remote-weapon stations, active protection systems, top protection, programmable rounds, and additional sensors. Germany is upgrading 104 Leopard MBTs to the Leopard 2A7V standard,

[27] McKinsey & Company., *The Future of European Defence…*, 16.
[28] Björn Müller, *EU Tank Arsenal…*

mainly Leopard 2A4, for a total of $850m or $8.2m each.[29] A further 101 Leopard 2A6 will be upgraded to Leopard 2A7V for $350m or $3.5m per unit.[30] The upgrade of the Challenger 2 is estimated at $5.0m per MBT increasing the life expectancy by 15 to 20 years. Enhancing a M1 Abrams with a new fire control system is estimated at $2.0 to 3.0m per unit.

The reduction to one European tank type would accelerate the creation of common doctrines for the use of MBTs leading to higher combat power in multinational operations.[31]The elimination of redundant MBT types would significantly reduce maintenance cost by a increasing the potential for multinational cooperation in weapon system maintenance, for example lowering the cost of spare part inventories. Common training, exercises and maintenance using existing facilities would save further costs.[32] While the savings linked to lower operational costs are difficult to estimate, it can be assumed that all MBTs will receive a life extension program. The cost is estimated at minimum $4.0m or half the sales price of the new MBT. As for the MBT production phase experience curve effects apply for the enhancements. Those are therefore estimated at 50% of the effects calculated for the production phase or $1.6m in the best case of one manufacturer or $0.6m per MBT in the worst case of four manufacturers.

Disposal Phase

The MBT's disposal can be effected by scrapping after salvaging usable pieces or by selling to other countries. Typically this phase will cause only relatively minor cost or

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[29] Jakub Palowski. Leopard 2A7 Tanks with European Support. "There are no other versions envisaged with the RFI. https://www.defence24.com/leopard-2a7-tanks-with-european-support-there-are-no-other-versions-envisaged-within-the-rfi-analysis

[30] Bundesministerium der Verteidigung. „*428 Millionen Euro für Bündnis- und Landesverteidigung*". Accessed 15 May 2019. https://www.bmvg.de/de/aktuelles/428-millionen-euro-fuer-landes-und-buendnisverteidigung-35514

[31] Björn Müller, *EU Tank Arsenal…*

[32] European Defence Agency, *optimizing Europe's….*, 39.

[32] Jürgen Schnell, *Militärökonomie und …*

even profits. Furthermore, the impact of the fragmented European procurement is low. Therefore the cost of fragmentation for this phase is evaluated with zero.

Results of the MBT Life Cycle Cost Analysis

The classical rationalization methods for weapon systems are normalization, standardization, and reduction of the model range. In case of a single European MBT type the average per unit cost for the development and production phase as well as the updates are estimated at $7.9m ($0,2m for development, $5.1m for production, and $2.6m for updates). The cost for production and updates is optimized because the cumulative produced units double 3.25 times from the assumed base production of 500 MBTs to the total demand of 5,000 MBTs in 30 years. In case of four MBT models the cost per unit is estimated to be at $11.3m ($0,9m for development, $6.9m for production, and $3.4m for updates). In fact, the fragmented MBT manufacturing industry boils down to four separate experience curves. The development costs can only be imputed to 1,500 MBTs per manufacturer. The experience curve is suboptimal since the assumed base production of 500 MBT will only be doubled 1.5 times. Hence, the cost of fragmentation can be assessed to be $3.4m per unit, the difference of the per unit average cost of $7.9m and $11.3m respectively. The total savings for a given a production of 175 MBTs per year would amount to $0.6bn per year or 30.5% of the yearly MBT procurement budget for the fragmented MBT manufacturing industry.

CONCLUSION

The current European MBT types are arriving at their zenith with their development potentials being exhausted to a large extent. This could be the moment to

overcome the complexity caused by the variety of different MBT types currently in operation in Europe. A standardized European MBT would promote the standardization of Europe's highly varied inventories, while enhancing the interoperability and yielding efficiency and effectiveness gains. The costly fragmentation of the European defence industry is endangering the defence competence of Europe by its inadmissible lack of efficiency. This paper confirms the possibility expressed by top-down estimates that 30% of the overall procurement budget of the European nations is wasted due to the cost of fragmentation of the European defence industry.

Major changes require high pressure. Hopefully, the current pressure is high enough to change defense procurement paradigms after 70 years and to increase the efficiency of the European weapon procurement at least for MBTs. The European nations and their allies require the efficient use of their limited defence budgets more than ever. Their armed forces have the right to fulfill their missions with a sufficient number of modern weapon systems.

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