

A HOLISTIC APPROACH TO THE TANK DEVELOPMENT

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**The enemy always attacks on two occasions:
When he's ready, and when you're not ready. (Murphy).
Speed is the essence of war. (Sun Tzu)**

Abstract

The paper reports on the philosophy of tank development that started from the basic concept of the T 72 tank and led to the new Croatian tank *Degman*. The starting point for development of this excellent combat system, for the time being most suitable for high-speed and round the clock operations, was recognition of its basic concept as an appropriate response to future operations needs, that are and probably will be wars of manoeuvre. In step by step development passing through M-84, M-84A, M-84AB models, the most recent result - tank *Degman* – represents a completely new combat system grown-up by marriage of the basic concept with new technologies and solutions, all under a new spirit. The spirit has been a holistic approach to tank development dealing with the most important issues: **instead of installing more power to get greater power to weight ratio – get more power density and more effective power on the sprockets** (more mobility, agility and manoeuvrability); **instead of more fire power – be first to hit and to hit well** (more fight-ability); **instead of more armour protection – avoid the hit by agility, manoeuvrability and fight-ability** (more self protection), etc. The paper presents the results of that approach of development and renders an account on evolution of the public opinion since 70's up to present day.

Key words: MBT, Tank, Degman, Transmission, TITR

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Introduction

Main Battle Tank (MBT) is **offensive, highly efficient fighting system intended to realize highly-demanding tasks/mission on the integrated battlefield**. The technical meaning of this definition comprises: high mobility and high fire-power fighting system combined with excellent communication and information capabilities.

How successfully and thoroughly could MBT accomplish its mission goals giving **effective response to all existing threats** to the mission and its own survivability and synergize all tactical activities with “neighbours”? What do we really mean by “to achieve the mission goals”?

Firstly: to **identify** the targets as mission goals and/or mission threats (including Friend-or-Foe identification) and to **disable or eliminate** threats to achieving mission goals. Secondly: to **avoid and/or survive** enemy attack and hit, and be able to **continue the mission** as long as necessary. And finally, if/when mission is complete: **safe return** !

Due to this philosophy **key points** on Integrated battlefield are **mission, threats** and MBT **fight-ability** and **ability to be independent** but also **to be interdependent**.

***Fight-ability** means get quickly at the right place, at the right position, at the right moment, be first to hit and to hit well (disable the threat), capability to avoid and survive a hit, capacity to continue the mission as long as necessary – as quickly as really possible, with the highest possible rate-of-fire and the highest possible hit probability.*

That is why we recognized fight-ability as a focus – the main MBT characteristics which covers all other characteristics usually defined as important: mobility, fire power and protection.

*In our approach MBT is **NOT described by a triangle** (mobility, fire-power and protection)- it is described by a **PYRAMID**.*

The **basis** of pyramid is MOBILITY (which includes agility and manoeuvrability), the sides are FIRE-POWER (Fire-on-the-move, ALS, etc.), PROTECTION (Survivability) and COMMUNICABILITY (covering communication and information capabilities). Somewhere inside the pyramid are all other characteristics (mass, silhouette, cruising range, transportability, etc.). Finally, the **total content of the pyramid represents FIGHT-ABILITY**.

Directly or indirectly, **mobility influences other important MBT characteristics** (a typical example is improved survivability as a result of better agility and manoeuvrability) .

Tank Development Leading to the Behemoths

Since beginning of the 70's a creation of a paradigm concerning future tank characteristics was in full swing and quickly spread out around the world. The future tank characteristics were concisely stated: fire power – protection – mobility. Since nobody knew (and never will) how much of each one is needed, the tank development has been aiming to get **more of everything**: more fire power, more protection and more mobility. Today we can clearly see the results: the calibre of the main armament increased (from 90/105 mm up to 120/125 mm), the ammunition assortment enriched (in effectiveness and variety), the Fire Control Systems became highly sophisticated, the armour became multilayer and thicker, and a big amount of engine power has been installed (1100 kW), Table 1. Even a new term has been born “vetronics”- vehicle

around electronics – issued from a fully computerised French tank LECLERC. Many billions of dollars have been spent on development. Have we really got a combat system for the future operations – a winner, as some of the public say? Is the assessment of the Editor of THE TANKS OF THE WORLD, the edition issued in year 2000: “*Together with M1A1/A2 ABRAMS and LECLERC the LEOPARD 2 marks the highest current standard in MBT technology. Good fire power, excellent armour protection and high mobility*”, Table 1, true or false?

Table 1: Some of tank characteristics for latest development models*

Latest models	USA	UK	FRANCE	GERMANY
Tank model In production	M1A2/ 1996	CHALLENGER 2/1993	LECLERC 1991	LEOPARD 2 1979
Engine power [kW]	1.100	882	1.100	1.100
Length of hull over tracks [m]	7,92	8,327	6,88	7,66
Width [m]	3,657	3,518	3,71	3,7
Height [m]	2,886	2,95	2,78	2,78
Combat weight kg	57.150**	62.000**	54.500**	55.150**
Power-to-weight ratio [kW/t]	19,3	14,2	20,2	19,9
Main armament calibre [mm]	120	120	120	120
Weight of complete round [kg]	19 –24.5***	19-23***	>20***	17-23***
Assessment given in THE TANKS OF THE WORLD Edited by Wolfgang Schneider – 8 th Edition, Bernard & Graefe Verlag, 2000	Good fire power, excellent armour protection and high mobility. High full consumption no submerge crossing capability.	Good armour protection, average fire control system, low mobility	Due to the digital vehicle electronics this tank represents a high standard of modern MBT technology partly ahead of Leopard 2 A4 or M1A1 ABRAMS	Together with ABRAMS and LECLERC it marks the highest current standard in MBT technology. Good fire power, excellent armour protection and high mobility.

* Source [1,2]

** There are significant indications [4] saying that latest models of those vehicles have a **mass close to 70 tons**.

***Manual vs. automatic loading ? Influence to rate-of-fire ?

Let see what we are talking about:

No doubt, there is an **application and demonstration of the most modern technologies**, but in short: **all of those vehicles became behemoths**. And they have

been recognised as such since 1985 [3] and nowadays it is clearly and explicitly said: “dooming the behemoths” [4].

Concerning **firepower** [5], is it really the most (and only) important to get big calibre, effective ammunition, sophisticated Fire Control System and multiplied and stabilised vision instruments? The ammunition became heavier (more than 20 kg) and **without an automatic loader a crewman has a hard work to do** and he is supposed to do it at a much greater vehicle speed and accelerations (if any) on off-road conditions. Are a man (any man) muscles and psychophysical constitution at the level of the need imposed by the technologies? Besides, a tank on the battlefield is supposed to move as quickly as possible from one position to another to get a better fire position. **How quickly a behemoth can do that?**

Concerning the **protection**, no doubt that the armour is important to minimise the impact of a hit. Thus the armour itself contribute to hit survivability, but the protection as a whole is not solved by the armour. What about hit avoidance? “*Getting the first aimed round off will remain an effective means of hit avoidance*” – says Mr. Boltè [6]. Doesn’t it refer to the firepower characteristic of the tank? Besides, **rapid changes of position** capitalising natural covers and **changing directions in moving are tangible benefits to hit avoidance**. Does a behemoth have this ability, no matter of what its power (fire and engine) is? **In addition, a behemoth means a big target and a much bigger (higher) probability to be hit.**

Concerning **mobility**, no doubt that an amount of power is needed to make a vehicle mobile. Although a lot of words and scientific papers have been written about tank mobility, do we really realise what a mobility is? **Is mobility of an elephant (having an impressive power) greater than mobility of a leopard?** Do we have problem with our perception or the names are confusing us? Do behemoths have this ability?

It is evident that mobility contributes to the overall performances of the vehicle.

Unfortunately, it seems that, on the first place, the awareness of this led the development of all those tanks to get the attribute of behemoths.

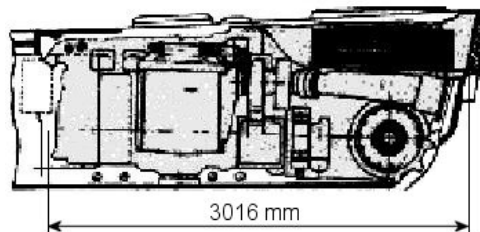


Figure 1: The power pack of the LEOPARD

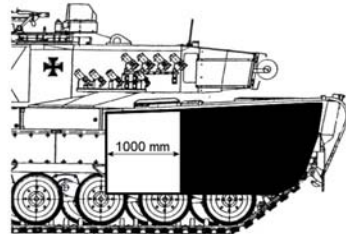


Figure 2: The new EuroPowerPack in the Leopard 2

The development of the **LEOPARD 2** started with the ambition to get power to weight ratio of 22 kW/t. It was supposed to get it with an engine of 1100 kW, which means that the weight of the vehicle should not exceed 50 t. But with an over 7 m³ armoured volume of the power train [7], Figure 1, it must had been difficult to imagine how the vehicle can be below 50 tons.

Mr. R. Hilmes in his article “Battle tank mobility” in 1985 [7] announced that a new development of a much smaller power pack had been under way. And it appeared by the end of the last century as “EuroPowerPack” of 1100 kW for MBT. However, it

seems that some more power will be needed (1,215 kW) for modernisation of the LEOPARD 2, Figure 2 [8]. No doubt that this new power pack is a great achievement, especially the new MTU engine in it.

But, will this new power pack turn the behemoth into a real leopard?

Tank M1 ABRAMS followed the same concept of development, although with different solutions and technologies concerning the propulsion of the vehicle. There is a gas turbine AGT 1500 of 1.100 kW and DDA transmission X1100-3B. The result at the beginning of its production in 1980, concerning the mobility was far from what it was expected to be at the beginning of development. In 1985 it was also given the attribute of behemoth [3] and with the continuing increase of the weight of the vehicle the problem probably even deteriorated.

The French **tank LECLERC** is the latest result of Western Tank Development School following the paradigm: firepower-protection-mobility and breaking itself against it. The French started an engine development project in early 70's and developed the famous *hyperbar* engine VX8 1500. It was an excellent achievement in technology of hyper-pressure air alimentation system. But the vehicle as a whole was not what it was wanted to be at the beginning of development. Even before the prototype LECLERC was promoted (1990), Mr. G. Turbé [9] said that the power pack of the vehicle has **2 m³ more than it should have**. In 1994 the technique director of the transmission producer SESM, Mr. P. Tosi said [10]: *"The power train is probably one of the most important parts in the design, then in the operation of the battle tank"*. He pronounced the ultimate truth but at the same time he put the heat under engine designers saying: *"We have to wait for the arrival of less voluminous engines with a form which is better adapted to obtaining an important gain on the volume of the power packs"*.

In 1997 Mr. R. Fletcher in his article titled *"Dooming the behemoths – European Nations Consider Innovative Approaches To Reduce Tank Size And Weight"* [4] says: *"Forward-looking military analysts are questioning whether the considerable weight of main battle tanks – such as the French Leclerc and German Leopard 2 – are the best suited to meet the future needs of the armoured force"*.

The Russian Tank Development Philosophy

The prototype of the Russian tank T-72 was completed in 1970, it entered production in 1974 and its first public appearance was in October 1977, on the occasion of the visit of the French Defence Minister to a Soviet Guards Division. The prototypes of the LEOPARD 2 and M1, and almost everything about them had already been known. The appearance of the T-72 impressed the journalist so that they exaggerated publishing some of its characteristics, based more on emotions and wishful thinking than on facts. Like, for instance, top speed of unattainable 100 km/h, which information can still be found in some Western books. The appearance of the T-72 was really impressive. It was something different compared to what had been known as result of Western development. A powerful weapon of 125 mm, effective kinetic energy

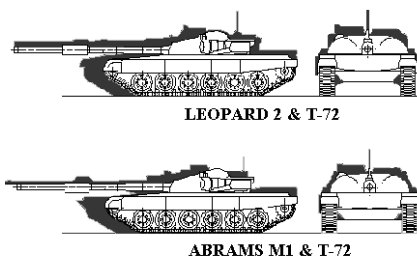


Figure 3: The silhouette of the T-72 compared to Leo 2 and Abrams M1

ammunition (more than 1600 m/s muzzle velocity) and probably highly resistant armour under assumption that a designer that made a powerful weapon had also made appropriate armour. And, above all, a small size of the vehicle – small dimensions, low silhouette, and weight of only 41 tons, Figure 4.

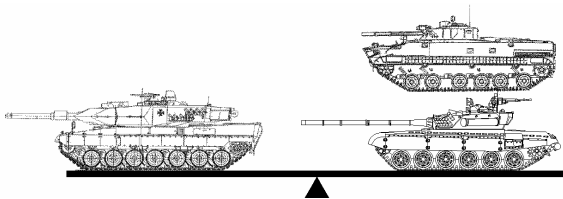


Figure 4: The weight of Leopard 2 is balanced with the weight of the T-72 and IFV BMP3

small weight of only 980 kg. – a V 12 diesel, of 38,8 litres. But the transmission was **something never seen before**. It is so well integrated into the hull that one has difficulties to realise that there really was transmission in the power train box. The

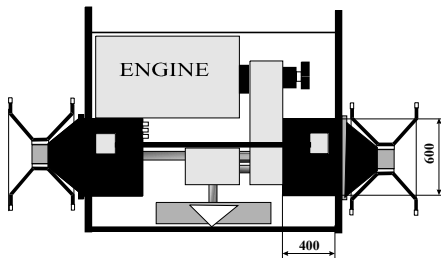


Figure 5: Power train of the T-72

The small size of the vehicle was result of elimination of one crewman, due to an **automatic loader**, and an unusual concept of the **power train**. The power train consists of V-46 engine of 575 kW and a mechanical transmission. The engine was nothing unusual, except its

transmission consisted of two gearboxes integrated with the final drives and there were only two cylinders of transmission itself $\text{\O} 600 \times 400 \text{ mm}$ entering the hull, which is only $0,23 \text{ m}^3$, Figure 5. The whole power train took the **volume of only $3,2 \text{ m}^3$** , which meant a **power density** of the engine-transmission compartment of **180 kW/m^3** . Compared to Leopard 2, there was more than 20 kW/m^3 greater power density.

All in all it was a combat system, a MBT, of incredible overall characteristics: powerful **no-man-loaded weapon**, effective ammunition, probably highly resistant armour, **extremely small dimensions and weight**, very **low silhouette**. Concerning the propulsion power, this vehicle with 14 kW/t power-to-weight ratio was far from the aimed 22 kW/t of the Western tank development.

The question is whether the development of this vehicle followed the paradigm: firepower-protection-mobility or not? Would it be, as a combat system - as a whole, better if there was a power pack of 7 m^3 and 1100 kW ?

Public Opinion Shift

The 70's were full of articles in the military and defence reviews spreading the paradigm firepower-protection-mobility, fostering especially mobility and creating a model of reference from LEOPARD 2 project requirements and development aims: 22 kW/t (30 HP/t) and transmission full of hydraulics.

At the beginning of the 80's, the issues arising from the recent tank development seemed not to be what was wanted. International Defence Review in its supplement 9/95 BATTLE TANKS showed the courage of a strong opposition to the current model of reference. Mr. Ch. Jenkins says [3]: **"Small is beautiful"** – *"There is a large body of opinion which says that the current generation of behemoths, such as Challenger,*

Leopard 2 and the M1 Abrams, is the last of its kind...”. Mr. Boltè concludes his article [6]: “The tank as a system” – “Protection and effectiveness of the tank in fulfilling its role of providing mobile, offensive firepower on the battlefield have a synergistic effect on each other, so that neither protection alone nor weapon system effectiveness alone deserves over-emphasis at the expense of the other”. Mr. R. Hilmes [7], although still under the reign of the

same model of reference, and treating the symptom of mobility insufficiency, emphasises at the end of his article: “The task facing the designers of the next generations of battle tanks is difficult, but nonetheless urgent – to bring together into a harmonious whole all those performance characteristics that enhance mobility.” This statement of Mr. Hilmes is very interesting. It represents a turnaround over question of mobility. He emphasises that we need a **“harmonious whole” to “enhance mobility”**. He gives us the dimensions of a MBT that would not have a weight over 50 tons, Figure 6.

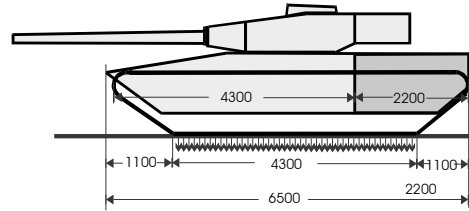


Figure 6: Mr. R. Hilmes proposal for dimensions of a tank not being over 50 tons

In 1988 Mr. G. Turbé, again in IDR, had the courage to say, even before the prototype of the LECLERC was promoted, that its power pack is 2 m³ larger than it should be [9].

In 1997 Mr. R. Fletcher says clearly and openly [4]: “Dooming the Behemoths” – “Leopard 2 has spread across the continent from Sweden to Spain...But doubts are now being expressed as to whether such vehicles, weighing close to 70 tons, are really suitable for future operations, which are more likely to be wars of manoeuvre. Automatically loaded Russian vehicles, such as T-72 and T-80 tanks, are smaller yet well-armoured, weighing in at around 50 tons. This successful Russian tanks have prompted more than a few Western European defence officials to question whether the size and weight of their forces’ tanks should be reduced to make them more suitable for high-speed, round the clock operations.”

No doubt that Mr. Fletcher’s statement is true, but the question is whether behemoths can be reduced to fit the needs. Would such an endeavour give a result of a “harmonious whole”? It seems that the answer to this question is obvious looking at the solution Mr. Ch. Foos showed in the Jane’s Defence UPGRADES [8], Figure 2.

Another public advice shows also a paradigm shift of the public opinion concerning the model of reference in tank development. Mr. E. Biass in his article “Taking the T-72 into the 21st Century” in Armada International 1/99, concerning the upgrades of T-72 says [11]: “However, before describing the many and varied upgrades taking place and on offer, it is prudent to **consider the baseline configuration (frozen in 1973) from which they start.**”

From T 72 to the Croatian DEGMAN with a Holistic Approach First step: Tank M-84

The production of tanks in Croatia started at the beginning of 80’s under the licence of T-72. Although the tank T-72 already was a Harmonious Whole as a result of a different approach to the tank development, there was no sense to reproduce it. An opportunity to

make a step forward was challenging and at the very beginning of the production adoption the designers were supposed to make an **upgrade**.

At the other hand the reflection of the recent Western development showed an altered picture of the paradigm: firepower-protection-mobility, as a consequence of a symptomatic approach – of a separate treatment of each characteristic. Thus the cure of mobility insufficiency had the most drastic impact on the vehicle as a whole. As shown above – search for more mobility by installation of powerful power pack, apparently of the most modern technology, led to behemoths, more or less immobile as regards more accurate definition of what mobility is.

A meticulous study of the T-72 during preparation of the production in 1979-80 showed much more ingenuity than expected hiding behind such a result. Therefore some, apparently forgotten, principles had to be re-established before proceeding to an upgrade.

First: Return to the roots. Tank needs to provide *mobile and offensive firepower*. Thus its main characteristics is **fight-ability**. What does it mean? **Fight-ability is represented as a pyramid of characteristics** (covering mobility, fire power, survivability and communicability). Thus, there is neither simplified explanation of what a good tank is nor easy way of how to get it. However, the size, the silhouette and the weight of the vehicle are definitely the most important issues.

Second: Characteristics vs. Technology. Some technologies, popularised with recent tank development, became fashionable, without being submitted to real evaluation. For instance, application of hydraulics in power transmission units results in poor efficiency (loss of energy, creation of heat problems, which leads again to loss of energy to drive powerful cooling system), great dimensions and again everything which goes with it eventually finishing in the need for more energy etc. Applied technologies should be justified by introduction of corresponding quality assessment.

Third: Innovative solutions. The baseline T-72 configuration had to be frozen. There are always new solutions for improvement. Innovative solutions should be found out.

Modernisation of T-72 started on the basis of these three principles. Besides many smaller improvements in application of new homemade components, new computerised **Fire Control System made the main difference between T-72 and M-84 tank**. It was an important leap forward concerning hit probability. The production of M-84 started in 1984 and by 1988 the tank producer “Đuro Đaković Special Vehicles” in Slavonski Brod delivered 370 M-84 tanks.

Second step: Tank M-84A

The second step in tank development gave an important improvement to mobility, agility and manoeuvrability of the tank. The power of the engine was increased for 28% without any impact on the dimensions and the mass of the vehicle. The power density of the power train leapt from 180 to **230 kW/m³** and the vehicle get 18 kW/t the power-to-weight ratio. This achievement was performed by an upgrade of the existing engine V46-6,

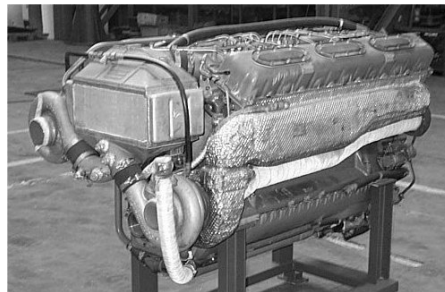


Figure 7: The 735 kW engine of the M84A tank

reinforcement of the existing transmission and a new cooling and air cleaning system. The upgrade of the engine was made by using the base of the existing engine [12] which possesses potential for much greater power, and a new supercharging as well as a new fuel injection systems were developed, Figure 7. The production of the M-84A started in 1988. By the end of 1991, 149 tanks were delivered to Kuwait Army, and some of them fought the Gulf war in 1991. The model delivered to Kuwait was designated M-84AB due to some other modifications (frequency hopping transceiver, navigation equipment etc.).

Third step: Innovative Solutions for a New Combat System DEGMAN

The upgrade of the original engine up to 735 kW in the second step of development had shown that the potential of this engine was much bigger and there was an opportunity for further improvement up to 900 kW, even more. But the increase of the power of the vehicle up to 735 kW led also to an important increase of the average off-road vehicle speed and further increase of the power subsequently caused that average speed started to provoke transmission problems. The greatest Russian authority in this field, Prof. N.A.

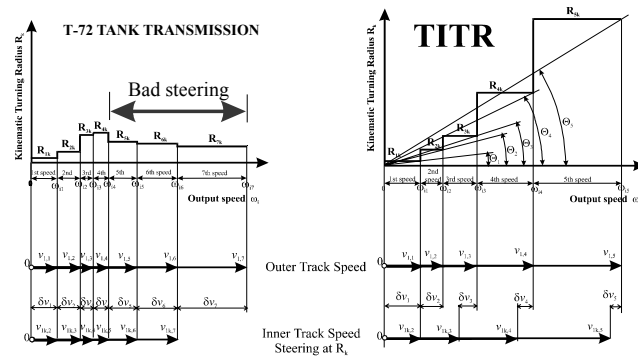


Figure 8: Transmission with Independent Turning Radii (TITR) and the T-72 transmission – steering kinematic characteristics

Nosov [13], says that a transmission system like in the T-72 can bring advantages only for **lower speeds**. In fact the arrangement of the cinematic turning radii, the most important thing for a transmission for high-speed tracked vehicles, of the T-72 transmission, Figure 8, is adequate only for moderate speed. Significant increase of the vehicle speed provokes steering with low cinematic radii that affect the operating efficiency of the transmission and probably stability of the vehicle in steering. Thus, there certainly is a lack in the steering ability which transmissions with two simple gearboxes (as in T-72) cannot avoid if the average vehicle speed is to high. A new transmission concept (granted patent) named “Transmission with Independent Turning Radii” (TITR) was invented giving an excellent arrangement of the turning radii [14], Figure 8, and it wiped the barrier for further increase of the power out.

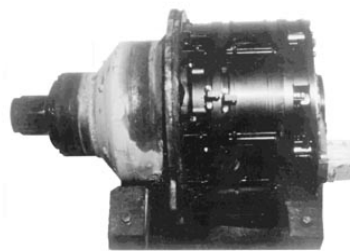


Figure 9: The gearbox of the TITR transmission fits the hull of the T-72 transmission

An ingenious application of the new TITR concept enabled use the T-72 transmission technologies and opened the way to get a new transmission of excellent characteristics go into the same hull of the original T-72 transmission, Figure 9.

The development of a new 900 kW engine, based also on the original V-46, but this time with many changes and upgrades on the almost all components of its base structure, has given an **incredible power density of the power train of 260 kW/m³**, which is far greater than any other tank power train up to date.

The new power train of 900 kW had given the vehicle an important increase of the off-road average speed so that the running gear had to be also improved. A new torsion bar running gear turned the vehicle into durable and comfortable off-road voyager.

And, finally, respecting more than 2000 years old Sun Tzu doctrine: **"Speed is the essence of war"** we improved the most important MBT characteristics directly influencing tank fight-ability pyramid, Figure 10:

- the highest possible cross-country mobility, agility and manoeuvrability using described high density power-train
- high fire-power using the existing 125mm main gun and new FCS and All-electric gun&turret drive (high speed, all weather, fire-on-the-move), but also improved Automatic Loader (with 15% higher rate-of-fire)
- protection and survivability using new welded&multilayer turret, add-on armor, Antiexplosion and Fire Extinguishing System and Laser Warning System, but also having a bigger chance to avoid the hit through a better mobility and agility.
- communication and information capabilities using Frequency hopping radio and Hull Management System enabling independent and interdependent data-transfer.

Conclusion

Holistic approach, step-by-step development making careful selection of applied technologies and constant alert for innovative solutions led to wide-ranging modernisation of the T-72 tank without alternation of its base line. The T-72 tank has thus evolved into an outstanding combat system under the name of DEGMAN, capable to answer the needs of future operations.

It is difficult to admit, but simplified translation of the paradigm firepower-protection-mobility in the tank development led to a disaster. But there are always innovative solutions which could be found out to answer the needs of the near future until a revolutionary leap as an All Electric Combat Vehicle [15] or a new architectures [16,17,18, 19] solve the problem of the far future.

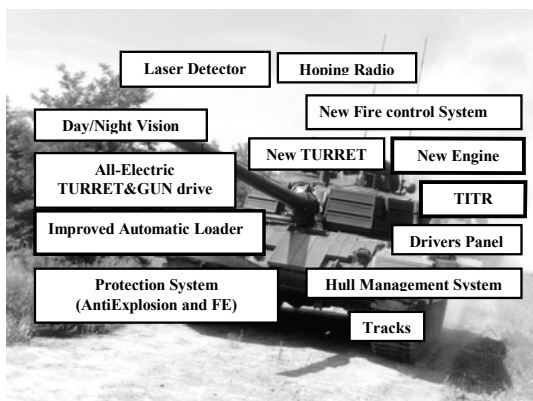


Figure 10: Degman MBT

BIBLIOGRAPHY

- [1] Tashenbuch der Panzer TANKS OF THE WORLD – Edition 8, Bernard & Graefe Verlag
- [2] BATTLE TANKS – Supplement to International Defense Review 9/95
- [3] Jenkins, C.: “*The Old, the New and the Future*”, BATTLE TANKS – Supplement to International Defense Review 9/95
- [4] Fletcher, R.: “*Dooming the behemoths – European Nations Consider Innovative Approaches To Reduce Tank Size And Weight*”, Armed Forces Journal International, May 1997
- [5] Fletcher, R.: “*Firepower for Future Tanks*”, BATTLE TANKS – Supplement to International Defense Review 9/95
- [6] Boltè, L. Ph.: “*Tank Survivability on the Modern Battlefield*”, BATTLE TANKS – Supplement to International Defense Review 9/95
- [7] Hilmes, R.: “*Battle Tank Mobility*”, BATTLE TANKS – Supplement to International Defense Review 9/95
- [8] Foss, F. C.: “*EuroPowerPack for Leopard 2*”, Jane’s Defense Upgrades, Volume IV, No 17 (1-15 September 2000)
- [9] Turbé, G.: “*Leclerc*”, International Defense Review, 5/1988
- [10] Tosi, P.: “*The Tank Power Train – Its Influence in the Architecture of the Vehicle*”, International Defense & Technology, June 1994
- [11] Biass, H. E.: “*Taking the T-72 into the 21st Century*”, Armada International, 1/99
- [12] Ilijevski, Ž., i dr.: “*Povećanje snage turboprednabijanjem jednog motora posebne namjene*”, Promet, vol. 7,1995, suppl. br. 3
- [13] Nosov, A. N.: *Расчет и конструирование гусеничных машин, МАШИНОСТРОЕНИЕ, ЛЕНИНГРАД, 1972,*
- [14] Ilijevski, Ž., Koroman, V.: “*Transmission with Independent Turning Radii (TITR) for Tracked Vehicles*”, Proceedings of the 7th European ISTVS Conference - Ferrara, Italy, October 8-10 1997, 180-187
- [15] Grosch, H.: “*All Electric Combat Vehicle (AECV) – Vision and Reality*”, Military Technology – MILTEHC, 9/99
- [16] Kovalev, V., Batenin, V., Starostin, M.: “*With a new Tank into the new Century*”, Military Parade, November – December 1998
- [17] Brilev, Oleg: “*The tank on the threshold of the 21st century*” Military Parade, January-February 1998.
- [18] Kedrov I., Sokut S.: “*Russians develop new-generation Main BattleTank*”, Nezavisimaya Gazeta, March 2000 (www.russia-news.com)
- [19] “*Russia develops new low profile Main Battle Tank*” Jane’s Defence Weekly, March 2000 (www.TankSim.com)
-