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DEVELOPMENT PERSPECTIVES OF THE FIELD ARTILLERY CAPABILITIES FOR MOUNTAIN UNITS

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Abstract:
Artillery represents the main fire support asset for maneuver units, characterized by high fire power, maneuver capability and precise engagement capacity in all types of operations and in any weather conditions. Field artillery is known as "The King of battle" because of its ability to produce massive damage on enemy forces. The fire support system integrates all the available assets for executing lethal and non –lethal tasks and capable to execute the maneuver of fire.

Keywords: capability, effectiveness, military, system

1. Introduction

Implementing a new capability in a military system is always a huge challenge for specialists, but also for decision makers. Operational requirements are always at a high level, but the budget ceiling is limited. So, specialists and project managers need to use a scientific approach to develop some alternatives in order to facilitate the political-military leaders to make the best possible decision. Military decision makers need to understand and assess the benefits and consequences of their decisions in order to make cost efficient, timely and successful choices.

The majority of defense planning activities tend to be demand-based, meaning that strategies, capabilities, and capacities are based on ideas about the requirements of potential future engagements. These demands can be derived from either threats or desired capabilities, or some combination of the two. It is a top-down planning method that begins with high-level strategic demand signals from which it derives requirements. On the other hand, supply-based planning begins with a specific real-world constraint, such as current force size, capabilities mix, or budget limits, and builds forces from that baseline. It is more of a bottom-up planning method that starts with a base of existing capabilities and a presumed resource constraint and builds upward, making incremental planned changes to the current force. In both demand- and supply-based planning approaches, policymakers develop requirements, assess capabilities and capacity, account for constraints, and incorporate risk. [1]

2 General aspects

2.1 Capability based planning

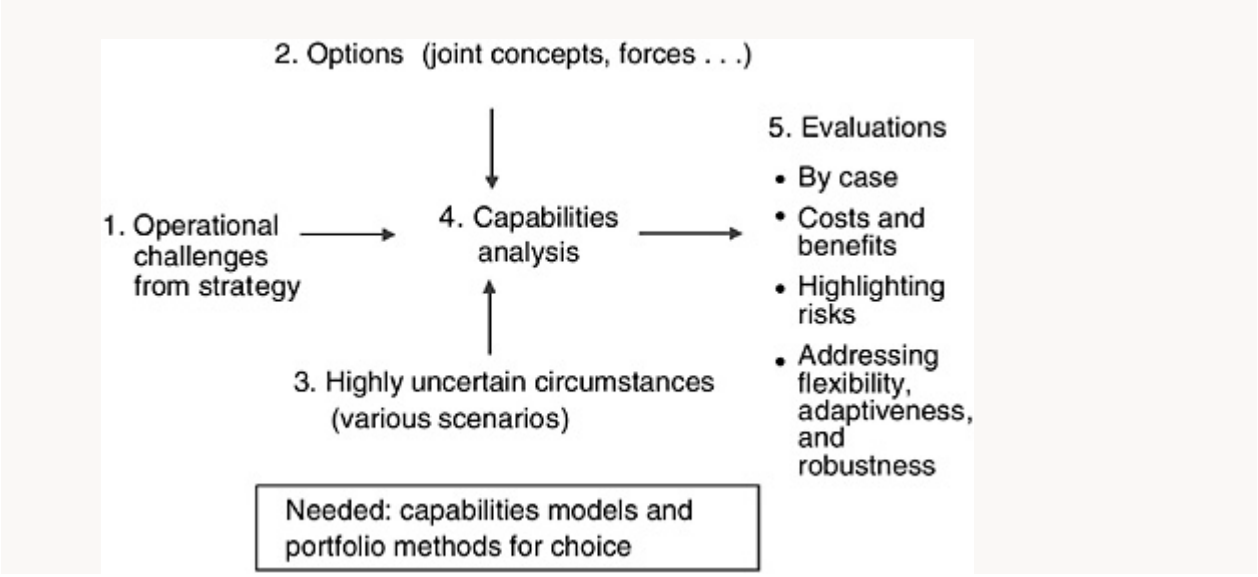
There is no official government definition of capabilities-based planning, but one of the most used is: "Capabilities-based planning (CBP) is planning, under uncertainty, to provide capabilities suitable for a wide range of modern-day challenges and circumstances while working within an economic framework that necessitates choice. [2] Paul K. Davis considers this "a method to inform decisions regarding DOD planning, resourcing, and operations that

addresses uncertainty and risk through agile analysis of a broad spectrum of potential challenges and circumstances leading to competitive development of robust DoD capabilities achieved within an economic framework necessitating choice".

While individual interpretations vary, capabilities-based planning (CBP) is substantially different from the "threat-based or requirements-based" analysis that was focused on point (or individual) scenarios. Indeed, the shortcoming in the earlier analysis was more the point scenarios than use of threats (obviously, planning should consider a range of specific threats).

An important aspect related to the capabilities based planning process costs "refers to the necessity to identify the life cycle of a capability. Any type of capability is generated, implemented (maintained) and then, at a certain moment, we may need to replace /renew it or even cancel it, as the priorities, challenges and risk levels change. The resources behind these capabilities may be used or reallocated for other purposes and this process may generate various costs which need to be estimated and taken into consideration for the alternatives analysis."[3]

The primary distinctions between these types of analysis are in the manner of dealing with uncertainty, in the reckoning of risk, and in the way of making choices. The core idea of the CBP approach is to confront—rather than discount—uncertainty, to express risk in meaningful terms, and to weigh costs and benefits simultaneously. The objective is to put premium value on portfolios of assets (including organizations and skill sets) that best satisfy joint needs and offer flexibility, adaptability, and robustness to hedge risk across a wide range of possible futures.



The figure above illustrates the key elements of capabilities-based planning. [2]

Military capability is defined by the National Strategy as "the mix of measures and actions including elements of Doctrine, Organization, Training, Materiel, Leadership development, Personnel, Facilities and Interoperability (DOTMLPFI) required to achieve the desired effect and fulfill an objective".

There is a six-step generic algorithm for developing a military capability:

a. Analysis of strategic environment;

b. Identify capability needs;
c. Derive capability requirements;
d. Conduct gap analysis and fulfilment;
e. Identify and select possible solutions;
f. Conduct implementation of the best solution.

The optimization of the military capability production process "is considered analogue with the production of goods and services, the basis of the market economy. Each military capability can be considered as a mix of resources which will be used to perform a certain mission. This mix of resources must consider first of all the purpose of its existence and generate the maximum benefit. At the same time, because of the resource scarcity, the use of this mix must be considered in the economic context".[4]

2.2 Initial assessment-case study

The republic of Montania is a country from the Central Eutropia having a population of 11 million. The country is bordered by mountains at north, east and south and by river Blue in the western part. Almost 65% of the country has mountain areas. The middle of Montania is dominated by a large plateau, with dense populated areas and the place of the most economical activities. In the north Montania has a common border with Urania, a country with rigid autocracy. There is an old diplomatic conflict between Montania and Urania due to some historical territorial dispute. On short term there are few chances to begin a conflict, but on long term situation could go worse. Urania's Army has better fire support capabilities than Montania. Their field artillery mountain systems are The Chinese PL-96 122 mm towed hovitzer (a modern copy of the Soviet D-30 howitzer), with an enhanced firing range of 18 km and a weight of 3,2 tones. This aspect was revealed as a weakness in The Military Strategy.

Army of Montania is composed of 8 brigades, 3 of them being mountain brigades. 1st Mountain Brigade has the area of responsibility The Northern Mountains, 2nd is in charge with The Eastern Mountains and the last one with the Southern Mountains. Each mountain brigade has an artillery battalion. The artillery battalions are operating the old M 30 122 mm howitzer having the readiness level of 65%.

This artillery system is at the end of its lifecycle and operation and maintenance cost increased a lot. There is a challenge to find spare parts and the ammunition stocks will be at the minimum level in the next 3 years. Also the operational capabilities of this system are at a low level. Every battalion has 18 howitzers, so total need is 54 howitzers.

The Defence planning guidance states that the mountain brigades will replace the actual artillery systems in the next planning cycle, in order to fulfil the new operational requirements. Ministry of defence budget is 1,5% of GDP(apox. 6000 million $). Land Forces program has allocated a budget of 900 million $ and Field artillery subprogram budget limit is 40 million $.

A team of specialists has the task to analyse the operational requirement for this systems and the available assets. They will present some alternatives for the program manager of Land Forces programme in the next planning meeting.

Based on general capabilities standards, the artillery systems for mountain units have *the mission* to provide decisive lethal and non-lethal fire support, rapid target acquisition and engagement in order to destroy or annihilate the enemy's objectives and to integrate the all fire support elements. Artillery represents the main fire support asset for maneuver units, characterized by high fire power, maneuver capability and precise engagement capacity in all

types of operations and in any weather conditions. The fire support system integrates all the available assets for executing lethal and non –lethal tasks and capable to execute the maneuver of fire.

3. Capabilities needs and operational requirements for field artillery systems for mountain units

Mountain operations are influenced by rough terrain, by rapid weather changes, lower temperature and forest areas that limit the maneuver. Weather conditions are various from low temperatures during winter to high temperature during summer. Due to the rough terrain command and control are disrupted, favouring isolated small operations.

The fire support operations in mountain areas are influenced by the following aspects:

- mobility is limited;
- disposal and force protection possibilities are limited;
- difficult support for isolated units;
- specific ballistic aspects(vertical paths, no fire areas, meteorological corrections);
- difficulties to identify targets because of limited observation;
- difficulties to deliver the logistic support;
- command and control are disrupted;
- USS communication means are limited.

Taking in consideration this factors, the artillery systems that operated in mountain areas require increased maneuver capacity, a higher firing range, a short readiness term, interoperability and high precision.

3.1 Short term objectives:

- Developing advanced artillery systems that operate in an integrated network, using high precision projectiles with synchronized effects, capable to use different types of ammunition (lethal and non-lethal;

- Ensure the possibility to an extend deployment and enhanced capabilities to observe and discover targets;

- Integration of indirect fire support systems in the ISTAR systems;

-Capability to operated advanced types of ammunition to achieve higher precision and low rate of consumption.

3.2 Medium term objectives:

- Developing artillery systems with high deployment capability, efficient and capable to locate and engage targets in any conditions;

-Capability to maximize the equipment and ammunition availability and to integrate the logistic support.

3.3 Capabilities needs for mountain field artillery

In order to fulfil the mountain operational environment requirements, the artillery units need to have these capabilities:

- independent tactical deployment capability;
- full spectrum fire support missions;
- all weather and all terrain mission capability;
- rapid reaction capability in order to reduce risk of enemy response;
- deep fire support capability, in order to destroy planned and unplanned targets, enemy armoured vehicles included;

- the capability to communicate with other forces using interoperability procedures;
- artillery force protection means;
- C2 capabilities;
- artillery radars for target acquisition;
- enhanced equipment for target detection, selection, tracking and communications;
- high level of firepower using modern ammunition;
- high firing range.

3.4 Operational requirements for mountain field artillery

- High mobility in the mountain area (passing of slopes of 30-40%);
- Minimum indirect fire range using standard projectile shall be no more than 4 km (T=0).
-Maximum indirect fire range when firing standard projectile shall be no less than 18 km. Maximum range when firing assisted projectile shall be no less than 23 km.
- C2 systems that operate in cold environments for extended periods of time, including satellite tracking systems;
- Capability to transport crew and ammunition;
- Speed of 65-80 km/h on paved roads and 25-40 km/h on all terrain;
- Maintain the equipment and engine efficiency up to 2000 m;
- Ballistic protection against medium intensity explosive ammunitions;
- Armoured crew protection.

4. Possible solutions for field artillery capabilities for mountain units

Taking in consideration all the operational requirements, the specialists' team has identified three possible solutions for mountain troop's artillery system:

- Hawkeye 105 mm self-propelled howitzer on HMMWV chassis;
- M198 medium-sized 155 mm towed howitzer;
- M119A2 lightweight 105 mm towed howitzer.

4.1 Hawkeye 105 mm self-propelled howitzer on HMMWV chassis
The main characteristics:

Dimensions and weight	
Weight	~ 4.4 t
Length	~ 5 m
Width	~ 2.4 m
Height (in travelling order)	~ 2.3 m
Armament	
Main gun	105 mm
Barrel length	27 calibers
Machine guns	Optional
Maximum firing range	12.5 / 15.1 km
Maximum rate of fire	10 - 12 rpm
Sustained rate of fire	3 rpm
Elevation range	- 5 to + 72 degrees
Traverse range	360 degrees
Mobility	
Engine	General Engine Products 6.5-liter diesel
Engine power	190 hp
Maximum road speed	over 100 km/h
Range	~ 400 km
Maneuverability	
Side slope	30%
Vertical step	0.3 m
Emplacement	3 minutes

The Hawkeye is one of the lightest self-propelled howitzers in the world today. It requires less crew (only 3) and can be briefly redeployed. This artillery system is well suited for shoot-and-scoot missions. It can fire a couple of projectiles and leave its firing position before the enemy opens counter battery fire or takes other offensive engagements.

The Hawkeye fires standard NATO 105 mm ammunition. Maximum range of fire is 11.5 km with conventional projectile and 15.1 km with rocket assisted projectile. The Hawkeye can fire indirect and direct fire modes. Another unusual feature of this lightweight system is that it offers 360 degrees field of fire.

The Hawkeye has rapid rate of fire. It can launch up to 10-12 rounds per minute. Sustained rate of fire is 3 rounds per minute. Due to its short range this artillery system is intended for operation near the frontline. It should best exploit itself for shoot and scoot type attacks. The Hawkeye mobile howitzer can be prepared for firing and leave the firing position much faster than the towed 105 mm howitzer.

This artillery system incorporates a soft recoil technology, which reduces carriage loads and allows to mount the Hawkeye on light 4x4 vehicles such as the HMMWV.

The Hawkeye has an automated digital fire control system. It takes minimal time to fire the first round. Also this artillery system can is rapidly emplaced and can briefly leave its firing position. The M1152A1 HMMWV has an armored cab, which provides some degree of protection for the crew. [3]

3.2 M198 medium-sized 155 mm towed howitzer

The main characteristics:

Armament	
Gun bore	155 mm
Barrel length	39 calibers
Projectile weight	44 kg
Maximum range of fire	22 km
Maximum range of fire (with rocket-assisted projectile)	30 km
Maximum rate of fire	4 rpm
Sustained rate of fire	2 rpm
Elevation range	- 5 to + 72 degrees
Traverse range	45 degrees
Dimensions and weight	
Weight (in combat order)	7.17 t
Length (in combat order)	11 m
Width (in combat order)	8.53 m
Mobility	
Side slope	25%
Road towing speed	72 km/h
Cross-country towing speed	8 km/h
Emplacement	7 minutes
Displacement	~ 6 minutes

The Rock Island Arsenal M198 was for almost 3 decades the primary towed artillery piece of the US military, and is still in use with several other countries.

The M198 has two broad towing arms, which are bent slightly to the left at the ends, and have a prominent hitch near the end of the left arm. The barrel is long, and tapers sharply halfway between the carriage and its double-baffle muzzle brake. The gun sits atop a sliding mount, in a square-cornered, U-shaped fixture, the latter of which is hinged at the front of two towers (which the breech recoils between when fired). A crew of 11 is required to operate the M198 normally. Approximately 6 minutes are required to set-up an M198 for fire missions.

The M198 and can safely be towed cross-country at 8 km/h, over improved secondary roads at 40 km/h, or over paved roads at 72 km/h. The M198 may be delivered by parachute, or sling-loaded underneath a CH-47 Chinook. The M198 155 mm cannon has a tube 39 calibers long, giving it an effective range of 22 km with a standard projectile, and 30 km with a rocket-assisted

projectile. The rate-of-fire for the M198 is 4 rounds/min maximum, or 2 rounds/min sustained. Service life of this howitzer is 1 750 rounds at full charge. [6]

3.3 M119A2 lightweight 105 mm towed howitzer
The main characteristics:

Country of origin	United States/UK
Entered service	1989
Crew	5 men
Armament	
Gun bore	105 mm
Maximum range of fire	17.5-19.5 km
Maximum rate of fire	8 rpm
Sustained rate of fire	3 rpm
Elevation range	- 5 to + 70 degrees
Traverse range	45 degrees
Dimensions and weight	
Weight (in combat order)	2.3 t
Length (in combat order)	5.5 m
Width (in combat order)	1.78 m
Mobility	
Side slope	35%
Road towing speed	70 km/h
Cross-country towing speed	8 km/h
Emplacement	6 minutes
Displacement	~ 5 minutes

The M119A1/A2 howitzer is a lightweight towed howitzer in service with the US Army. The howitzer provides direct and indirect fire support to the forces deployed in combined arms operations. It is manufactured by the Rock Island Arsenal-Joint Manufacturing and Technology Centre (RIA-JMTC) under joint US/RO (Royal Ordnance) partnerships.

The M119 was first deployed in the 7th Infantry Division, Fort Ord in December 1989. US Army began the Light Artillery System Improvement Programme (LASIP) Block I improvements in 1998. The programme added a new low-temperature recuperator, an improved trail access cover, simplified tail light assembly and brackets to include a chronograph and battery computer system. The existing M119 gun system received a new low blast overpressure muzzle brake (LBOP) in February 2017. It transmits propellant gases to the rear of the gun and also reduces auditory and non-auditory health hazards.

The M119 can fire all standard NATO 105mm ammunition including the M1 high explosive rounds, M913 high explosive rocket-assisted shells, M314 illuminating star shell and M60/M60A2 white phosphorous smoke cartridge.

The M119 can be easily moved and rapidly deployed in the field to deliver optimum firepower with less combat weight. The M119A1/A2 howitzer has a lower silhouette and can

fire without a recoil pit. It is primarily towed by the high-mobility multipurpose wheeled vehicle (HMMWV). It can be routinely airdropped by parachute and also carried underslung by the CH-47 Chinook.[7]

5. The most appropriate solution proposal

5.1 The comparison of the main characteristics

	Weight t	Slope	Response time min.	Firing range km	Maximum rate of fire	Hit probability	Crew
Hawkeye 105 mm self-propelled howitzer	4.4	30%	3	15	10	80%	3
M198 155 mm towed howitzer	7.3	25%	7	22	4	90%	9
M119 105 mm towed howitzer	2.3	35%	6	18	8	85%	5

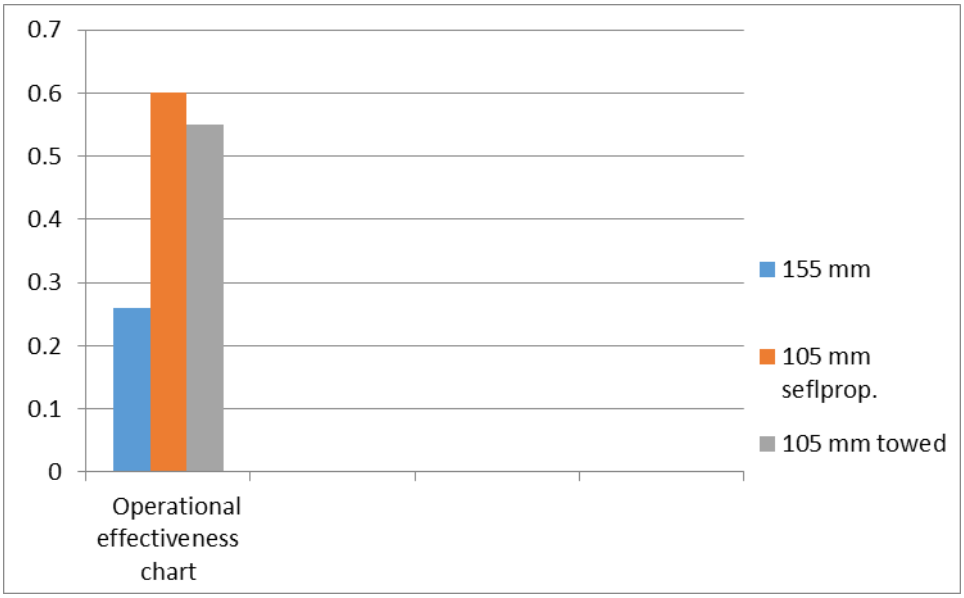
Analysing the operational capabilities of these systems, we can see that M198 has a higher range, but a low level of mobility because of weight. Hawkeye 105 mm has a very good firing rate but has a small range of 13 km. Also, M119 has a good firing rate and a proper weight but has a limited response time.

5.2 Effectiveness analysis

	Weight 0.13	Slope 0.17	Response time 0.16	Firing range 0.14	Maximum rate of fire 0.13	Hit probability 0.12	Crew 0.15	**TOTAL**
Hawkeye 105 mm self-propelled howitzer	0.58	0.5	1	0	1	0	1	**0.60**
M198 155 mm towed howitzer	0	0	0	1	0	1	0	**0.26**
M119 105 mm towed howitzer	1	1	0.25	0.45	0.66	0.5	0.66	**0.55**

Hawkeye 105 mm self-propelled howitzer has the highest level of effectiveness having good mobility features, a good firing rate and a small crew. The second level of effectiveness is

for M119 105 mm towed howitzer also with good mobility features, with an enhanced firing range and good rate of fire. The lowest level of effectiveness is for M198 155 mm towed howitzer that has low mobility features and also low rate of fire.

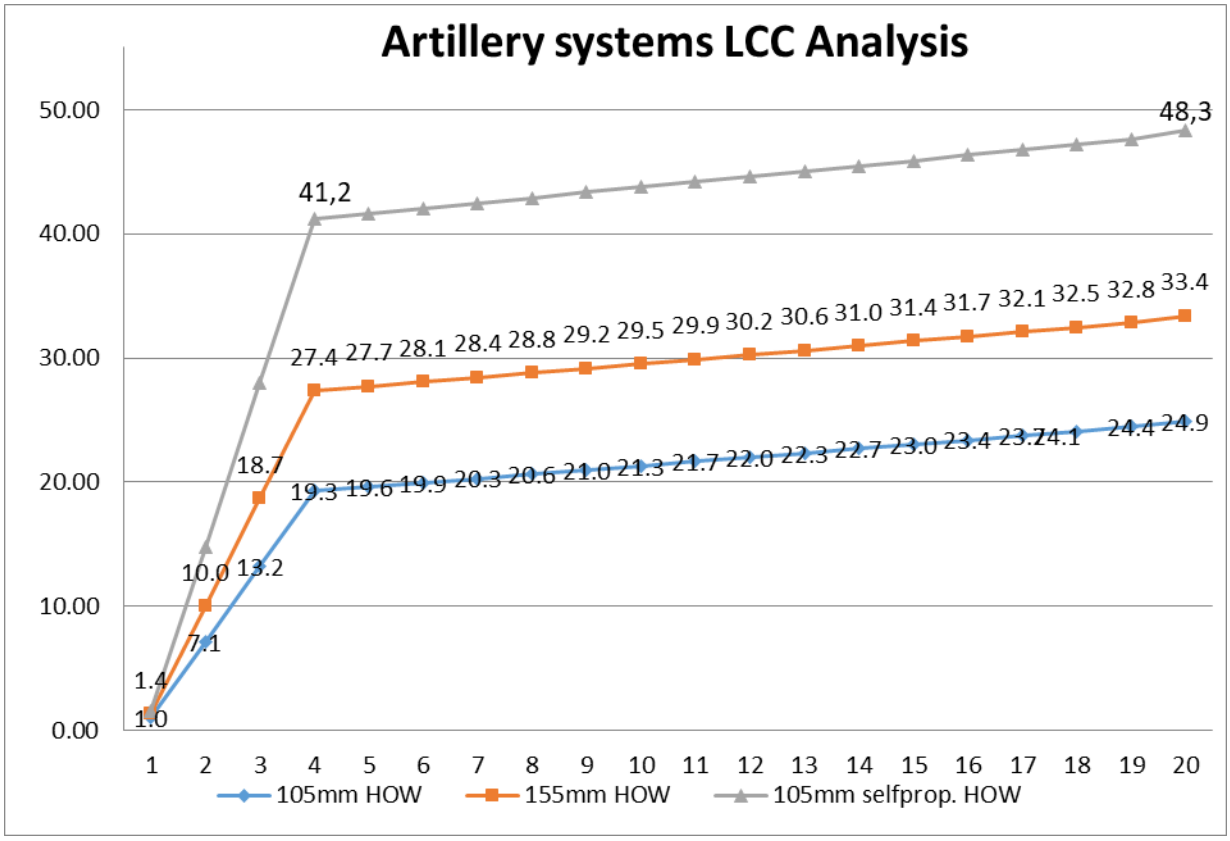


5.3 Life cycle cost analysis

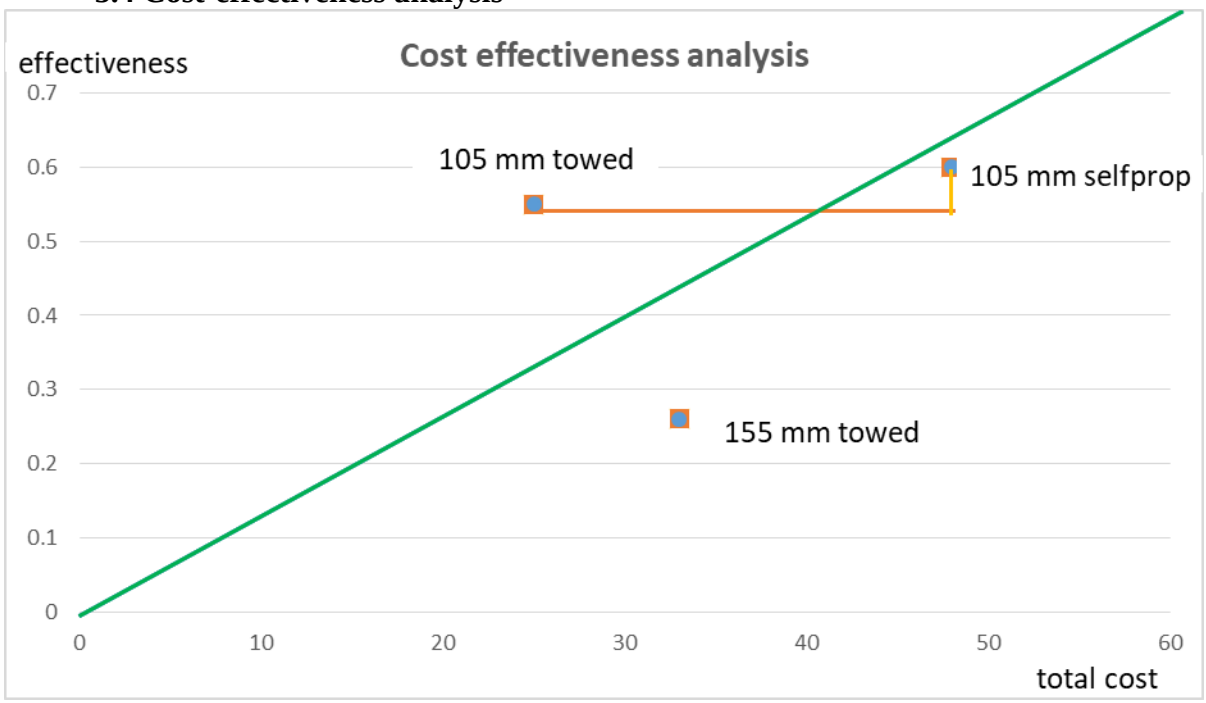
The life cycle cost chart with detailed cost for each expense is presented in Annex 1. [8]

The total cost of an alternative includes all the costs of the system over the life-cycle of the system, estimated based on expected operating conditions.

For life cycle cost analysis specialist took in consideration a period of 20 years, an inflation rate of 0,02, training inflation of 0,03 and maintenance inflation of 0,04. They consider buying 18 systems per year in the next 3 years.



5.4 Cost-effectiveness analysis



The optimal solution taking in consideration the effectiveness but also the total cost is **M119 105mm towed howitzer.** This is the only system that in on the graph above the cost-effectiveness line.

Also *the marginal cost and marginal effectiveness* analysis revealed us that for a small amount of effectiveness (only 0.05) we will have to double the cost if we want to have Hawkeye 105mm self-propelled howitzer that is the most effective system. The effectiveness will increase with **9%,** but the cost will raise with **96%**

Land Forces program has allocated a budget of 900 million $ and Field artillery subprogram budget limit is 40 million $. So, the budget limit is another argument for our proposal.

Cost-effectiveness matrix

	Effectiveness	**Total LCC**
Hawkeye 105mm self-propelled howitzer	HIGH	HIGH
M198 155mm towed howitzer	LOW	MEDIUM
M119 105mm towed howitzer	HIGH	LOW

Also in the cost –effectiveness matrix we can see that **M119 105mm towed howitzer** is the system with high effectiveness and low price, so it should be the most appropriate solution for mountain troops.

5.5 Defining the capability based on DOTMLPFI model

Doctrine: a new manual has to be developed for operating the new capability
Organization: no change because this system has the same crew number.
Training: is needed for crew and for technical support team
Material: systems and ammunition acquisition. A new contract for spare parts and maintenance.
Leadership: no change
Personnel: no change because this system has the same crew number.
Facilities: -new hangars.
Interoperability -need to implement some standard agreements for ammunition.

6. Conclusion

Cost effectiveness analysis is an important tool for decision making because it reduces uncertainty and risk in taking decisions, but does not eliminate it. There no exists the best decision for all situations. The best alterative needs to be linked by a specific environment and is affected by the competition for resources between different priorities. The military leaders tend to use of methods based on its experience in operational matters, using experience as a guide in predicting operations. The Resources management theory help the decision maker's to develop a priority list for the factors that make up a decision, as well as how each alternative option weighs against those factors.

Starting with valuable analysis of the strategic environment and deriving capabilities need and requirements, specialists could identify some realistic solution to fill the gap in capabilities. After a solid analysis of effectiveness and also of the cost implications, decision makers can select the optimal solution and they must implement it in a proper way, adapted to that military system.

Capabilities-based analysis is conducted to provide well-articulated alternatives to leadership. The alternatives need to be distinct, viable, and realistic, linked by the budget constraints. These choices should be developed taking in consideration the demands of the national military strategy and associated joint needs.

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