# A STUDY REGARDING THE ANALYSIS OF THE FULFILLMENT OF THE OPERATIONAL MILITARY REQUIREMENTS BY THE LIGHT OFF-ROAD ARTICULATED VEHICLES

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***Abstract:*** *Why would be interesting to use this type of vehicle (light off-road articulated) in the military field? In order to answer this question we have to analyze the capacity of the light articulated off-road vehicle to fulfill the general operational military requirements. A light off-road articulated vehicle is a vehicle with the maximum weight less than three tones and consisting of two equal vats connected to each other through a pivoting bearing which allows both parts to move around the longitudinal central axis of the vehicle. This type of vehicle is quite rare in the world. Generally, they are prototypes or limited series. One of these type of prototype is DAC 2.65 FAEG which were made in Brasov, Romania and it is studied inside of the laboratories from "Henri Coandă" Air Force Academy.*

***Keywords:*** *light off-road articulated vehicle, operational military requirements, fulfillment, DAC 2.65 FAEG…*

## 1. INTRODUCTION

The special wheel vehicles have a high viability to fulfill the military missions and they emerged as a real necessity of the fulfillment of combat missions in off-road conditions with high speed, without any technical malfunction, with a range as high as possible and a good protection of their passengers. There are some technical solutions as the special vehicles are completely different concepts than normal wheel vehicles because these vehicles must act in extremely off-road conditions, in many situations it could be necessary to pass different kind of obstacles (ditches, berms, channels, streams, lakes etc.).

A light off-road articulated vehicle is a vehicle with the maximum weight less than three tones and consisting of two equal vats connected to each other through a pivoting bearing which allows both parts to move around the longitudinal central axis of the vehicle (Fig. 1).

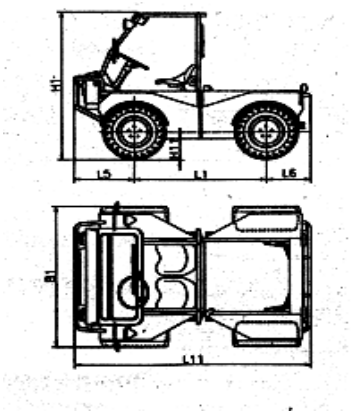

Fig. 1. The light off-road articulated vehicle

This type of vehicle is quite rare in the world. Generally, they are prototypes or limited series. They were suggested for the military area but so far they have not been successful.

The working environment general requirements for the military vehicles are [1]:

- environmental temperature: $+50^0$C ↔ $-40^0$C;
- the air relative humidity: maximum 98%;

- in mountain area the engine must work without ignition failure and power reduction;
- the act of the ambient must be characterized by heat, cold or/and much noise.

Also, for the light off-road articulated vehicle, the engine must give a specific output of 22-30 kW/t in order to assure a normal dynamicity [1].

## 2.THE LIGHT OFF-ROAD ARTICULATED VEHICLE MADE IN ROMANIA – DAC 2.65 FAEG

In the late 80's, the designing engineers from the National Institute of Road Vehicles (INAR) and ROMAN/DAC Truck Factory conceived a light off-road articulated vehicle named DAC 2.65 FAEG. It was made in some variants depending on the existing subassemblies. They were inspired by the CROCO/RHINO/ ALLIGO vehicle which was made in Germany. The body of the vehicles is identical. But it is only the body and the general conception that are identical.

Only five units were made and another two ones as empty bodies. Two of them have Wankel rotary engine (probably identical to the CROCO/RHINO engines). Another unit has Fiat Panda 1,4 liters engine and other two were made using Dacia 1400 cmc, 65 HP, engine. Only one from the last two ones is still functioning and all the following details refer to this one (Fig. 2).

Fig. 2 DAC 2.65 FAEG

The studied DAC 2.65 FAEG vehicle has a conception of the power unit and a body identical to CROCO and RHINO vehicles.

The other subassemblies are completely different because they were assimilated from the repetitive manufacturing of that time: the engine is Dacia 1400 cmc, the calipers are Dacia model but they were modified and placed on the all four wheels, on the planetary shafts (similar to Oltcit vehicle), the central break pomp (double circuit) is ARO model etc. The vehicle has a fluid converter (unknown model) connected with a gear box with 2x2+1x2 not synchronized velocity steps and a front rear splitter unit. This ensemble has a common oil sump. At the same time the ensemble of gear box and front rear splitter unit is a two steps transmission reduction and a distributor gear through front and rear axles.

The front and rear axle differentials are 'worm and wheel' limited slip type and they have power take-off (PTO). The front PTO was designated for a capstan and the rear PTO was designated for the propellers (water propulsion).

Weights and dimensions:

- wheelbase: 1634 mm / front overhang: 750 mm / rear overhang: 565 mm;
- overall length: 2950 mm / overall width: 2060 mm / overall height: 2050 mm;
- ground clearance: 270 mm;
- unloaden weight: 1600 kg / trailer weight: 1000 kg.

The declared performances:

- speed in 1-st velocity step = 0-20 km/h (off-road);
- speed in 2-nd velocity step = 0-50 km/h (on road);
- maximum declivity = $33^0$;
- maximum lateral declivity = $30^0$;
- braking runaway (50 km/h) = 19,3 m;
- exterior acoustical level = 81 dB.

## 3. THE ENCODING OF THE GENERAL OPERATIONAL MILITARY REQUIREMENTS

Why would be interesting to use this type of vehicle (light off-road articulated) in the military field? In order to answer this question we have to analyze the capacity of the light articulated off-road vehicle to fulfill the general operational military requirements. These ones will be encoded as in table nr. 1.

Tabel 1 The encoding of the general operational military requirements

| **The encoding of operational requirements** | **Operational requirement** | **Operational "subrequirement"** |
|---|---|---|
| 1 | Constructive simplicity | |
| 2 | High reliability | |
| 3 | Compactness | |
| 4 | Tactical-operational mobility | |
| 4.1 | | - marching |
| 4.2 | | - in different climatic conditions |
| 4.3 | | - at night |
| 4.4 | | - off-road conditions |
| 4.5 | | - deformable terrain (eg: swamp) |
| 4.6 | | - on the water |
| 4.7 | | - no adherence conditions |
| 5 | Low overall dimensions | |
| 6 | Low weight | |
| 7 | Easy exploitation | |
| 8 | High maintainability | |
| 9 | The uniformity of components used as spare parts | |
| 10 | High ergonomics for the crew | |
| 11 | Protection of transported materials | |
| 12 | High range | |
| 13 | The possibility to use different fuels (multi-fuel engine) | |
| 14 | Crew protection | |
| 14.1 | | - against projectiles |
| 14.2. | | - against radiation |
| 14.3 | | - against shock wave |
| 14.4 | | - against CBRN attacks |
| 15 | Transportability | |
| 15.1 | | - by their own means |
| 15.2 | | - by landing means |
| 15.3 | | - by aircraft |
| 15.4 | | - bt naval means |

## 4. THE FULFILLMENT OF THE OPERATIONAL REQUIREMENTS BY THE LIGHT OFF-ROAD ARTICULATED VEHICLE - particularization for DAC 2.65 FAEG

The fulfillment of the operational requirements by the light off-road articulated vehicles will be analyzed as follows:

**1.** This requirement is fully accomplished by all these types of vehicles because they have as main characteristic the constructive simplicity. **Requirement accomplished (RA).**

**2.** Theoretically speaking, all these vehicles must have a high reliability because of the constructive simplicity. The DAC vehicle could have some problems because of the low quality of components. (Eg.: the engine and brake system). **RA**

**3.** The compactness is a specific characteristic of these types of vehicles. **RA**

**4.** The mobility requirements are accomplished because:

1.1 The vehicles do not have a high marching mobility as they are designed to be driven in off-road conditions. They do not have the possibility to move with high speed and they do not have a high range on the road. **Unfulfilled requirement**.

1.2 The vehicles do not have problems with cold weather starting because they have Otto engines but they do not have covered bodies, so, they cannot protect the carried passengers. The result is a low mobility during winter. Furthermore, the DAC vehicle has problems with engine cooling during summer because the cooling system has to be redesigned. **Unfulfilled requirement**.

1.3 The vehicle has a good illumination system. The travel during night, even in off-road conditions, is done without problem. **RA**

1.4 The travel in off-road conditions can be done without problems due to the special profile of the tires, to the very high approach and rear overhang angle, fair ground clearance, lower robustness area of the body and mainly due to the pivoting bearing which permit the vehicle to follow the conformation of the crossed area exactly. **RA**

1.5 It is impossible for the vehicle to be stuck in the mud (according to manufacturer declarations) due to the special profile and very wide tires (the overall surface of the tire contact patches can be compared to the low surface of the vats) and due to the fact that the vehicle transmission (and planetary shafts too) is inside the vats. In extreme situations the vehicles can "crawl" on the mud effectively. However, tests have not be done yet (in case of the DAC), therefore, these considerations are only theoretical. But the requirement can be considered accomplished. **RA**

1.6 The vehicles are designed to be amphibious. The propulsion can be done using only the wheels or the wheels combined with a propeller or a system of propellers which are trained by a power take-off from the rear axle differential. **RA**

1.7 The vehicles have high performances in non-adherence conditions due to the special profile of the tires, their compactness and the descended center of gravity. **RA**

We have to mention that 4.1 "subrequirement" is not mandatory to be accomplished because the vehicle was not designed to move in marching conditions using its propulsion systems. It is going to be transported on the truck platform (the dimensions are not a problem).

Regarding the 4.2 requirement, all the light off-road articulated vehicles have the possibility to have mounted a covered body in order to protect the passengers. But in this situation the dynamic performances will decrease.

The DAC technical failures (regarding the inadequate engine cooling) are due to the wrong designing of the cooling system. The engine position does not encourage the fresh air cooling because it is really "sunk" into the front vat which is completely tight by the superior driver and co-driver floor. In this situation the engine must work into a not ventilated place. The radiator is located out of the body and its link with the engine is done by metal tubes and rubber couplings. The problem is that one of the metal tubes is located next to the muffler (3-4 mm) at approximately 60 cm. That's why a supplementary heating of the cooling liquid is done.

**5.** The dimensions of the vehicles are very low due to their remarkable compactness**. RA**

**6.** Pressure per unit on ground area is very low due to high width of the tires. The weight is very low for this type of vehicle. **RA**

**7.** The exploitation is very easy because the vehicle is very simple mainly due to the automatic transmission. **RA**

**8.** The vehicle maintainability is very high due to easy access to the subassemblies. In an extreme situation the entire power unit system can be lift using a light crane in order to make maintenance operations easier**. RA**

**9.** The uniformity of the components depends on the modality of designing the vehicle. Taking into account that the manufacturers of these types of vehicles do not produce them "starting from nothing", it is assumed that the mounting was done by using the parts which are on the automotive market. For example, for the DAC vehicle there were used components which were produced on the Romanian automotive industry in '80's when this vehicle was designed. Only few components were projected particularly for this prototype. **RA**

**10.** Unfortunately, the ergonomics cannot be very high because of the lack of suspension and shortage of space. But these types of vehicles are not used for endurance missions. **Unfulfilled requirement**.

**11.** The transported materials cannot be protected very well because the vehicles do not have a covered body. **Unfulfilled requirement**.

**12.** The range in off-road conditions is remarkable (until 500 km) due to the flexibility of the fuel tanks capacity (supplementary canisters can be added very easily). **RA**

**13.** The use of different types of fuels depends on the adopted engines. Because of the limited space this requirement depends very much on the technological progress in the engine domain. The electric engine could be a good solution mainly because there is enough space into the rear vat in order to place the engine and the batteries there. **Undetermined parameter**

**14.** The requirement regarding the crew protection cannot be accomplished because the body is not covered and the passengers are vulnerable (shock waves, projectiles, CBRN attack, radiations, climate conditions etc.). **Unfulfilled requirement**.

**15.** The transportability of the vehicles is remarkable due to low dimensions and weights and compactness. The vehicle can be palletized very easily and carried on the platform of the ordinary truck. It could have problems only during the road marching because of its low maximum speed. **RA**

## 5. CONCLUSIONS
## – identification of the possibilities to use the light off-road articulated vehicles in the military field.

Taking into account the results of the analysis made in the chapter 4, there could be identified the next areas where this type of vehicle can be used:

- desant missions; the low weight, the compactness and the maneuverability allow these vehicles to be easily transported by the chopper; it seems that some successful parachuting tests were done at the beginning of '90's;
- engineering vehicle; mission vehicle - disaster response, forestry - monitoring uprooting, fire suppression, open pit mining surveillance, driving in coastal areas, maintenance of pipelines, telecommunication masts and critical infrastructure, expeditions, film industry, geological examinations, rescue operations and as towing and carrier vehicle for a large variety of add-on equipment;
- mobile platform (Fig. 3) capable to be used as:
  - fighting mobile cell able to act in mountain and forest areas where it could successful fight against low altitude targets ("helicopters hunters");
  - mobile point observer for the mountain artillery battalions;
  - reconnaissance missions subunit (using an UAV system);

- light rocket launcher capable to act following the principle “hit and run”.

Fig. 3 Mobile platform (technical revision)

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