Beyond Line of Sight Anti-Armor Missile for Land Vehicles

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ABSTRACT TITLE

MBDA France, which collects the experiences and the skills of the former entities AEROSPATIALE MATRA MISSILES and MATRA Bae DYNAMICS, provides numerous weapons systems including missiles, integrated on ground vehicle.

Within the framework of Advanced Concepts Studies, carried out for the benefit of the French Agency Procurement (DGA), MBDA France studies new missiles concepts, which should be integrated on the future light armoured vehicle for the Army (EBRC Engin Blindé à Roues de Contact). It will be one of the technological features of BOA (a French acronym meaning "Bulle Opérationnelle Aéroterrestre")

The conventional requirements linked with missile weapon system integrations are reminded, but some of them become prominent, specifically the system architecture and human engineering specifically for those implementing the "man in the loop" concept..

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1.0 INTRODUCTION

MBDA is a leading global player in the field of missiles and missile. MBDA is supported by major shareholders: BAE SYSTEMS, EADS and FINMECCANICA.

MBDA is Number 1 in Europe, Number 2 World-wide and is as prime contractor-ship of some of the world's most advanced future missile systems.

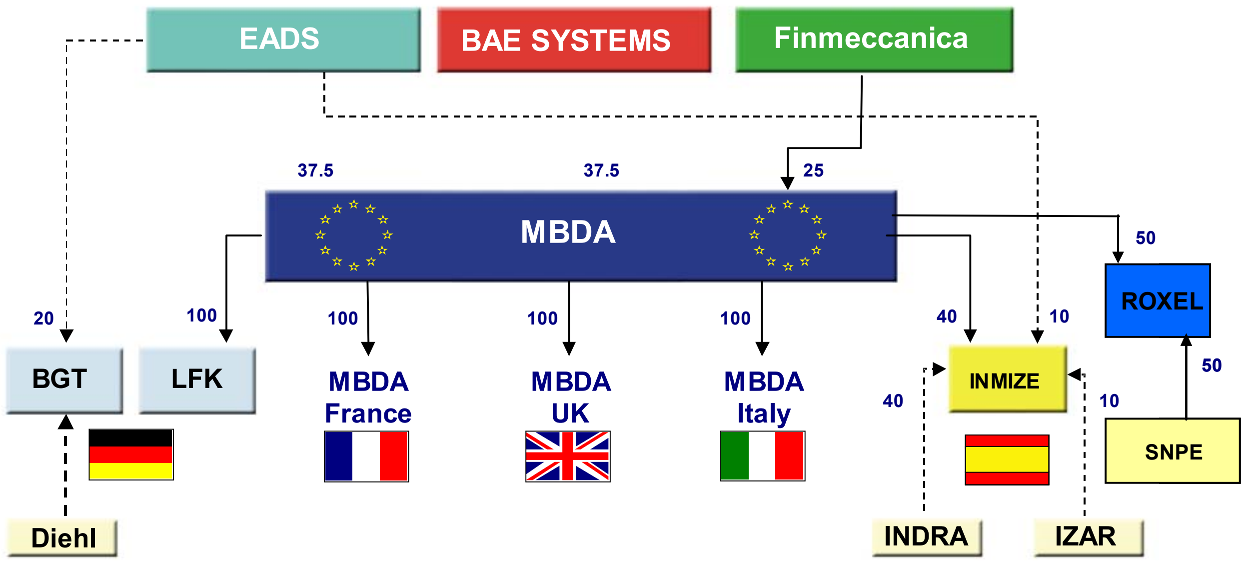

Figure 1: Representation of MBDA's Structure.

MBDA France collects the background, experience and skills from the former AEROSPATIALE Missiles and MATRA DEFENSE companies.

For the land weapon systems, MBDA's offer covers the full array of market segments. MBDA has a huge experience in both the weapon systems, and their integration into the different platforms.

This document describes the main requirements linked with missile weapon system integration into a land vehicle, and stresses on the integration constraints relevant to the missile systems beyond line of sight, one feature of which may be their use with the "man in the loop".

The first part of this document will review the experience gained by MBDA France in the integration of missile systems into the Army's land vehicles.

In the second part, the standard and specific requirements connected with the integration of this type of concept into vehicles will be presented through the example of a missile weapon system with the man in the loop.

As a conclusion, stress will be put on the fact that the system's overall operational performance results from optimum integration between the vehicle and the associated weapon systems. Therefore, the weapon system integration constraints, specifically for missiles, must be taken into consideration as early as possible during both the vehicle and the weapon system design phases

2.0 MBDA'S EXPERIENCE: EXAMPLES.

MBDA's Experience: Examples MBDA France has carried out the integration of many missile weapon systems on land vehicles, and is working on development programs and on mass production programs. Those integrations are made together with vehicles companies like GIAT Industries, PANHARD, …

A few examples are given below to illustrate this experience as:

- Lightweight tracked armored vehicles (HOT on AMX 10 WIESEL MAK)

Figure 2: HOT MOWAG.

- Wheeled armored vehicles (HOT VAB or MOWAG PIRANHA).

Figure 3: HOT VAB.

Figure 4: MOWAG PIRANHA

- Lightweight wheeled vehicle (HOT and MILAN System on P4).

Figure 5: Milan System on P4

- FSAF system vehicles.

Figure 6: ASTER Land System

- The UNIMOG 4WD vehicles for the MISTRAL systems (MCP).

Figure 7: Mistral System (MCP)

- Vehicles for advanced research projects, using the free space inside the vehicle's cabin for accommodation and for the operator to control the firing system.

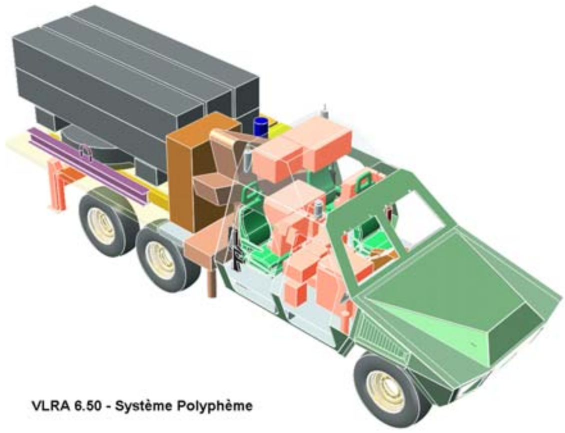

Figure 8: POLYPHEM Missile Project (Man in the loop)

- Programs in the feasibility study, development or mass production. Let us mention a few examples:
    - Mass production of the ASTER and firing control system for French and Italian armies,
    - VLMICA program, for adapting the MICA system to land applications, with each section composed of six vehicles (radar vehicle, engagement vehicle and four missile launcher vehicles),
    - SYMBA for MARS program, for adapting the MISTRAL weapon system on armored vehicles,
    - New missile weapon system concepts, designed for integration on the French Army's future lightweight armored vehicle (known as EBRC, a French acronym meaning “Engin Blindé à Roues de Contact”). These new concepts are briefly described below.

3.0 EBRC AND MISSILE WEAPON SYSTEMS WITH THE MAN IN THE LOOP.

In a post-cold war geostrategic context, where combats become ever more entangled, weapon systems have to adapt themselves. The logic based on replacing an equipment by another one is now outdated; a new and different system has to be devised. It is why a new program, called BOA (a French acronym meaning “Bulle Opérationnelle Aéroterrestre”) has to aim at revamping the future functional French Army's organization by the year 2015. This BOA concept relies on the combined action of an array of entities (troops, vehicles, UGV, UAVs…), which will be capable of communicating, observing, collecting intelligence and acting, all at the same time, by using the existing and future technologies.

EBRC, a new lightweight armored vehicle studied by GIAT Industries, will be one of the technological features of BOA.

Within this framework, the EBRC has a twofold usage:

- adapting armored combat to the special requirements of urban area engagements,
- creating a new reconnaissance capability within contact combat.

Between the heavily protected and armed LECLERC and the VBL (Light Armored Vehicle) designed for swift actions, the EBRC will be suitable for both high and low intensity actions, combat on open ground as well as engagements in urban areas. It shall be capable of meeting operational needs expanded to more diversified missions than those assigned today to wheeled armored vehicles (ERC SAGAIE, AMX 10 RC). It is designed both as a combat vehicle, and as a system capable of federating the action capabilities of the other components in the joint services environment, due to its integration into the "battle space nervous system".

EBRC should provide, not only with a line-of-sight firing capability (e.g., a gun), but also with a firing capacity to engage targets beyond the line of sight.

Therefore, in 2003, DGA [French DoD] has contracted MBDA France to do studies for the requirement specifications and for the realization of the preliminary design concepts of missile systems that could be deployed on the EBRC.

The operational requirement specification has been defined on the basis of several operational scenarios. It has highlighted the major and critical operational functions, as regards the design of a missile system for the EBRC, namely:

- line-of-sight firing, during an unforeseen or prepared confrontation, as a complement to a medium-caliber gun,
- beyond-line-of-sight firing up to the range required for covering the BOA's Zone Of Interest (ZOI),
- maximum *versatility* to be able to reach all the defined targets, while demanding effectiveness against the latest-generation tanks,,
- control of collateral-damage with a metric accuracy, a warhead tailored to the target, and the capacity to keep "the man in the loop" until missile impact.

Relying on a functional analysis approach, preliminary missile system studies have been conducted. These studies have demonstrated that a land combat missile, meeting the requirements, could be produced and ready for commissioning by the years 2012 to 2015.

A missile meeting the whole requirement, especially the operational effectiveness; and offering the best trade-off between constraints, efficiency, system ease of use, and cost could have a guidance system with the man in the loop, allowing the gunner to control the missile by means of a high-quality target image. Thus, the gunner would be autonomous, as regards missile guidance. In its principle, the guidance requires a data link for the operator to receive "what he does not see directly". The missile thus includes a sensor and transmits information in the form of images, whereby the operator can designate the target.

The main advantage of this configuration is that it makes the gunner invulnerable, as he can remain invisible to the enemy, while still controlling the missile engagement.

Such a missile must have a large enough caliber to meet the lethality requirement and to be capable of carrying a high-performance imager, while remaining compatible with on-vehicle integration constraints (launcher's weight and volume for instance).

4.0 REQUIREMENTS FOR MISSILE WEAPON SYSTEM INTEGRATION ON VEHICLES

This section defines the requirements linked with missile weapon system integrations, specifically for those implementing the "man in the loop" concept.

This list is not exhaustive; however, it addresses the main issues.

These requirements relate to:

- the system architecture,
- the mechanical architecture,
- the electrical architecture,
- human engineering,
- the constraints on the vehicle and the missile system,
- the constraints related to the environment in or around the vehicles.

These requirements are conventional; however, with the new types of weapon systems, some of them become prominent, specifically the system architecture and human engineering.

System architecture

For optimizing the missile weapon system mission, full mastery of C^2 (Command and Control) is indispensable, in order to fire the missile(s) under the best possible conditions. Actually, the issues to be considered involve the missile performance capabilities, the constraints related to the tactical situation, the threats existing on the flight path and the target locations. This mastery makes it possible to offer the operators optimized weapon system operation in regard to the missions to be fulfilled (firing time, flight time, best flight path, selection of the appropriate missile on the target, etc.).

The fire control built into the vehicle must supply the information required for preparing the missile, prior to launching, for it to fulfill the assigned mission and the missile weapon system must send to the fire control the information relevant to mission progress, as it is executed.

Mechanical architecture

The layout of the specific missile weapon system components (firing installation and ammunitions) in the proposed vehicle must take the following issues into account:

- 1) The field of regard (azimuth and elevation) requirements to obtain the best possible missile firing zone.
- 2) The problems linked with ammunitions reloading on the firing ramps, without jeopardizing personnel safety, and integrating the environmental constraints (low temp., high temp., EMC, NBC).

  Several solutions could be considered, depending on the operational requirements:

  - automatic loading (barrel, rotary hold, etc.),
  - semi-automatic or fully manual reloading by the operators;
- 3) Increasing the ammunition storage capacities.

  Generally, a trade-off has to be achieved between the operational requirement (life profile, number of missiles to be fired per wartime mission day), the space allocated inside the vehicle and its mobility requirements (payload).

  Several solutions could be considered:

  - vertical ammunition storage, 2 solutions:
    - the ammunition is locked on a ramp moveable in azimuth or/and bearing and the missile is firing from this ramp,
    - the ammunition is stored and launched vertically which imposes constraints on the missile for trajectory shaping in the departure phase,
  - reduction of the ammunition's volume and weight,
  - reduction of the number of specific components required for operating the missile weapon system.

Electrical architecture.

The vehicle must deliver the power necessary for operating the missile weapon systems (rotating joint, vehicle's engine stopped or running) under optimum conditions, and in emergency mode to complete a mission.

Generally, this integration constraint translates into a power network quality and the need for buffer batteries (climatic environment resistance, load, etc.).

Human engineering

This issue is very important for missile weapon systems with the man in the loop.

The following Man/System interface requirements (non-exhaustive list) must be addressed:

- to supply the operator with the information strictly necessary for satisfactory running of the mission, and at the right time for facilitating decision making;
- to be compliance with the safety rules applicable to the operation of our weapon systems,

- to use of standard interfaces (type of display screen, controls, etc.);
- to define common elements for the man-machine interfaces of the different weapon systems present in the vehicle, in order to facilitate the operational tasks, eliminate the sources of error during system communications, and simplify operator training;
- to optimize and share the workload between the operators present in the vehicle for the different phases of missile weapon system operation;
- to manage the operators' actions, coordinating them for the simultaneous operation of the different systems;
- to retain full control of the engagement nearly till the missile impact (final target choice possible a few seconds before impact). This new requirement imposes a high-quality display, quasi-real-time refresh of the image delivered by the missile and special operator training (integrated or not training resources).

Vehicle and missile weapon systems requirements

The requirements relevant to the vehicle are as follows:

- no restriction of the tactical and strategic mobility performance, which implies, for instance, compliance with the axle load limits and the road, rail and airlift gauges;
- non-increase of the infrared or electromagnetic signatures of the vehicle carrying the missile weapon systems, by limiting the number of elements radiating to the outside of the vehicle's envelope and manufacturing low-signature ammunitions.

Environmental requirements

These requirements are related to the use of the missile weapon systems in a terrestrial environment. Some of the issues are listed below:

- mechanics (vibration, shocks, etc.),
- EMC: electromagnetic radiation from the vehicle environment towards the ammunition and the firing installation, and vice versa.

These requirements are taken into consideration as early as the missile system design stage. The environment seen by the missile weapon system's components built into the vehicle must be fully controlled. The substantiation of compliance with these requirements imposes extensive qualification tests.

Personnel safety requirements

The presence of missiles on-board the vehicles may not jeopardize personnel safety. This requirement imposes choices as regards the design of missile weapon systems (ammunition insensitivity (MURAT) level, definition of firing lines with safety interlocks built into the firing installation, etc.).

Requirements related with the cumulative compliance with new civilian regulations and military regulations

For instance, compliance with the Highway Code and environmental protection result in new constraints imposed for the integration of our systems.

For example, compliance with the environmental protection rules imposes new types of vehicle engines with electronic control. The massive introduction of electronics into military vehicles must nevertheless remain compatible with the EMC environments demanded for the ammunition and faced on a battlefield.

5.0 INTEGRATION OF A MISSILE SYSTEM ON THE EBRC.

The feasibility studies conducted on the beyond-line-of-sight missile systems have also allowed MBDA France to identify with GIAT Industries the main constraints relevant to the integration of such a missile system into EBRC.

This section gives the main conclusions of this preliminary study.

The main EBRC characteristics considered for this study are the following ones:

- weapons: medium-caliber gun (40 mm) and missile weapon system capable of engaging targets in line of sight and beyond the line of sight;
- combat-ready weight: to be achieved < 18 tons;
- 3-member crew.This study has allowed a first EBRC solution to be proposed that associates a medium-caliber gun firing function with a missile firing function with the man in the loop.

Several potential architectures enable the integration of this new missile weapon system into the vehicle. Two examples given below illustrate this integration.

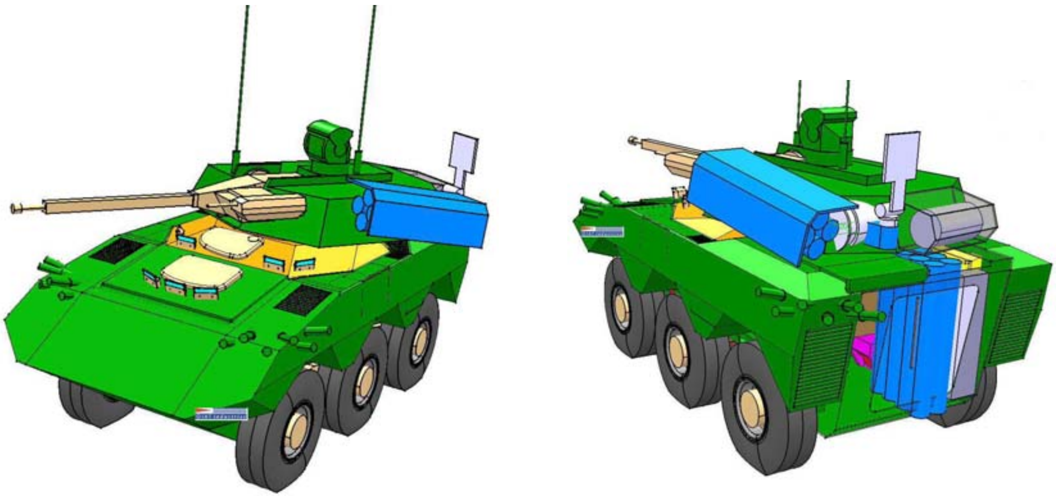

Figure 9: Example with a Mount of 4 Ready-to-Fire Missiles and Storage Hold.

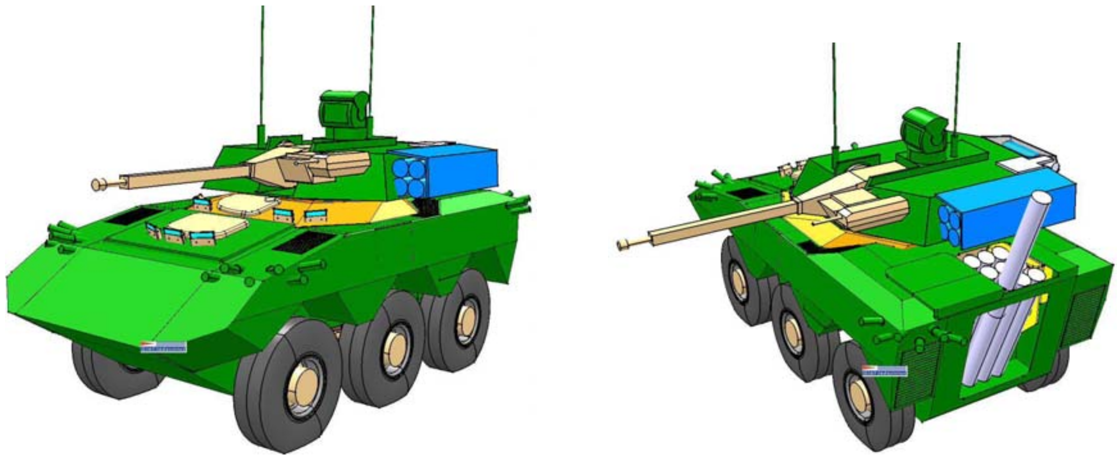

Figure 10: Second Example of Missile System Integration on EBRC

The feasibility of the integration of the Man/System interface activity, induced by the missile weapon system management, with the other EBRC operation activities, has been studied. The adequacy of the Man/System interface concepts, currently considered for the EBRC, with the requirements of the operator activity could be demonstrated. The integration solutions, in particular, allow the missile and gun firing functions to be used in close association.

As a conclusion, the missile weapon system integration solution has been judged satisfactory, with regards to all the studied issues, a good performance/complexity trade-off has been achieved. The studies should be continued, so as to further detail these conclusions, before development work is initiated.

6.0 CONCLUSION

MBDA has extensive experience both in weapon systems and in their integration into different platforms, in particular for land systems.

In order to optimize the integration of our conventional missiles, a dialog must be set up, as early as possible, right from the missile weapon system and/or hosting platform feasibility study phase, between these platform designers and our weapon designers. This close dialog allows the requirements of each party to be addressed as early as possible in the feasibility phases, so that optimum and consistent integration of all the different weapon systems present on the considered platform can be achieved.

However in recent years, this integration has had to consider new issues:

- the introduction of the new missile systems with the man in the loop during missile firing,
- large quantities of information delivered to the operator in charge of weapon system control, for optimizing the mission, specifically with regards to the final target choice.

The role of the operators present in the platforms, till the impact on the designated target, and their workloads at the different instants of their missions, must be addressed from the very beginning of the study of these new missile system integration. The strictly necessary and sufficient information must be provided to the operators, at the right time, to help them make a good and fast decision during their missions.

Generally, one of the judgment criteria the operational staff uses to assess weapon system quality is tightly related to the quality of the man/machine interface and the human engineering inside the vehicle.