UDK: 623.4.081:623.467
COSATI: 16-04, 16-01

Choice and analysis of the launcher interface optimal solution for an anti-tank guided missile

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This paper describes the design and functional parts of an anti-tank guided missile launcher. The detailed analysis of the launching tube interface is made with respect to the structural parts and their function. Also, the criteria for the interface optimization estimation are given, as well as the methods for it main characteristics verification.

Key words: **anti-tank missile, guided missile, rocket launcher, launching tube interface, command and launch unit, connector, micro cable guidance.**

Notation and symbols

ATGM – anti-tank guided missile
BRM – booster rocket motor
BRMI – booster rocket motor ignition
CLU – command and launch unit
COM – command signal
EMI – electro-magnetic interferences
GND – signal ground
GS – gyroscope signal
IED – ignition electro-detonator
LB – lithium battery
LT – launching tube
MC – micro-cable
MCRC – micro-cable returning conductor
PTL – pyrotechnic lock of the missile
PTLI – pyrotechnic lock ignition
PTLRC – pyrotechnic lock switch returning conductor
SRM – sustainer rocket motor
START – start of the missile
TB – thermal battery
TBGI – thermal battery and gyroscope ignition
TBL1 – test before the trigger activation
TBL2 – test before the missile launching
THCW – tandem hollow charge warhead
TVC – thrust vector control
TVSINC – signal for the flare synchronization and power supply
J_1 – CLU connector
J_2 – "umbilical" connector
J_3 – micro-cable connector
J_4 – lithium battery housing connection
J_5 – pyrotechnic lock connection

Introduction

The ATGM launcher is an assembly which has to provide:

- missile launching from the LT from an adequate platform and from various combat positions of the gunner, vehicle or aircraft and
- electrical connection (interface) between the missile in the LT and the CLU.

The launching platform could be:

- the gunner's shoulder,
- bipod, for the sitting and kneeling combat position,
- tripod, for the lying combat position,
- rail on the armored vehicle or helicopter.

The interface between the missile in LT and the CLU enables:

- the missile launching sequence initiation,
- the second generation ATGM flight guidance by the CLU commands sent to the missile control system via communication link between the launcher and the missile and
- the target identification and choice before firing the third generation of self homing head ATGWs.

Design and functional parts of the launcher

An example of the ATGW launcher is shown in Fig.1. The main functional parts of the launcher are:

- missile within the LT,
- CLU and
- tripod.

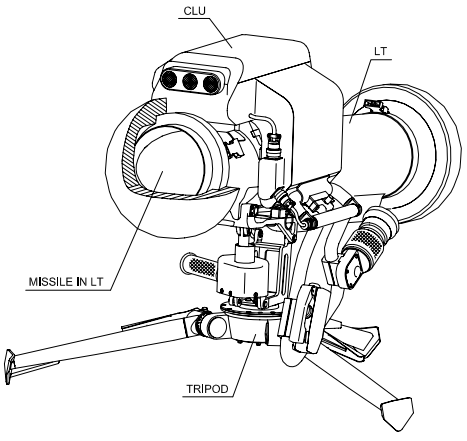

Figure 1. ATGW launcher

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The UVL is an optoelectronic device intended for the second generation anti-tank missiles guidance to the line of sight defined by the gunner while aiming at the target.

The tripod is a stable platform from which the target is to be identified and selected and the missile is to be launched and guided up to the target, from lying combat position of the gunner. It is composed of: the direction mechanism with legs, the elevation mechanism and the LT mount (Fig.2).

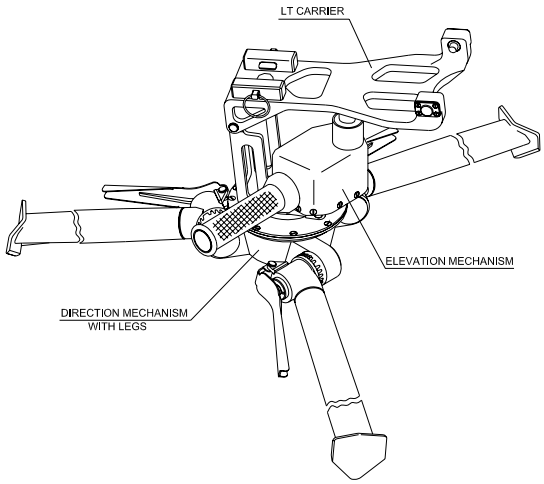

Figure 2. Tripod

The missile, within the LT, is hermetically shut for protection. The LT acts as the missile container during the storage, transportation and firing. The LT overview is shown in Fig.3.

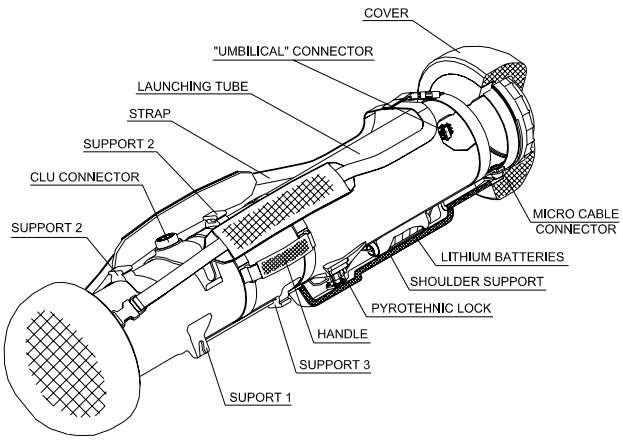

Figure 3. Launching tube

The subparts of the LT are intended for:

- missile protection (front and aft cover, shoulder support),
- missile transportation within the LT (strap and handle),
- missile locking within the LT (pyrotechnic lock),
- mechanical connection between LT with tripod and CLU (supports 1, 2 and 3),
- electrical connection between the LT and the CLU (LT interface with connectors).

Launching tube interface

The LT interface (Fig.4), connects the missile electronical blocks with the CLU in order to initiate the sequences of the missile launching and guidance during the flight to the target [1].

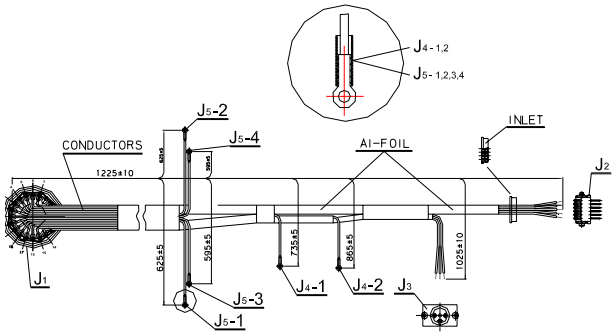

Figure 4. Launching tube interface

Electrical connection between the CLU and the LT interface is made by J_1 (Fig.5). The "female" part of that connector is a part of the LT interface, and the "male" part of that connector belongs to the CLU interface. J_1 has 20 contacts and both parts of the connector are hermetized with respect to the moisture. The contacts from 1 to 14 are for the missile launching and guidance, and the rest of them are for the measurement, testing and training equipment attachment.

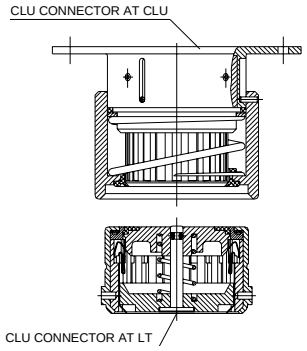

Figure 5. CLU connection pair J_1

Electrical connection between the missile and the LT interface is achieved via J_2 and J_3 (Fig. 6–7). The "male" part of J_2 and the "female" part of J_3 belong to the LT interface and the opposite parts of those connectors belong to the missile interface. J_2 has 6 contacts. The "male" part of J_2 (on the LT), has two degrees of movement freedom in order to make fastening with the "female" part of J_2 (on the missile) as easy as possible (Fig.6). The contacts are easy to disconnect during missile launching and are placed in the housing made of AG-4V isolating substance. The interface wires run through the inlet from the outer side of LT to the connector J_2, at the inner side of LT, (Fig.4).

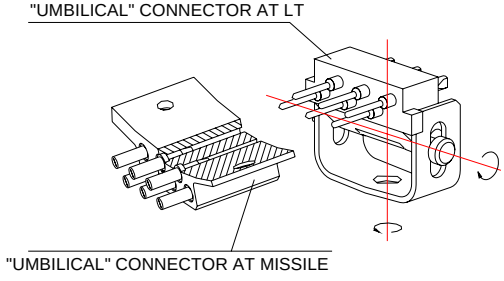

Figure 6. "Umbilical" connection pair J_2

Below the J_2 housing on the missile, there is a conducting foil, a shortcut between the missile housing and contact $J_{2\text{-}6}$.

J_3 has 3 contacts. The "male" part of J_3, on the missile, is designed in order to withstand the first jerk of the micro cable in the moment of launching, as well as the BRM burning products influence which finishes its work in the LT, (Fig.7).

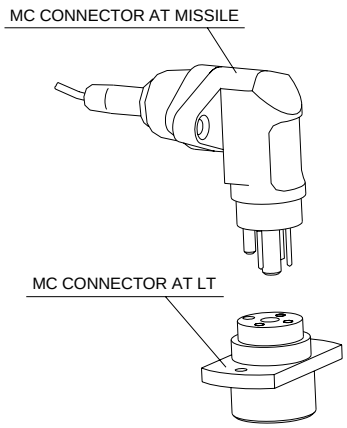

Figure 7. Micro cable connection pair J_3

The lithium batteries housing is connected to the LT interface via contacts $J_{4\text{-}1}$ and $J_{4\text{-}2}$. Batteries give the electrical energy needed for the continuous CLU operation, TB ignition, the gyroscope gas generator ignition and the missile flare electronics operation, up to the moment when TB accomplishes it operational regime during the missile launching phase.

The electrical part of the PTL is a part of the LT interface. The PTL igniter is placed at $J_{5\text{-}1}$ and $J_{5\text{-}2}$ contacts, while the PTL switch is placed at $J_{5\text{-}3}$ and $J_{5\text{-}4}$ contacts. The PTL is unlocked by activation of the electrical detonator of its igniter which generates the gases. Due to the overpressure of the gases, the PTL piston moves towards its extreme position, making the missile free to be launched from LT. In this position, the switch contact is closed and gives a signal that the PTL is unlocked.

The LT interface is protected by polyethylene cover intended for the interface mechanical protection during transportation and handling. Under the cover, there is a thin aluminum foil which, exploiting $J_{2\text{-}5,6}$, is connected with the missile in LT, thus making the continual protective shield of the LT and the missile interface against EMI. This protection does not cover three MC conductors because they are not protected on the MC coil, but are mutually braided to minimize the EMI, negative effects.

The interface conductors cross-section is determined mainly with respect to their length and minimization of the LT mass, because the electrical currents through interface are pretty low.

The electrical outline of the LT interface is shown in Fig. 8. Utilizing J_1, the LT interface and J_2, the CLU initiates the sequence of events during the missile launching, [2]. Via J_1, the LT interface and J_3, the CLU automatically generates and sends command signals towards the missile.

How does the LT interface work? The voltage of +15V at the LB housing exit connections $J_{4\text{-}1}$ and $J_{4\text{-}2}$ is transmitted to the CLU input utilizing connections $J_{1\text{-}1}$ and $J_{1\text{-}2}$. When the gunner turns on the switch in the LB circuit, then the CLU is supplied with electrical energy. Utilizing contacts $J_{1\text{-}12}$ and $J_{2\text{-}3}$, the CLU sends complex impulses TVSINC for the flare electronic block supply switching operation mode and the vertical synchronization impulses from the CCD camera of the CLU coordinator, in order to establish the synchronization between the coordinator and the flare. When the synchronization is established at the coordinator working frequency, then the TBL1 allows the gunner to go on with the missile launching sequence. [2].

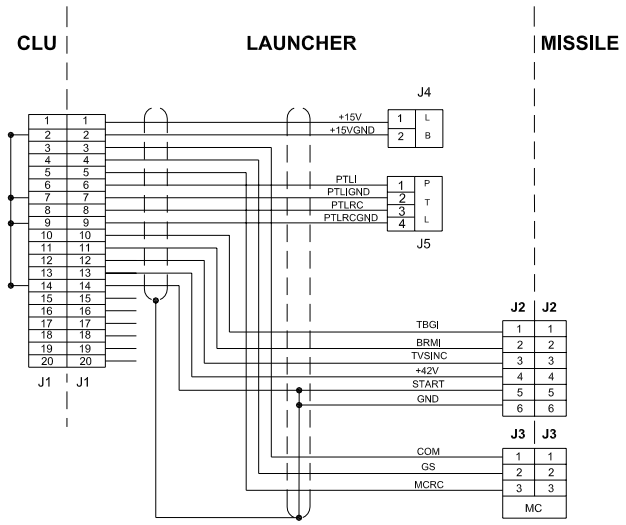

Figure 8. LT interface electrical scheme

When the gunner presses the CLU triggering button, the TBGI signal, exploiting connections $J_{1\text{-}10}$ and $J_{2\text{-}1}$, simultaneously activates electrical detonators of the TB and the gyroscope gas generator igniters. The TB voltage (+42V) control is made by the CLU, using contacts $J_{2\text{-}4}$ and $J_{1\text{-}13}$.

When the TB achieves its operational mode, launching sequence continues by PTL signal activating electro detonator of the PTL via contacts $J_{1\text{-}6}$ and $J_{5\text{-}1}$. When unlocked, the PTL switch generates the PTLRC signal and, utilizing connections $J_{5\text{-}3}$ and $J_{1\text{-}8}$, gives the information to the CLU about the PTL condition. However, if TB achieves its operational mode and PTL is unlocked, the TBL2 permits the missile launching, activating the BRM, via connections $J_{1\text{-}11}$ and $J_{2\text{-}2}$, by the BRMI signal, [2].

The missile motion along the LT is followed by disconnection of J_2 and a shortcut between connections $J_{2\text{-}5}$ and $J_{2\text{-}6}$. In that way, the START signal is generated at the missile side and the SRM ignition delay line is activated as well as the THCW fuse arming sequence, [2]. The J_2 disconnection is accompanied by the TB voltage drop (+42V) at the contacts $J_{2\text{-}4}$ and $J_{1\text{-}13}$, which activates the CLU coordinator program, [3].

After launching, the missile and the launcher are linked only by the triple wired MC, which is connected to the LT by J_3. The CLU sends COM signals towards the missile via $J_{1\text{-}3}$ and $J_{3\text{-}1}$ contacts. Exploiting contacts $J_{3\text{-}2}$ and $J_{1\text{-}4}$, the GS signals are sent from missile to CLU, while MCRC is common to both directions of communication, via $J_{3\text{-}2}$ and $J_{1\text{-}5}$ contacts.

Returning conductors GND for all of the signals: +15V, PTLI, PTLRC, TBGI, BRMI, TVSINC, +42V and START are jointed into a single point within the CLU housing and are connected with the protective shield of the interface and missile.

The interface described above, satisfies the following basic criteria for solution optimization:

- EMI protection,
- minimal number of interface conductors, connectors and sockets,
- minimal number of contacts in the connectors.

Interface characteristics

The LT interface main characteristics which can be identified by adequate measuring methods are:

1. **EMI characteristics** in the sense of immunity and permitted emissivity which do not violate the function or degrade the characteristics of the other system components.
   Influenced by the EMI, the currents induced in the TB, gyroscope gas generator, PTL, BRM and SRM igniting circuits must be kept at the values lower than those which can activate electrical detonators and cause incidental ignition. For every single type of electrical detonator, the current intensity by which a detonator must not be activated and intensity by which it must be activated, are defined in advance. The ATGM comprises the EMI sources such as: short impulses during the TB, gyroscope gas generator, PTL, BRM and SRM igniters activation or TVC system operation. Those EMI sources are not strong enough to activate electrical detonators in the neighboring ignition circuits. For EMI protection, the interface and the missile shield are the utmost impotance. The EMI characteristics are tested in accordance to the MIL standards 461 and 462.
2. **Electrostatic discharge immunity** during handling and transportation is related to electrical detonators activation prevention in adequate igniting circuits and to degradation or failure of the semiconductve components within the system. Similar to the previous case, the electrical shielding of the interface and conductive protection of the missile body are the most important .
   The current induced by the gunner electrostatic dicharge, while handling the missile within LT, is simulated by 5pF condenser discharge through the 5KΩ resistor in the electrical detonator circuit, which is charged under 30KV voltage.
   The current induced by the electrostatic discharge during the missile transportation by the helicopter, is simulated by the 1000pF condenser discharge in the electro detonator circuit, which is charged under 300KV voltage.
3. **Isolation resistance** between the neighboring conductors of the interface must be greater than 50MΩ during the 500V direct test voltage implementation. During the 650V alternative test voltage of 1KHz frequency implementation for 1s, penetration and spark jump between the interface neighboring conductors is not allowed.
4. **Interface functional characteristics** are approved on the control panel which has to indicate the connection break or crossing.
5. **Interface dimensional characteristics,** in reference to the conductors length and cross-section diameter, are controlled by connecting all the interface connectors and contacts to the appropriate positions on the testing LT. For this purpose, the testing LT acts as a control tool.

Conclusion

Basic functional parts of the launcher are: the missile in the LT, the CLU and the tripod. The CLU is an optoelectronic device intended for the second generation anti-tank missile guidance to the line of sight defined by the gunner while aiming the target.

LT acts as missile container during storage, transportation and firing. The LT interface connects the missile electronic blocks with the CLU in order to initiate the sequences of the missile launching and guidance during its flight up to the target. Electrical connection between the missile and the LT interface is realized through J_2 and J_3. Electrical connection between the CLU and the LT interface is realized through J_1. The LB housing is attached to the LT interface by J_{4-1} and J_{4-2} contacts. The PTL igniter is on J_{5-1} and J_{5-2} contacts while the switch in PTL, which gives information about the PTL condition, is on J_{5-3} and J_{5-4} contacts.

Utilizing J_1, LT interface and J_2, CLU initiates the sequence of events during missile launching. Utilizing J_1, LT interface and J_3, the CLU automatically generates and sends the command signals to the missile flying to the target. This interface satisfies criteria adapted for the solution optimization evaluation: EMI protection, minimal number of interface conductors, sockets and connectors and minimal number of contacts in each of the connectors.

The main characteristics of the LT interface, identified by the appropriate measurement methods, are: EMI characteristics concerning immunity and permitted emissivity, electrostatic discharge immunity during the handling and transportation, isolation resistance between the neighboring conductors of the interface, functional and dimensional characteristics referring to the conductors length and cross-section diameter.

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Received: 22.02.2005.

Izbor i analiza optimalnog rešenja interfejsa lansera protivoklopne vođene rakete

Prikazana je konstrukcija i funkcionalne celine jednog rešenja lansera protivoklopne vođene rakete. Izvršena je detaljna analiza interfejsa lansirne cevi sa aspekta sastavnih elemenata i njihove funkcije. Dati su kriterijumi za procenu optimalnosti rešenja i metode za ispitivanje osnovnih karakteristika interfejsa.

Ključne reči: **protivoklopna raketa, vođena raketa, lanser rakete, lansirna cev, interfejs, uređaj za vođenje, konektor, vođenje pomoću mikrokabla.**

Le choix et l'analyse de la solution optimale de l'interface du lance-missile antichar guidé

Dans ce travail on a démontré l'ensemble fonctionnel d'une solution de lance-missile antichar guidé. Une analyse détaillée de l'ifluence du tube de lancement du point de vue des éléments composants et de leur fonctionnement a été faite.Les critères pour évaluer l'optimalité de cette solution ainsi que les méthodes pour examiner les caractéristiques principales de l'interface sont donnés.

Mots clés: **missile antichar, missile guidé, lance-missile, connecteur, guidage par micro-cable, interface du dispositif de guidage, tube lance-missile**

Выбор и анализ оптимального решения интерфейса пускового устройства противотаковой управляемой ракеты

В этой работе показана конструкция и функциональные части одного пускового устройства противотаковой управляемой ракеты. Со стороны составных элементов и их функции сделан подробный анализ интерфейса пусковой трубы. Здесь приведены критерии для оценки оптимальности решения и методы для исследования основных характеристик интерфейса.

Ключевые слова: **противотаковая ракета, управляемая ракета, пусковое устройство ракеты, пусковая труба, интерфейс, устройство для управления, соединитель, управление при помощи микрокабеля.**