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EVALUATION METHODS FOR AERIAL TARGET-TYPE SELF-CONFIGURATION SYSTEMS DESIGNATED FOR TRAINING FIRING WITH SELF-DIRECTED AIR-TO-AIR AND GROUND-TO-AIR OPERATIONAL MISSILES

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***Abstract:** The purpose of this paper is to expound testing and evaluation methods for aerial target-type self-configuration systems, designated for training firing of A/A and G/A operational missiles, in order to integrate them on MiG-21 Lancer and IAR-99 ȘOIM aircraft.*

A. GENERAL

Since 1994, RoAF MiG-21 aircraft have undergone a comprehensive modernization program aimed both for integration of modern avionics and weapons system and for developing of a new weapons configuration; this process led to expanded opportunities to address combat missions, improved operational performance of aircraft and their approach in terms of requirements applied in NATO.

Both verification and validation of ammunition performance for air-to-air missions as well as crew training run by real firing against air targets imitating the essential characteristics of operational targets. For IR/radar homing air-to-air missiles, this requirement implies the use of air targets, consistent in terms of the IR radiation wavelength with missile detection systems and capable of reflecting the radar energy emitted by guiding system or/and missile seeker head. Currently, the products observing these conditions are small air parachuted target type self-configured systems.

The constructive solution proposed by S.C. ELECTROMECHANICAL S.A. Ploiesti, integrating components made by suppliers in the field of domestic defense industry, has resulted in a product type parachuted aerial target, which obtained the validation by going through a comprehensive program of testing and evaluation, both on the ground (using existing test facilities of the national industry in field or belonging to MoD) and in flight (using RoAF MIG 21 Lancer and IAR 99 SOIM aircraft and ground based and airborne testing facilities owned or developed by R&FTC Craiova for this program).

The purpose of the testing was to check how the parachuted aerial target type self-configured system meets the Air Force requirements stipulated in the product specification and to establish the key functional performance that enable the develop of an operational use for this product. This paper dealt with the assessment methods used to achieve the objectives contained in the test and evaluation plan of aerial target type self-configured systems, created and produced by R&FTC Craiova.

B. ISSUES ON THE METHODS USED FOR EVALUATION

The methods used for evaluation aimed to deal with three main aspects, namely:

1. Checking the interfacing and the separation of aerial target type self-configured systems and IAR 99 SOIM and MIG-21 LANCER aircraft;
2. Validation of IAR 99 SOIM and MIG-21 LANCER aircraft armament configurations including aerial target type self-configured systems with parachute, as following:
 - Checking products reaction in the aircraft flight envelope for armament configurations with these products;
 - Checking the products separation from aircraft, checking the operational safety and establishing the launch envelopes;
 - Assessing the product safety in operation, highlighting the peculiarities of operation and validation of operating procedures;
3. Determination of operating performance and demonstrating the operational performance of the products.

C. OVERVIEW OF EVALUATION METHODS USED

1. Products assessment methods based on processing, analysis and interpretation of data obtained from tests performed on the ground and CFD simulations.

Assessment Method	Products subject to testing / Test facilities / Specialized equipment	Test and Evaluation Objectives

Assessment Method	Products subject to testing / Test facilities / Specialized equipment	Test and Evaluation Objectives
<p><i>a. Checking product interfacing and fixing on IAR-99 SOIM and MiG-21 Lancer aircraft pylons;</i></p> <p><i>b. Checking the product separation from the aircraft pylons.</i></p> <p><i>- Stage 1 - Dynamic tests on the ground.</i></p>	<ul style="list-style-type: none"> - IAR 99 SOIM aircraft equipped with holding pylons provided with locks LA-350; - MiG-21 Lancer aircraft hardpoint equipped with locks MRU-A-000; - Load air target-type self-configured systems (model equipped with initiation systems); - Ground based acquisition system for measuring digital signals; - Quick video camera. 	<ul style="list-style-type: none"> - Dimensional and inertial characteristics, identification and marking; - The product fixing on aircraft pylons/hardpoints; - The connecting elements between the warhead / arming mechanism and aircraft; - The product trajectory during the stage of separation from aircraft, in aerodynamic no-loading conditions; - Interfacing systems and arming fuse operation in time of 300 ms; - Product operation.
<i>Preliminary analysis of the product launch manner.</i>	Dedicated computer system for CFD analysis using	Determination of aerodynamic characteristics of the product in terms of carrier aircraft motion in



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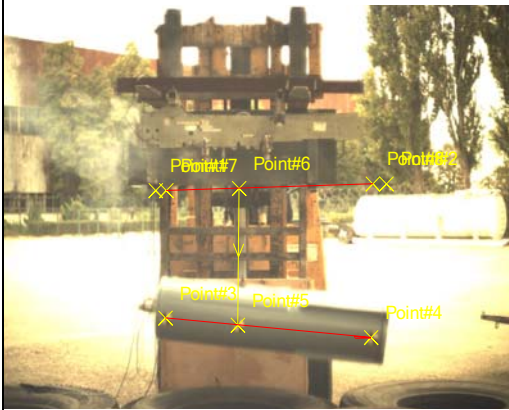
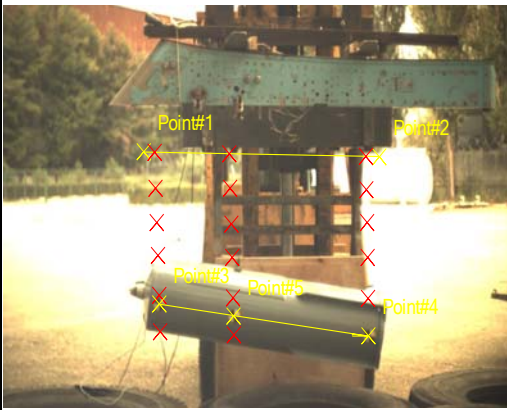


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Assessment Method	Products subject to testing / Test facilities / Specialized equipment	Test and Evaluation Objectives	Assessment Method	Products subject to testing / Test facilities / Specialized equipment	Test and Evaluation Objectives
<i>Preliminary calculation of vertical distances covered by the product from the separation until the</i>	FLUENT simulation environment .	proximity, during the separation process. Estimation of product trajectory during the separation from aircraft, for launching points to establish the	<i>moment of becoming target.</i>		launch envelope. Estimating the risk of product interference with the carrier aircraft, in the launch diagram;

The tests course:

The evaluated objectives	Aircraft Type	
	IAR 99 SOIM	MIG-21 LANCER
Fixing the product on aircraft hardpoints and checking the interfacing between aircraft and product.		
		
Verification of product separation from the aircraft and determination of product motion parameters in terms of launch without aerodynamic load.		
	<p>Acquired and analyzed parameters:</p> <ul style="list-style-type: none"> • Speed on the two axes; • Pitch angle; • Time; • Covered distance in free fall from launch; • Launch synchronizing with the movement of product; • Measuring the interfacing electrical signal. 	



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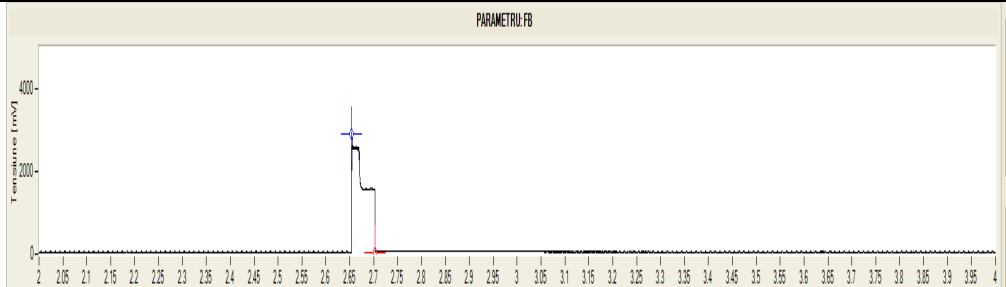
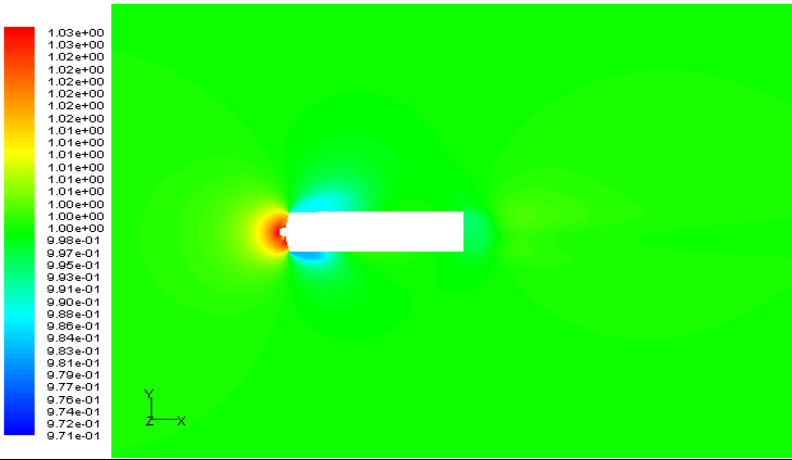


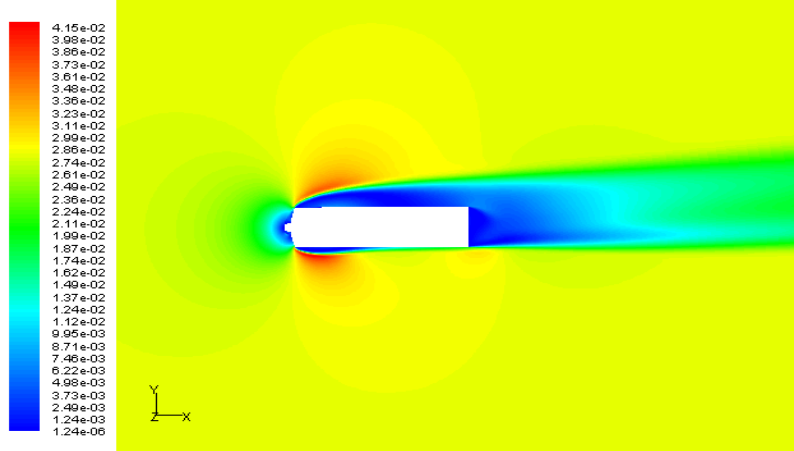
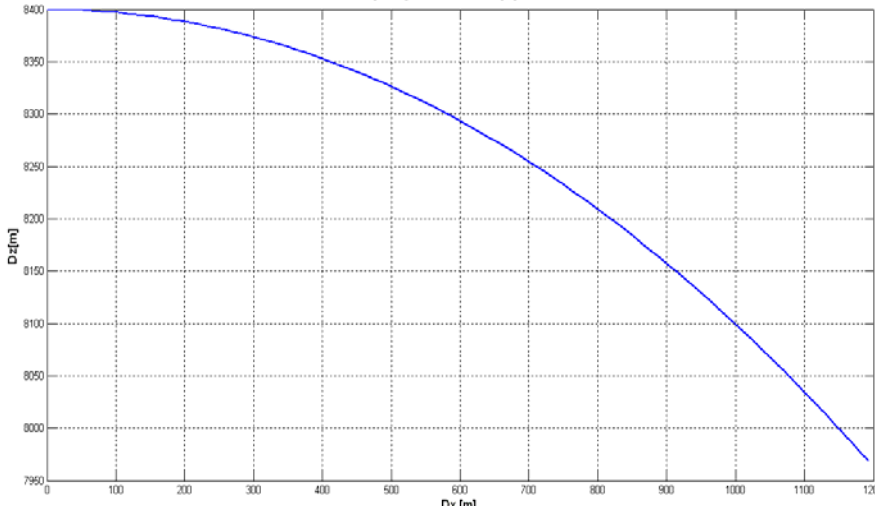
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The evaluated objectives	Aircraft Type	
	IAR 99 SOIM	MIG-21 LANCER
Checking electrical control signals – Fuse arming.	 <p>Acquired and analyzed parameters:</p> <ul style="list-style-type: none"> • Control signal time; • Time of 28V signal that appears on MTI (A1); • Time of 28V signal that appears on cable Bomb (A1-MTI)); • Time interval between signal A1 and A1-MTI signal occurrence 	
<p>Estimation of the product trajectory during separation and after separation during the reconfiguration as a target.</p> <p>Determination of the product aerodynamic characteristics in undisturbed current and in proximity to aircraft.</p> <p>Risk assessment of interference between released product and carrier aircraft in the estimated launch envelope;</p>	<p>Estimation of product aerodynamic characteristics for different conditions of release. Distribution of static and dynamic pressure for an angle of incidence of 5 degrees and Mach = 0.2 - undisturbed current;</p>  <p>Profiles of Static Pressure (atm)</p> <p>Oct 22, 2010 FLUENT 6.3 (3d, pbns, ss9kw)</p>	

The evaluated objectives	Aircraft Type	
	IAR 99 SOIM	MIG-21 LANCER
	 <p>Profiles of Dynamic Pressure (atm) Oct 22, 2010 FLUENT 6.3 (3d, p6ns, ss90e)</p>	
	<p>In order to achieve the objectives, the following features were estimated by modeling and simulating:</p> <ul style="list-style-type: none"> • Aerodynamic coefficients and pressure center position during the launch of the product for different values of incidence angle and Mach flight number. • Preliminary calculation of vertical distances covered by the product from separation until the moment of reconfiguration as a target. 	
	<p style="text-align: center;">TRAIECTORIA TPDM DIN MOMENTUL LANSARII PINA IN MOMENTUL FORMARII CA TINTA PENTRU dt= 9.5[s]; CAS-lansare =300[km/h]; H-lansare=8400[m]; CONDITII STANDARD</p> 	
	<p>Assumptions for calculation:</p> <ul style="list-style-type: none"> — gravitational acceleration is a constant independent of altitude; — have not taken account of the influences of the wind; — the atmospheric parameters are those corresponding to standard atmosphere; — forces acting on products are the resulting mass and aerodynamic forces; — not have to consider the aerodynamic moments caused by the resulting aerodynamic forces; <p>In order to determine the ballistic motion of the product were developed in Taylor series the differential equations of motion in launching</p>	



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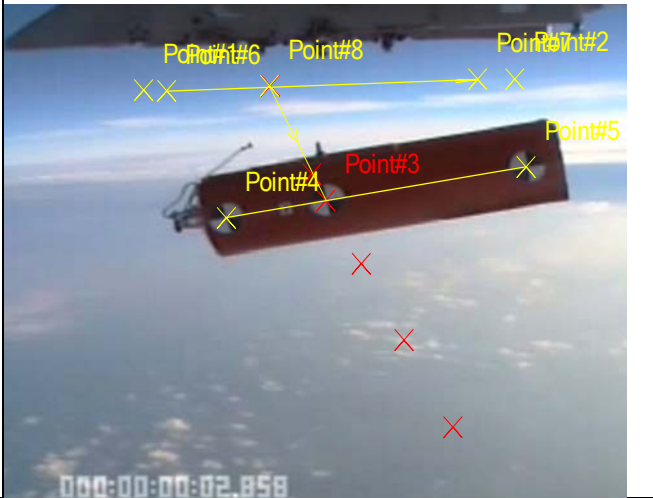
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The evaluated objectives	Aircraft Type	
	IAR 99 SOIM	MIG-21 LANCER
	point for which $X = Y = Z = t = 0$.	

2. Products assessment methods based on processing, analysis and interpretation of data obtained from tests performed in flight.

Assessment Method	Specialized equipment	Test and Evaluation Objectives
<i>Checking the products reaction in flight envelope of MiG-21 Lancer and IAR-99 SOIM aircraft.</i>	<ul style="list-style-type: none"> - Flight data acquisition and recording system ACRA KAM-500; - loaded aerial target type self-configured systems; 	<ul style="list-style-type: none"> - Products operational safety (in all stages of their use); - Products reaction in aircraft flight envelopes; - Products technical state after the flight.
<i>Checking the products separation from aircraft, operational safety and determining the launching envelope for MiG-21 Lancer and IAR-99 SOIM aircraft</i>	<ul style="list-style-type: none"> - Flight data acquisition and recording system ACRA KAM-500; - Real aerial target type self-configured systems; - Airborne video container boats; - Video recorder system on attendant aircraft; - EOTS system; - CRT system; 	<ul style="list-style-type: none"> - Product reaction during separation from the aircraft; - Product reaction on the trajectory after separation; - Determination of the launching envelope;
<i>Verification of products operational performance and safety in operation.</i>	<ul style="list-style-type: none"> - video recording system on the aircraft; - Real aerial target type self-configured systems; - IR self-directed air to air missiles, MAGIC -2; - Video recorder system on escort aircraft; 	<ul style="list-style-type: none"> - Products reaction after launch; - Products reaction on launching of self-directed air to air missile MAGIC - 2; - aiming the products after forming them as targets and igniting the torch, by IR missiles; - targeting IR guided missiles toward the product.

Objectives assessed	Results and issues concerning the objectives assessed
<p>Product reaction during separation from the aircraft;</p>	<ul style="list-style-type: none"> Launching the product from IAR99-SOIM – left pylon 



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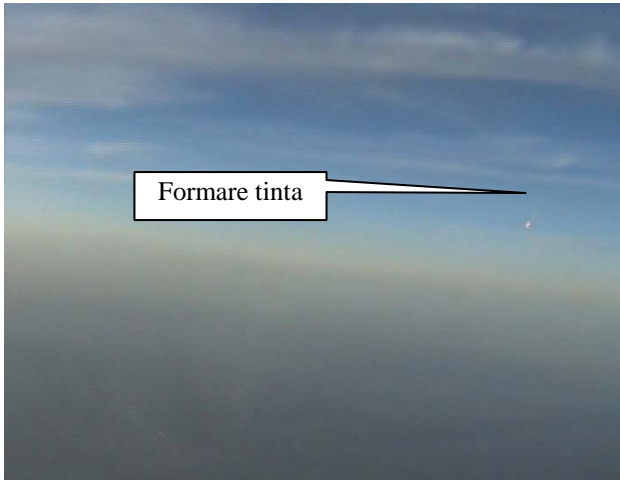



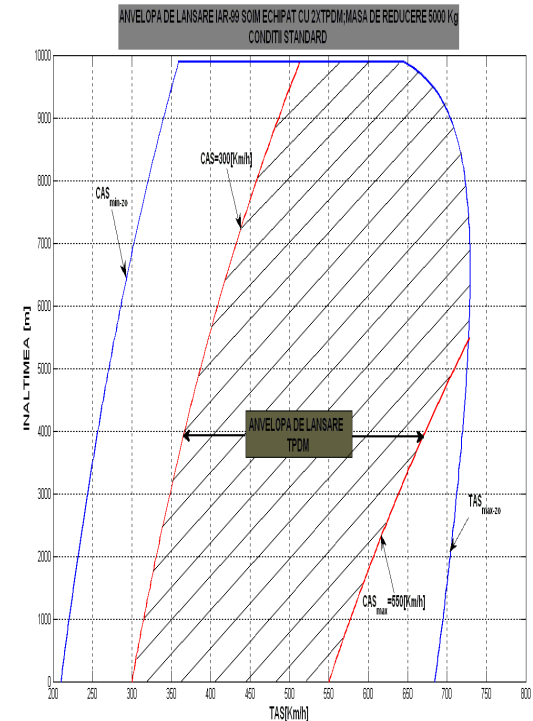
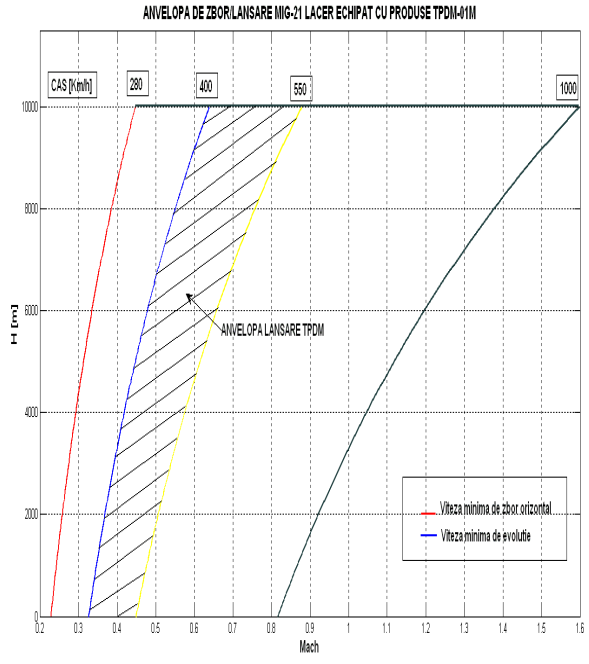
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Objectives assessed	Results and issues concerning the objectives assessed
<p>Verification de product reaction on the trajectory after separation;</p>	<ul style="list-style-type: none"> <li>• <i>Launching the product from aircraft MIG-21 LANCER</i> <li>  <li>• <i>Forming (reconfiguration) as target of the product</i> <li>  <li>• <i>The product operation as target</i> <li> 

Objectives assessed	Results and issues concerning the objectives assessed
<p>Determination of launching envelope.</p>	<p>Launching envelope <i>IAR-99 SOIM</i></p>  <p>ANVELOPA DE LANSARE IAR-99 SOIM ECHIPAT CU 2XTPDM, MASA DE REDUCERE 5000 Kg CONDITII STANDARD</p> <p>INALTIMEA [m]</p> <p>TAS [km/h]</p> <p>CAS_{min}=280</p> <p>CAS=300</p> <p>CAS_{max}=550</p> <p>TAS_{max}=750</p> <p>ANVELOPA DE LANSARE TPDM</p>
	<p>Launching envelope <i>MIG-21 LACER</i></p>  <p>ANVELOPA DE ZBOR LANSARE MIG-21 LACER ECHIPAT CU PRODUSE TPDM-11M</p> <p>H [m]</p> <p>Mach</p> <p>CAS [km/h] 280 400 550 1000</p> <p>ANVELOPA LANSARE TPDM</p> <p>Viteza minima de zbor orizontal</p> <p>Viteza minima de evolutie</p>



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Objectives assessed	Results and issues concerning the objectives assessed
<p>Aiming the products after forming them as targets and igniting the torch, by IR missiles.</p>	<p>Launching to MMR</p>  <p>Launching to BORESIGHT</p> 

D. RESULTS OBTAINED AFTER CARRYING ON THE TEST ACTIVITIES AND USING THE PRESENTED EVALUATION METHODS

1. During testing there were no incidents of malfunctions to affect the safety of crew or carrier aircraft.
2. The aircraft reacted normally in all phases of flight test, the flight parameters recorded during the launch showed no significant influence on the aircraft due to flight and launching the products, mounted on launching stations 1 and 2.
3. Integrated avionics and weapons system behaved according to the normal operation documentation of IAR 99 SOIM and MiG-21 Lancer aircraft, for the mode used to launch products.
4. All of the products launched by aircraft separated normally from hardpoints, were stable on the trajectory, the warheads were armed normally on the trajectory and have worked in accordance with technical specifications, so all technical and performance parameters were fulfilled.
5. Operational tests to verify operational performance on launch air-to-air missiles type 2 Magic have shown that TPDM-01M product can be discovered, aimed and followed by missiles, missiles launch

is running normally and they are directed toward the target.

6. Tests have achieved the objectives, the results have provided the information necessary for validate product configuration and validate new aircraft configurations used during testing and have allowed validation of the procedures for on ground and in flight operation of these products.