Integrated Electronic Warfare Framework for Infrared Self-protection of Transport Aircraft

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***Abstract* - In the African scenario, slow-moving airborne platforms such as transport aircraft have in recent years come up against a wide variety of threats, including several generations of man-portable surface to air missile systems (MANPADS or SAMS). With South Africa's role in the AU and NEPAD it has been widely accepted that support for UN-Sanctioned missions such as regional peacekeeping efforts, election support and the rendering of medical assistance, or the supply of food to isolated areas will become normal day-to-day events for military personnel and assets. This paper details the development over the past 15 years of an Infrared Electronic Warfare capability that makes use of integrated field evaluations and simulation to continuously evaluate and optimise the self-protection strategies of the South African Air force's transport aircraft.**

Fig 1 Infrared Shoulder Launch MANPAD

I. INTRODUCTION

You don't know what you don't know, and you don't know until you measure is a typical belief held amongst most Electronic Warfare specialists. Measurements during field tests, camps and training sessions and comparison to a predetermined baseline were considered the best method of optimising aircraft operating procedures against threats.

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These exercises would inevitably result in the deployment of aircraft and personnel engaged in the dispensing of various countermeasures in order to evaluate effectiveness.

The CSIR, in its role as a national Defence Research and Evaluation Institute, was tasked with finding solutions to the protection of South African Air force aircraft against Infrared guided threats.

II. DEFINING THE FRAMEWORK

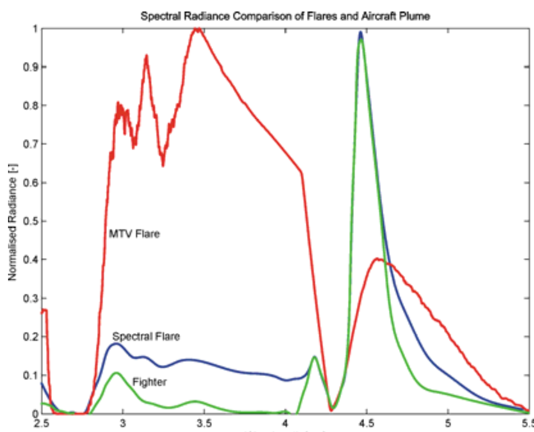

Fig 2 Spectral radiance comparison of countermeasure and aircraft plume

The first concerns, within the above scenarios, were raised around the verified effectiveness of traditional countermeasures and doctrines against IR Surface to Air missiles, given that 80% of all transport aircraft were brought down by the man portable shoulder launched variants in all recent conflicts.

In order to evaluate, objectively, the vulnerability of aircraft to the threats, a series of steps has to be taken, ranging from measuring the aircraft and environment, developing a detailed understanding of the threats (involving them in operational testing) and measuring the countermeasure and the doctrines in which they are employed.

With the introduction of IR thermal radiometers (Fig 3) it was possible to perform measurements and analytical calculations of

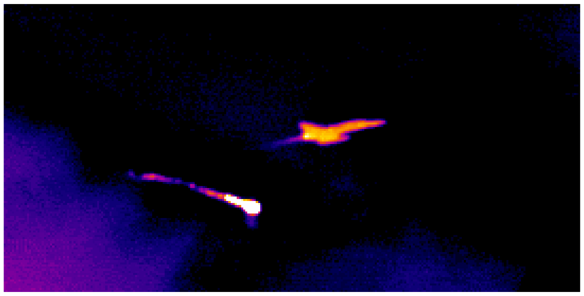

Fig 3 Thermal image of aircraft and countermeasure 3-5um

aircraft signatures, flares and backgrounds, and determine the signature vs. flare intensity to calculate a J/S ratio [1], [2] (the ratio of countermeasure energy to aircraft signature energy) (Fig 2) [5].

The key question however, revolved around how the threats could be included in a safe manner into the field exercises as the ultimate would be to test the effectiveness of flares against the actual missile threats.

The requirement led to the CSIR developing a process for aircraft self protection that involved missile instrumentation exercises and the development of an IR mobile laboratory (IRML) that would bring the threats in a controlled manner to the field test and evaluation exercises.

The IRML is a containerised field laboratory that integrates IR radiometers, instrumented missile systems and high fidelity data capture systems developed and optimised at the CSIR over many years, and has proven invaluable in the field evaluation of aircraft IR self-protection. These systems working in unison provides a skilled person with the necessary data to evaluate the survivability of the aircraft with its self protection suite and doctrine, and to make suggestions on improvements.

III. MODELLING AND KNOWLEDGE MANAGEMENT

However the teams involved in this area of research realised there was the potential for major value addition into this process. Large amounts of data were being gathered during these field trials and captured in the forms of reports, pictures and figures, and data tables. With the growth in simulation concepts and software rendering techniques, there was a new way of capturing the valuable data being collected; in the form of models, and a closed loop approach of measurements, analysis, and simulation was defined.

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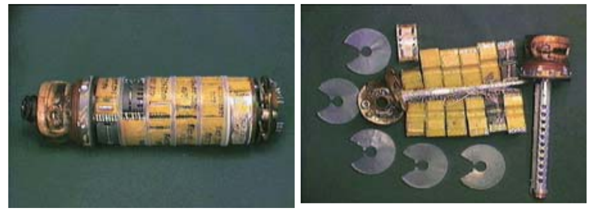

Fig 5 Electronics of IR Missile Seeker

The process of instrumenting the missile systems for integration into the IRML (Fig 4) presented the opportunity to capture the essence of their operation in models. Measurements of aircraft provide valuable data as to the nature of their IR signatures and the contributors to these signatures and could thus also be modelled. Due to the fact that these models were generated from actual IR measurements in the field and the laboratories they are classified as “real or high fidelity models” operating at the signal level.

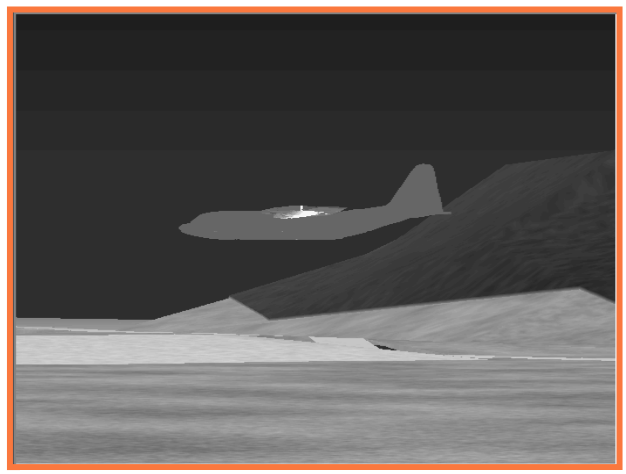

Fig 4 Synthetic IR image generated in computer simulation

The next challenging step involved using the environment measured data and understanding of radiometry to create a synthetic world [3], [6], radiometrically accurate in its physical representation. Software engineers, borrowing from work performed in computer graphics and gaming developed a virtual 3D IR world into which the models could interact (Fig 5), thus providing a level of testing, simulating, and evaluating resulting in significant cost and equipment lifetime.

The suite of simulation tools developed by the Electronic Warfare engineers and scientists opened up new areas of research in the areas of simulation, 3D computer image rendering, atmospheric physics and radiometry, computer systems and architectures in order to meet the requirements of the models and the desire to ensure that reality was accurately represented [3], [4].

A model creation and verification process was developed and fine tuned using tools and methods derived from the original measurement techniques. The IRML was upgraded to digital networks which enabled more data to be collected to validate model behaviour until confidence in its execution was achieved.

Detailed test points could now be simulated prior to field tests to predict behaviour of the aircraft and threats. Various countermeasure techniques that would require intensive flight clearance could be checked for effectiveness before involving any actual operational equipment or operators. Doctrines could be fine tuned and developed in a safe risk free environment. Flight trials became more than just trial and error exercises but enriched and rewarding exercises, as just the most promising options could now be evaluated.

IV. CONCLUSION

A part of the CSIR's technical advisory role to the SANDF is to assist in the setting up of specifications. By understanding the missile threat, the basic requirements for effective countermeasure performance specifications could be defined. Now however fine nuances in the threat operation and behaviour could be investigated more thoroughly. It became possible to identify in detail the reasons why certain countermeasure types and doctrines were ineffective. The simulation capability, together with the test and evaluation tools enables the CSIR to objectively examine products and to comment on their suitability or adaptability for the South African environment.

With the confidence in the simulation system, and the fidelity of the environments being rendered growing, new opportunities for the capability arose. This involved real-time hardware in the loop simulation using flight motion simulators to better characterise missile flight dynamics. The need to perform these simulations led to the requirement for wind-tunnel measurements and the development of higher fidelity models, for more effective threat behaviour representation.

More importantly, deviations in behaviour between the models and real systems were now captured and analysed to improve the fidelity of the models or the rendered environment.

The models have become knowledge repositories that grow with the data gathered, while skills and understanding of the subject of IR Electronic Warfare is deepened through the closed loop measurement, simulation and analysis process.

The CSIR team, with this innovation in creating an integrated capability, is a leading Infra-red electronic warfare centre, providing repeatable results taking all parameters into consideration to provide our DoD with the ability to evaluate options in a systematic and traceable manner such that solutions to a very important problem can be found.

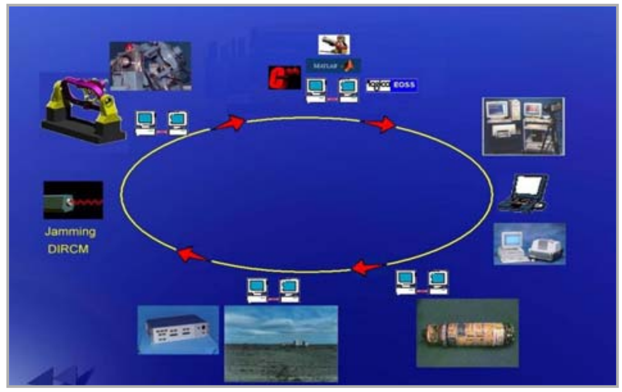

Fig 6 Integrated Infrared Electronic Warfare framework

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