) INTEGRATED AIR AND MISSILE DEFENCE

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TNO innovation for life

The objective of this TNO research programme is to build up, improve and broaden knowledge, know-how and infrastructure (software tooling, methodologies) about Integrated Air and Missile Defence (IAMD). The main research topics are focussed on Counter Rockets Artillery and Mortars (C-RAM), Long Range Ballistic Missile Defence (LRBMD) and defence against both improvised air threats and weapons of mass destruction.

This continuing effort of maintaining and expanding its knowledge base gives TNO the ability to support the Netherlands Armed Forces on policy development, procurement and exploitation questions and on joint and combined integration processes.

QUESTIONS

Considering the knowledge and operational needs mentioned above, the following underlying questions provide an indication of the program's direction:

- What are the implications of the evolved threat, such as long-range ballistic missiles (LRBM), very short range missiles (C-RAM) and improvised air threats, for the current NLD air and missile defence systems?
- Which future technological developments are important for the air and missile defence community?
- Considering the current operational defence systems, future modifications and future technological developments, how can the total system (weapon, sensor and command & control) effectiveness be determined?
- How can the joint NLD air and missile defence capability be optimized and what are the conditions and limitations with regard to combined operations?
- How can a priori knowledge or models of consequences of engagement/intercept be used in the planning and operational process to minimize casualties and damage on the ground?
- How can the TNO simulation suite JROADS be further developed and improved so that analysis on relevant NLD air and missile defence missions against the evolving threat can be performed?

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TNO

TNO is an independent innovation organisation. TNO connects people and knowledge to create innovations that sustainably boost the competitive strength of industry and the welfare of society.

TNO focuses its efforts on seven themes including Defence, Safety and Security: TNO focuses on a safe and secure society by creating innovations for people working in the armed forces, law-enforcement agencies, emergency services and industry.

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INTRODUCTION

The multi-year TNO research programme is one of the driving forces in the Netherlands (NLD) in IAMD developments for the coming years. The current NLD air and missile defence systems are capable to defend against conventional air threats, cruise missiles and short and medium range ballistic missiles. However, since nations and expeditionary forces around the world are confronted more and more with long-range ballistic missiles (LRBM), improvised air threats and very short range missiles (Rockets Artillery and Mortars), it is imperative to focus research on these topics as well.

BACKGROUND

TNO has a vast experience in IAMD and has expertise in analysis of Air and Missile Defence related questions for the Netherlands Armed forces, NATO and International Working Groups (e.g. MST support to NATO Study Support Group and NATO Missile Defence Project Group) and international governments and industry. Examples of national studies are: requirements formulation for the NLD Air Defence Command Frigate (ADCF), hard and soft kill analysis for naval operations in a littoral environment, Patriot effectiveness analysis and Patriot missile mix studies.

In the NATO ALTBMD programme TNO is the strategic partner for the NLD contribution to the Integration Test Bed (ITB),

comprising of simulated representations of the NLD Patriot and the NLD Air Defence Command Frigate. On the industry side, TNO is a member of the TeamSAIC consortium which has been contracted to support the integration of the ALTBMD programme. In that programme sensors and weapons systems now available, or coming online soon, are connected into an architecture that is based on the new command system for NATO air operations (NATO ACCS) in order to protect deployed forces from short range missiles and air breathing targets. TNO also has significant experience in Exercise Support and Live Firing Analysis. An example is TNO's participation in the multinational exercise Joint Project Optic Windmill (JPOW), where TNO has supported both the Netherlands and Italian Armed Forces in Modelling & Simulation Support, Training & Evaluation, Hardware-In-The-Loop Architecture Integration and After Action Analysis. Another example is TNO's leading role in the Joint Combined Analysis Team of the

TNO has developed a comprehensive software suite, JROADS, which can be used for all aspects of IAMD simulation: from very detailed analysis studies to planning, training and exercise & experimentation support. All elements that play a role in the detection, identification and intercept of enemy missiles and air breathing targets are brought together in the simulation tool

politico-military exercise Nimble Titan.

suite. Examples of the different elements that are integrated in JROADS are: identification of the missile using the infra red signature of the plume, decoys and debris behaviour, consequences of an engagement including possible contaminated areas on the ground and defence design and planning including optimising protection levels.

Thanks to this track record, TNO has the availability of skilled personnel with exhaustive knowledge in the Air and Missile Defence domain.

COUNTER ROCKETS, ARTILLERY & MORTARS (C-RAM)

Very short range missiles are a realistic threat in expeditionary operations. This research topic is focussed on Rockets, Artillery and Mortars (RAM). TNO will analyse and model future technological developments and possible courses of actions. Furthermore, TNO will investigate how the current NLD weapon systems could be able to defend against RAM threats and how new concepts and additional capabilities could contribute. The integration of maritime and land forces will also be considered. To minimize the consequences of the intercept on the ground. Insight in the engagement opportunities of the weapons could lead to an engagement procedure where the effects on the ground are minimized

) POWERFUL SIMULATION TOOLS



IMPROVISED AIR THREATS

Improvised air threats, such as small Unmanned Aerial Vehicles (UAV's) or renegade aircraft (hijacked or with unknown intent), are the focus of this research topic. The aim is to obtain more insight/understanding in the way how these threats could be used and deployed. In this study the technological trends of these threats for the period 2015-2020 will be investigated. Typical design issues, such as the flight performance, range, altitude and possible payloads are examined. Concerning renegade aircraft TNO will analyse the effectiveness of existing weapon munitions to disable the target and to minimize the consequences of the

intercept on the ground. Insight in the engagement opportunities of the weapons could lead to an engagement procedure where the effects on the ground are minimized.

LONG RANGE BALLISTIC MISSILE DEFENCE

The main focus of this research topic is Consequence of Engagement (COE) / Consequence of Intercept (COI) concerning LRBMs. An important aspect is to develop a debris prediction and planning tool to analyse the debris after intercept. Furthermore, the research will focus on how to predict the consequences after intercepting a biological or nuclear payload.



Using sensor technology methods for the purpose of threat typing will also have an important role. In addition it will be

INTERNATIONAL COOPERATION

Since Integrated Air & Missile Defence is predominantly a joint and combined effort, international cooperation between knowledge institutes, companies and organisations is of paramount importance. Only by working together, joining forces and exchanging research results, significant added value can be created. TNO has been working together in the past combining research with various international partners, such as the UK Missile Defence Center, TMS (Germany), Bruhn Newtech (Denmark), FFI (Norway) and DSTO (Australia). In the current programme, TNO is actively pursuing international cooperation in the research areas long-range ballistic missiles defence, defence against very short range missiles (C-RAM) and defence against improvised air threats. investigated whether fifth generation fighters can have an active role in IAMD, where the accent will be put on (infrared) sensor capabilities, early warning and shooter capabilities.

JOINT & COMBINED OPERATIONS

This topic will explore technical integration of landbased and seabased IAMD systems in a joint and combined capability. Specifically it will be investigated what the requirements should be for exchanging data on plot level and how new data-protocols could be implemented in IAMD operations. Also insight in the opportunities for the NLD IAMD systems to fulfil a multi mission role will be examined (Air Traffic Control, C-RAM, Air Defence). The development and expansion of JROADS models is foreseen within this research topic to support research programme as a whole.

