SAND2015-10710R

Project Accomplishment Summary

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Sandia National Laboratories
Operated for the U.S. Department of Energy by
Sandia Corporation
Albuquerque, New Mexico

PROJECT ACCOMPLISHMENTS SUMMARY

Cooperative Research and Development Agreement (#1573.101.00)

between **Sandia National Labs** and **Lockheed Martin Corporation Missiles and Fire Control**

Note: This Project Accomplishments Summary will serve to meet the requirements for a final abstract and final report as specified in Article XI of the CRADA.

Title: HTK Lethality Analysis CET

Final Abstract:

Sandia National Laboratories (Sandia) and the Lockheed Martin Corporation (LMC) collaborated to establish performance of the hit-to-kill lethal mechanism compared to other interceptor kill mechanisms. Multiple eulerian shock physics and couple shock physics/structural simulations were performed to evaluate the performance of two interceptor kill mechanisms – hit to kill and blast fragment – against a conventional target. These simulations showed each kill mechanism's advantages and disadvantages. Sandia/DOE benefitted by exercising the Sandia-developed computational codes with scenarios that had not been simulated before, providing insight and experience with highly relevant and timely intercept scenarios that will be representative of future work. LMCO benefitted by the experience using the coupled code which they acquired from SNL. They also were provided data that was relevant to interceptor systems being considered and in development. The public benefitted by providing information that will be useful in choosing an interceptor system that will be used for national defense at lower cost than relying solely on an extensive testing program.

Background:

Prior to the initiation of this project, the state-of-the-art of the process was to apply eulerian shock physics codes to the class of interceptor/target engagements. This process, while state of the art up to a few years ago, was limited in that structural response and debris propagation was not included in lethality simulations and consequence of intercept considerations; i.e. collateral effects on the ground. The former can increase the assessed lethality performance of an interceptor system while the latter can be used as a metric in assessing overall performance. SNL has been a pioneer in developing coupled shock physics/structural codes for weapon ground penetration that has been applied to missile defense scenarios. SNL has also developed post-processing tools, which are used to describe debris generated from an impact simulation which can then be used to fly the debris to the ground. LMCO used their missile flyout codes and trajectory analyses to provide likely intercept conditions for the impact simulations. They also used the trajectory codes to fly the debris to the ground, showing laydown for consequence of intercept considerations.

Description:

The purpose of the project was to establish performance of the hit-to-kill lethal mechanism compared to other interceptor kill mechanisms. LMCO provided the intercept conditions for both a hit-to-kill and a blast/fragmentation kill vehicle using their missile fly-out codes to determine likely and extreme engagement conditions. The hit-to-kill and blast fragmentation interceptor designs were also provided by LMCO. SNL then evaluated the lethality performance of each interceptor and engagement condition using both the shock physics code CTH and the coupled code Zapotec. The evaluation was based on the fraction of the target payload rendered ineffective. CTH provided a quick assessment of lethality performance while Zapotec provided the more detailed performance that included structural rather than overpressure

kills. CTH also provided insight into the response of the target materials that allowed the Zapotec simulations to be run more quickly without degradation of the confidence in the results.

This was the first time that Zapotec was used to simulate a large interceptor against a large target. In order to do so, the code was used in a mode uncharacteristic of uses in the past – both the interceptor and target were modeled as Finite Element Models and the localized highly deformed debris due to the impact was modeled with the shock physics code. Prior to this, the interceptor, the majority of which would be highly deformed at impact, would be modeled with the shock physics code. This allowed the simulation to run more efficiently and with more detail. Zapotec simulated the effects of the intercept on the target long after the CTH simulations can. During this time, debris interaction and structural response provides the opportunity for the target to break up further, capturing the enhanced lethality effects of the impact. Post processing tools provided debris information that, after being analyzed by LMCO with their tools that propagate the debris through the atmosphere to the ground, was used to predict areas affected on the ground by both the remaining effective payload and inert debris. This information can be used to determine if the mission of the target was thwarted and the threat to areas outside the defended area.

Benefits to the Department of Energy:

The Zapotec code was employed for impact conditions beyond for what it was used previously. The experience and techniques developed during this project have greatly enhanced the utility of Zapotec for missile defense lethality and consequence of intercept. An unanticipated benefit is that using the Zapotec code run with Finite Element descriptions of the interceptor and target could improve predictions of post intercept scenes observed by remote sensors. These are all benefits to the WFO programs involved in Missile Defense. While the target in this project was a conventional rather than nuclear target, the techniques in assessing the lethality of the intercepts can be applied to nuclear targets as well. The experience with the use of the both CTH and Zapotec are also applicable to detection of nuclear detonation with the post engagement scene predictions and in stockpile stewardship with increase utility of the computational codes used for that purpose.

Economic Impact:

The results of the project are applicable to current acquisition programs within DoD for Missile Defense. Comparing the lethality performance and consequence of intercept of systems with different kill mechanisms will aid DoD program leaders in selecting the right interceptor system for their applications. One system in the near term for which this will likely be useful is the selection of a system to protect aircraft carrier assets and offshore defense of ports and landings. Since test programs can cost in the hundreds of millions for single missile flight tests, preliminary work to reduce the need for that testing can mean significant reduction in costs.

Project Status:

The project completed its objectives and the results were reported to LMCO in 2/2012. However, the utility of Zapotec for use in missile defense applications was recognized by LMCO and a request was made for the code to be provided to LMCO Missiles and Fire Control in Grand Prairie, TX. The companion CRADA 1573.101.00 was extended to 12/2012 in order for SNL to provide support to LMCO to implement Zapotec and apply it to missile defense problems.

ADDITIONAL INFORMATION

Laboratory/Department of Energy Facility Point of Contact for Information on Project

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CRADA Intellectual Property

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SNL:
SCR698.0: "Zapotec Ver. 1.0." Author(s): ATTAWAY,STEPHEN W.; BELL,RAYMOND L.; BESSETTE,GREGORY C.; GOUDY,SUE P.; VAUGHAN,COURTENAY T.; SILLING,STEWART A.; YARRINGTON,LANE; YARRINGTON,PAUL; KOTERAS,JAMES R.

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LMCO:
Patent Number 5,358,912 - Radome Materials
Patent Application Number PCT/US07/74001 - Device for Penetrating and Exploding a Target

Technology Commercialization

None

Project Examples

Classified briefings are available.

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between **Sandia National Laboratories** and **Lockheed Martin Corporation Missiles and Fire Control**

This summary has been approved for public release by Sandia and Lockheed Martin Corporation Missiles and Fire Control

Sandia National Laboratories

By _____ 7/2/13
Robert J. Weir — Date
Principal Investigator

Sandia National Laboratories

By _____ 9.4.13
Manager — Date
WFO/CRADA Agreements

Lockheed Martin Corporation Missiles and Fire Control

By _____
Title: — Date

In order to expedite the process, if we do not receive your signed reply by 08/17/2013 we will assume your concurrence for the release of this document to the public.