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ISSUEBRIEF

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Universal Data Fusion: Enabling Cost-effective US/Russia/NATO Cooperative Missile Defense

As the proliferation of more capable missiles that threaten regional populations, governments, and commerce continues over the twenty-first century, so does the need to counter and disincentivize this proliferation with effective and affordable regional missile defenses. Missile defense systems are among the most expensive military capabilities, but their costs can be dramatically reduced, their performance improved, and geopolitical pressure increased if the United States, Russia, and NATO deployed systems cooperatively.

Aside from well-known political obstacles outside the scope of this brief, the key technical hurdle is the ability to universally fuse the missile tracking data from all available sensors while at the same time reducing the risks inherent to multinational collaboration and data sharing in the digitized battle domain. A window of opportunity currently exists to adopt missile defense sensor data standards to enable cost-effective development of universal data fusion devices for all missile defense systems on the international market. Europe is the ideal region to implement universal data fusion given US, Russian, and NATO proposals to explore cooperative missile defense.

Militaries, governments, population centers, and global commerce are increasingly vulnerable to the more accurate, faster, and longer-range missiles having proliferated in the international arms market. Their possession can be a source of regional instability that is disproportionate to the military power smaller countries or transnational terrorist groups typically possess. Unfortunately, few countries will be able to afford to counter with equivalent inventories of missile defense systems. Therefore, the viability of achieving cost-effective missile defenses depends on the willingness and technical ability of like-minded nations to share the cost through cooperative deployment.

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When there is an established, unified military command structure, integrated missile defense (where a central command directs the engagement of each attacking missile) offers the most effective use of available assets. The integrated command and control of NATO and US missile defense systems is being developed under the NATO Active Layered Theater Ballistic Missile Defense (ALTBMD) program by the end of this decade. However, while ALTBMD correlates the sensor tracking data and will provide direct command and control of the integrated NATO architecture of participating missile defense systems, it will not fuse the data of all cooperative missile defense systems and sensors deployed in a region by nonmembers of the Alliance.[1]

When countries have common strategic geopolitical and military objectives, but do not agree on a unified military command structure, cooperative missile defense improves the net effectiveness of a combination of autonomous missile defense systems. The United States, Russia, and NATO have a proven record of cooperating in these circumstances. The United States and Russia shared the burdens of defense in the 1940s through the lend-lease program in World War II and as recently as the 1990s in Bosnia. As stated by Colonel General Leontiy P. Shevtsov, Deputy to the Supreme Commander of the Stabilization Force (SFOR) in Bosnia in 1997, "the joint operation carried out by Russia and NATO shows that we can work together and achieve peaceful goals through military cooperation."[2] That pursuit of cooperation was extended to missile defense in 2002 with the inauguration of NATO/Russia missile defense studies and Theater Missile Defense Exercises.[3] At the November 2010 NATO summit in Lisbon, Russia further approved the involvement of their technicians in the planning and development of a European regional missile defense system. However, President Dmitry Medvedev cautioned that missile defense cooperation must be a "strategic partnership between Russia and NATO." As more countries develop and acquire missile defenses, partnerships are not only conducive to geopolitical viability, but also are a practical necessity for cost sharing.

While US, Russian, European, and other governments consider the geopolitical and operational aspects of cooperative regional missile defenses, industry could take meaningful steps to significantly ease the technical challenges of that cooperation. Fortunately, classical physics makes the task of cooperative ballistic missile defense much simpler than cooperative air defense which has been successfully implemented for decades.[4] While many companies have shown the ability to integrate their own missile defense products, they have not previously been expected to produce missile defense systems that can universally fuse data from any available sensor (regardless of the type, manufacturer, or country of ownership) deployed in a region. If steps are taken now, missile defense systems could be adapted to use universal data fusion to enhance their performance with all available deployed assets. Missile defense systems designed to work universally with other manufacturers' systems or components eliminate the need for a country to commit to a specific manufacturer's architecture, and thus, would be very attractive to international markets. The fact that many countries are acquiring new or upgrading existing missile defense systems during the remainder of this decade indicates that now is the opportune time to implement universal data fusion for missile defense.

Benefits of Universal Data Fusion for Missile Defense

There are many advantages for countries using sensor data fusion for missile defense cooperation. By sharing early attacking missile tracks from sensors closer to where the missile was launched, the area defended can be greatly increased. Additionally, earlier tracking of attacking missiles can increase the number of threat missiles in flight that can be simultaneously destroyed. Furthermore, earlier tracking of attacking missiles increases the number of shot opportunities available to destroy attacking missiles during flight (thus, greater probability that all missiles in a threat

1 John F. Morton and George Galdorisi, "Any Sensor, Any Shooter: Toward an Aegis BMD Global Enterprise," *Joint Force Quarterly* 67, (Fourth Quarter 2012), http://www.ndu.edu/press/lib/pdf/jfq-67/JFQ-67_85-90_Morton-Galdorisi.pdf.

2 Colonel General Leontiy P. Shevtsov "Russian-NATO military cooperation in Bosnia: A basis for the future?" *NATO Review* 45, no. 2 (March 1997), 17-21.

3 See "NATO-RUSSIA Council Practical Cooperation Fact Sheet," November 2012, 7, http://www.nato.int/nato_static/assets/pdf/pdf_2012_11/20121204_121128-NRC-factsheet.pdf.

4 The estimated trajectory of a ballistic missile can be accurately predicted using Kepler's laws and classical orbital mechanics. Therefore, fewer and less-frequent sensor updates are required for tracking missiles than aircraft. According to classical orbital mechanics, an accurate prediction of the trajectory of a ballistic missile can be based on seven parameters: three location coordinates in a common coordinate system, three momentum vectors, and the time of the observation.

Figure 1: Basic missile defense functions.

Figure 1.A

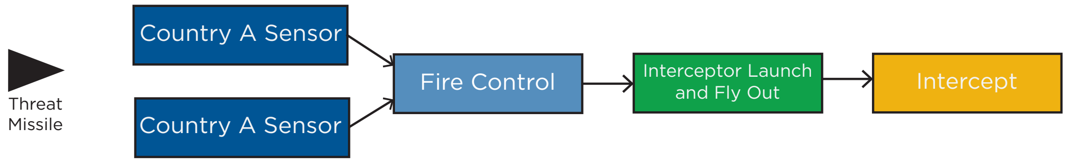
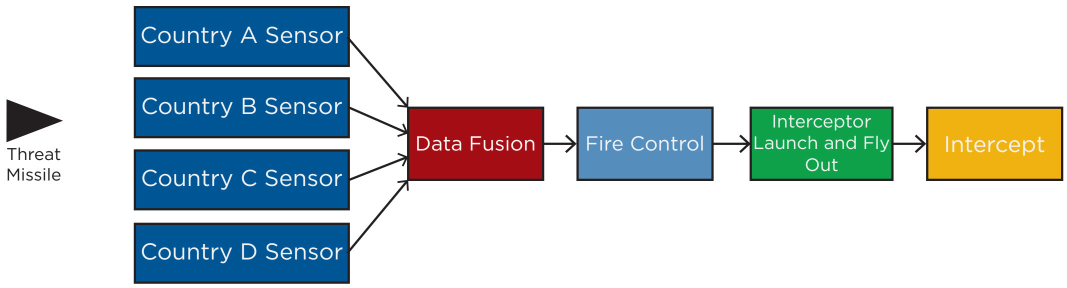


Figure 1.B



missile raid will be destroyed). Finally, earlier tracking of attacking missiles increases the ability to destroy attacking missiles at longer distances from the areas being defended. Against more sophisticated threats, the use of multiple, dissimilar sensors makes the attackers' effective use of countermeasures more difficult. These advantages extend to all intermediate-, medium- and short-range ballistic missile (IRBM, MRBM, and SRBM respectively) threats, which define regional missile defense scenarios.

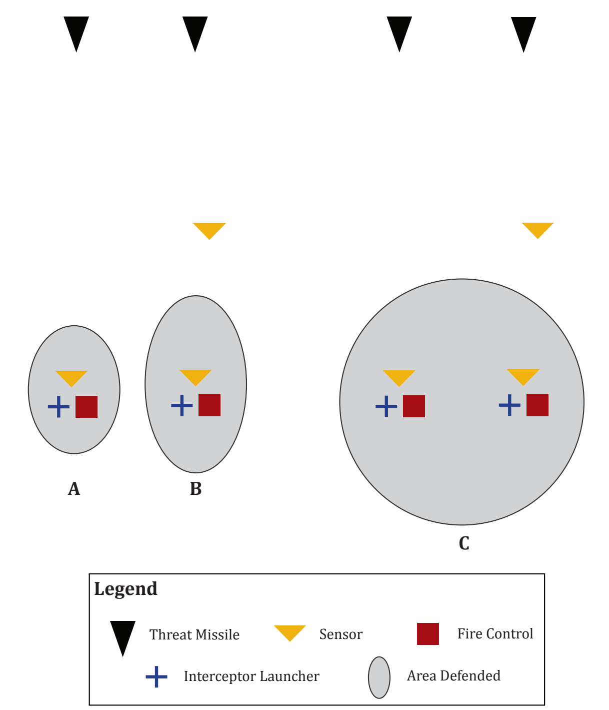
Figure 1 shows simplified missile defense functions for autonomous and cooperatively deployed missile defense systems. The autonomous systems (figure 1.A) rely solely on the threat missile tracking data provided by the sensors directly linked to their respective missile defense system. The cooperatively deployed systems (figure 1.B) perform the same functions, but the fire control function is performed using data that has been fused (or combined) from the input of all available sensors (including those deployed with other systems).

Figure 2 (next page) shows the geographical relationship between the location of missile defense components and the relative size of the area defended against a missile attack. Figure 2.A depicts the defended area of a notional autonomous missile defense system. Figure 2.B shows the relatively larger defended area when a forward-based surveillance sensor is added. Figure 2.C shows the increase in defended area by cooperatively fusing the data between the two systems.

The magnitude of the benefits of cooperation depends upon the extent to which participating countries are willing to use data from other cooperating missile defense systems. The simplest form of data fusion is to manually pass detection and track information between military staffs via voice links from non-collocated sites. Ballistic missiles, especially MRBMs with flight durations of around twenty minutes, follow predictable trajectories. Therefore, simply passing early detection and track (or "cueing") data from sensors that are closer to the launch location of a threat missile will alert a cooperating missile defense system that is closer to the intended target. The earlier notification of an incoming threat missile on a specific trajectory will allow the cooperating missile defense system to launch its interceptor sooner, thus extending the forward area that it can defend.

Collocating military staffs that manually transfer missile tracking information would provide the added benefit of developing an understanding of the operational characteristics of each other's missile defense systems. It would facilitate joint planning to maximize the area protected by the combined systems and the level of protection of prioritized facilities and assets. Furthermore, if the participating countries agree to allow their military staffs to manually coordinate their engagements, the missile defense

Figure 2: Missile defense asset relative geometries and defended areas.



system with the best geometry for a successful intercept and greatest inventory of interceptors could be assigned to intercept each threat missile. This would increase the number of threat missiles in flight that can be destroyed and improve the probability of successful intercepts. It would also more efficiently manage the inventory of interceptors consumed in a battle.

A higher form of cooperation is using automated transfer of missile tracking data between participating missile defense systems. The increase in the number of threat missiles that could be simultaneously engaged would enable defense against larger-sized missile raids. Automated transfer of data would also further extend the range that threat missiles could be engaged by enabling interceptors to be launched earlier in threat missiles' trajectories.

In cases where large missile raid sizes are a concern, such as the vulnerability of NATO and Russia to missile raids from the Middle East, the greatest benefit of automated sensor data fusion centers would be derived by real-time coordination of threat missile engagements. By knowing the real-time results of an attempted intercept of a threat missile, missile defense systems could utilize a combination of interceptors from cooperating missile defense systems to attempt subsequent intercepts. By increasing the number of shot opportunities to destroy threat missiles during flight, the probability that all missiles in a threat missile raid will be destroyed increases. Additionally, the combined inventory of NATO and Russian interceptors could be managed to minimize the risk of expending all interceptors defending a single high-value target where the threat has concentrated its missile attacks. At the highest level of cooperation, the engagement logic of cooperating missile defense systems could be automated to ensure each missile defense system takes maximum advantage of the other systems' sensor data and interceptor launch reaction times to counter multiple large raid-sized attacks.

Safeguards

Participating countries must agree to ensure transparency and cybersecurity of the automated data transfer mechanisms before they can utilize automated sensor data fusion capabilities. Data provided by a cooperating sensor can be screened to verify its trustworthiness before being utilized by a missile defense fire control system. Rejecting external sensor data or suddenly losing access to external sensor data will not degrade the original autonomous performance of a cooperating missile defense system.

Technologies now exist to allow the automated transfer of threat missile track data between missile defense systems in a secure fashion without risking one system contaminating the software of another system or exposing either system to a cyberattack. An IRBM or MRBM engagement timeline allows the tracking data from one country's system to be printed in tabular form and then optically scanned by a second country's system, thus allowing the automated transfer of data without requiring the exchange of electronic data packages. This "air gap" between the missile defense systems would facilitate the transparency of the information transferred while ensuring a verifiably high level of cybersecurity.

Although data could be automatically transferred between missile defense systems, this would not compromise the authority and autonomous control that cooperating countries would have over their own missile defense systems. Universal data fusion does not unify the command and control of missile defense systems. Rather, it optimizes the combined autonomous performance of cooperating systems.

Window of Opportunity

Recent technical achievements and the announced plans of the United States, Russia, France, Germany, Italy, Japan, and other countries interested in missile defense, makes now the optimal time to implement universal data fusion in missile defense systems. The ability to exploit data from dissimilar but cooperative missile defense systems is most efficiently incorporated as early as possible in the development process. The implementation of universal data fusion now will maximize the opportunity for cooperative US, Russian, Japanese, and European missile defense systems being developed or upgraded during the remainder of this decade.

The United States has repeatedly demonstrated sensor data fusion techniques to enable autonomous missile defense systems to use the data from different types of available sensors (regardless of manufacturer) to provide accurate midcourse tracking data. In March 2011, the United States destroyed an IRBM in flight with a short range Navy Aegis system consisting of a S-Band fire-control radar and a SM-3 1A interceptor (originally designed to only counter SRBMs) using fused early track data from a forward-based X-band radar that was located over 2,000 kilometers closer to the target IRBM launch site. In February 2012, the United States destroyed an MRBM in flight using another short-range Navy Aegis missile defense system, but this time using early track data from infrared tracking sensors on board a pair of orbiting satellites.

The Russians continue to develop more accurate, lethal, and effective anti-SRBM and anti-MRBM missile defense systems. The capability of the S-300 air defense system[5] varies greatly depending on the variant. However, the 1997 upgrade to the S-300 PMU-2 missile defense system provided effective antiballistic missile capability against SRBMs and some MRBMs, with lethality and range roughly equivalent to the PATRIOT PAC-2 and Aegis SM-2 interceptors. The Russian S-400,[6] originally deployed in 2006, has a planned upgrade for "hit-to-kill" kinetic lethality (where the interceptor collides with the threat missile similar to the THAAD system) by 2018.[7] The Russians also continue to develop the S-500 missile defense system[8] with projected capability that is similar to the Aegis SM-3 IIA interceptor that is currently being cooperatively developed between the United States and Japan. Additionally, the Russians are upgrading several mobile phased array surveillance and mid-course missile tracking radars and will soon have a new generation of long-range missile tracking radars operational in the near future.[9]

Europeans have also advanced their missile defense capabilities with the production decision in 2010 to upgrade the French SAMP-T air defense system and the Aster-30 interceptor with anti-SRBM capability similar to the US PATRIOT PAC-3 air defense system.[10] Additionally, the French have recently initiated the development of the Aster-30 block 2 with SRBM and MRBM capabilities similar to the US THAAD system.[11] Moreover, MBDA-Italy and MBDA-Germany have developed state of the art X-band fire control and UHF extended-range surveillance radars as part of their contribution to the MEADS program.

Steps to Develop Universal Missile Defense Data Fusion

The steps to implement universal sensor data fusion are dependent upon the participating countries' expectation of the level of mutual cooperation. The simplest form of data fusion is sharing only the approximate sensor picture and status (i.e.,

5 Original S-300 versions were anti-aircraft with a fragmentary blast warhead with a proximity fuse. S-300 variants were designed by subsidiaries of Almaz-Antey: NPO Almaz (lead designer), NIIP (radars), MKB Fakel (missile designer), and MNIIRE Altair (Naval versions) and produced by JSC Kalinin Machine-Building Plant, ZiK. The upgraded S-300 PMU-2 (1997) has capability similar to the US PATRIOT system. See Jane's, http://www.janes.com/products/janes/defence/det-modules/weapons.aspx.

6 "Russian S-400 Triumf Air Defense System," *RIA Novosti*, last modified June 19, 2013, http://en.rian.ru/infographics/20120824/175413675.html.

7 Martin Sieff, "Russian S-400 air defense system may be world's best," United Press International, December 31, 2008, http://en.rian.ru/military_news/20110408/163433985.html.

8 "Russia Eyes 2016 Fielding of S-500 Antimissile System," Global Security Newswire, June 28, 2013, http://www.nti.org/gsn/article/russia-eyes-s-500-antimissile-system-will-be-available-3-years/.

9 "Two New Russian Radars to Start Work Next Year," *RIA Novosti*, June 6, 2013.

10 "Aster 30 SAMPT/T–Surface-to-air Missile Platform/Terrain," *Army-Technology.com*, http://www.army-technology.com/projects/aster-30.

11 Pierre Tran, "MBDA Positioned to Score Big in 3 Deals" *Defense News*, May 12 2013, http://www.defensenews.com/article/20130512/DEFREG01/305120007/MBDA-Positioned-Score-Big-3-Deals.

the number of missiles being tracked and their approximate trajectories) between the missile defense sensors operating in the same region. While this may facilitate the deconfliction of operations, there is little enhancement to missile defense capability.

An initial step to implement universal data fusion is to formulate a mutual expectation of cooperative regional missile defense by analyzing high-level performance characteristics of potential cooperative missile defense assets. The fidelity of the analysis is driven by the technical detail that each country agrees to share and the willingness to create medium-fidelity simulations. Cooperative missile defense does not require software or hardware design data to be revealed to other participating countries. Once countries agree upon the level of data sharing and cooperation, a next step would be to exchange a functional description of each participating missile defense system. A functional understanding of the cooperative systems would be sufficient if data reporting formats and protocols are universally accepted. Participating countries can use this information to create and test prototype automated data fusion devices and to assess the appropriate modifications required to current missile defense system designs.

Regardless of the ultimate level of cooperation anticipated, the most important step in universal sensor data fusion is to agree on missile-tracking sensor data reporting formats and protocols. The resulting data fusion devices could be designed for use in either mobile or fixed site data fusion centers. As the data fusion devices are being developed, US, Russian, NATO, and other potential cooperative countries' military staffs should continue to develop tactics to optimize the benefits of cooperative missile defense. Finally, live fire exercises and flight testing of all participating missile defense systems would verify compatibility and build confidence in using sensor data fusion devices.

Applying Universal Data Fusion to the Missile Defense of Europe

Universal data fusion for cooperative regional missile defense could be applied to any region of the world to dissuade the use of ballistic missiles. European missile defense is especially challenging given the breadth and geometry of the many potential threat missile launch sites in the Middle East and North Africa. The net result of combining the current and projected US, Russian, and European missile defense and sensor systems, however, could synergistically result in an effective cooperative regional missile defense. Leveraging the combined fixed and mobile surveillance and tracking sensors across the European region makes US, European, and Russian cooperative regional missile defense clearly advantageous from a technical, operational, and economic perspective. This cooperative capability could feasibly protect European and Russian cities west of the Ural Mountains. Because of the NATO commitment to the persistent missile defense of its member countries' territories, the most cost-effective missile defense architecture is a combination of mobile and fixed missile defense sites (such as the planned Aegis Ashore sites in Romania and Poland). Aside from US, French, Italian, German, and Russian missile defense assets, the wide variety of land-based, space-based, and maritime sensors developed and possessed by other NATO nations could make additional significant contributions to the cooperative missile defense of Europe and Russia.

Conclusion: Universal Data Fusion for Europe and Other Regions

Cooperative regional missile defense would dramatically reduce the cost and synergistically enhance the effectiveness of responses to the growing proliferation of missiles in the twenty-first century. For Europe, recent US successes in fusing missile defense sensor data and the US, Russian, and European regional missile defense capabilities being developed by the end of this decade have created a window of opportunity to efficiently implement universal sensor data fusion. Thus, the initiative to create universal missile defense data fusion devices should begin now. Countries in all regions—including the Middle East and the Asia-Pacific—considering the acquisition of cost-effective missile defense protection will be attracted to missile defense systems that offer the capability for universal data fusion and the flexibility to cooperatively deploy with a wide variety of missile defense assets.

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