ADDENDUM

To: Recipients of *Protecting Commercial Aviation Against the Shoulder-Fired Missile Threat* by James Chow, James Chiesa, Paul Dreyer, Mel Eisman, Theodore W. Karasik, Joel Kvitky, Sherrill Lingel, David Ochmanek, Chad Shirley (OP-106-RC, 2005)

From: RAND Corporation Publications Department

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Re: Corrected pages (pp. xiii, 20–21)

Acknowledgments, page xiii, add the following after the second to last sentence:

Following the original publication of this document, subsequent discussions with Mr. James Peppler at the Mitre Corporation were helpful in clarifying technical issues on countermeasures.

Chapter Six, page 20, first paragraph, add the following after the sentence that ends ". . . appears contradictory":

It should be noted that the Air Force has not experienced any eye-safety incidents during employment of militarized versions of these systems and does not limit the operation of these systems in any portion of the flight regime for eye-safety reasons.

Chapter Six, page 21, third paragraph, add the following after last sentence:

It is important to consider that aircraft-based countermeasures do not typically invoke the need to include flight corridor adjustments.

We regret any inconvenience.

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Stringent requirements for the MWS are high probability of detection and high accuracy. The tendency of the MWS to generate false alarms must also be taken into account, for three reasons. The first is that false alarms could lead to laser illumination of objects other than MANPADS and thus possibly to blinding of observers on the ground (this particular example would also require a false positive from the fine tracker). Laser eye-safe ranges for the DIRCMs being tested are on the order of several hundred feet. Because this is less than the minimum range of IR SAMs, the MWS could be set to ignore objects at such close range, which should rule out damage to the unaided eyes of persons on the ground. Evidence we have received to date concerning observers using binoculars appears contradictory. It should be noted that the Air Force has not experienced any eye-safety incidents during employment of militarized versions of these systems and does not limit the operation of these systems in any portion of the flight regime for eye-safety reasons. The second reason is that false alarms lead to slewing of the turret, which may ultimately shorten the time-to-maintenance or time-to-failure of this key component. The final reason is that false alarms could set off the contingency plans of local law enforcement, airport authorities, and airliners, which will limit their effectiveness during actual firings and accumulate in cost over time. There is no way to mitigate this problem, so minimization of false alarms will be an objective in MWS design.

Optical MWS sensors fielded thus far have typically operated in the UV "solar blind" region of the spectrum. This is the UV band in which upper atmospheric ozone almost completely absorbs solar radiation. In the absence of a missile plume, the sensor can be triggered by only a few manmade and natural sources, including high-intensity lamps, aircraft afterburners, corona discharges, and lightning. Unfortunately, these sources are not rare in urban areas.

Proposals for improving the MWS false alarm rates have included emplacing the UV sensors on the ground (false alarms looking skyward are presumably lower); adding a different phenomenology detector, such as a Doppler radar or one-color mid-wave IR (MWIR) sensor; or replacing the UV detector with a two-color MWIR detector. MWIR sensors employing large focal plane array (FPA) detectors are on the verge of supplanting UV MWS systems on the next generation of fighter aircraft, though MWIR false alarm rates remain a contentious subject. Manmade sources of MWIR false alarms are more numerous than UV sources, but the high resolution of FPAs may enable the MWIR sensors to kinematically discriminate the stationary sources.[4] An important advantage of MWIR is its immunity to absorption by ozone in the lower atmosphere, which can be problematic for UV sensors in the urban environment.

In addtion to fasle alarm rate issues, the sequence of events following initial detection by the MWS, which includes slewing of the turret, fine tracking, and then a dwell period to break the seeker's lock, requires that the turret focus on one threat at a time. The DIRCM has some limitations against multiple threats, and though one could equip an aircraft with multiple turrets to increase the number of near-coincident launches that can be defended, this would obviously increase installation and operating costs by nearly that multiple.

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[4] That is, use the motion of different objects relative to the airborne MWIR to determine which are actually stationary on the ground.

As with flares, laser DIRCMs are not effective against laser beam riders (for which they may only furnish a beacon), RF CG missiles, and future imaging IR seekers. Current research is exploring whether IR focal planes might be disabled or degraded with increased laser power, but this is speculative and represents a departure from the basic DIRCM concept.

To sum, a single-turreted laser-based countermeasure system would have good effectiveness against single shots by the majority of current MANPADS threat types and some dual coordinated firings but would not fully protect against all possible attacks.

High-Energy Lasers

It was recently reported in the press that Northrop Grumman's ground-based mobile tactical high-energy laser (MTHEL) test-bed has destroyed artillery shells and Katyusha rockets in flight. The rocket is almost certainly a more hardened target than a SAM, which suggests that high-energy lasers might be used to protect commercial aircraft from shoulder-fired missiles in the vicinity of airports.

A palletized variant[5] of MTHEL, called Hornet, has been proposed for a wholly ground-based defense against MANPADS. The Hornet system would include a radar air picture to designate vectors along which the laser could not fire because friendly air traffic might be in the line of sight; netted IR search-and-track (IRST) systems for acquiring and tracking SAMs,[6] and for pointing the laser; and a megawatt-class deuterium fluoride chemical laser weapon housed in a turret on the ground.

Advertised performance of a single Hornet site indicates capability to defend against salvos of three missiles out to a range of at least five kilometers, with single-missile protection out to ten kilometers.[7] Robust protection of a large airport such as Reagan National would require a minimum of three sites. This assumes flight-corridor adjustments to keep aircraft above the SAM ceiling except when required for landing and takeoff. Many more would be required without corridor adjustments. It is important to consider that aircraft-based countermeasures do not typically invoke the need to include flight corridor adjustments.

The primary advantages of HELs for SAM defense are the ability to counter every current and future seeker technology, the robustness of a lethal kill as compared to smart jamming of the seeker, and the potential for defending against a wide variety of threats, including artillery, rockets, some cruise missiles, and hostile unmanned aerial vehicles (UAVs). HELs cannot operate under all weather conditions. Conditions that render the HEL inoperative will usually deny capability to MANPADS as well, but this is not true all the time. A spatially inhomogeneous fog layer may occasionally shut down the laser while leaving an open patch in which the

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[5] That is, one packaged for installation aboard a vehicle.

[6] Including initial detection sensors onboard the aircraft would not be incompatible with the Hornet concept and might improve response time in built-up areas.

[7] Fewer missiles can be destroyed at greater distances because the dwell times have to be longer to compensate for the dissipation of energy.