

cloud cover would imply a shorter launch-delay time, it is essential to tighten the 7-km estimate before making such certain conclusions. Estimates should also be made on a more careful regional basis—a general mid-latitudes average might differ significantly from a specific estimate for Iran or North Korea.

Even if one were to accept the article authors' basic technical analysis, there is still reason to question how they translate it into judgments about North Korea and Iran. Consider the authors' first conclusion on North Korea: "Using terrestrial-based interceptor rockets to defend the 50 states against liquid-propellant ICBMs [intercontinental ballistic missiles] launched from North Korea may be feasible, but that would push the limits of what is possible physically, technically, and operationally." Presumably, that statement refers to the 10-km/s I-5 interceptor, since only that interceptor is characterized in the article as "a surface-based interceptor with a performance at the limit of what might be practical." Yet the study refutes their conclusion—twice! In its executive summary, the study states that defending against North Korea "would require interceptors with speeds of 6.5 km/s"—those would be the less capable I-4, not the envelope-pushing I-5. And further on, in the detailed discussion of North Korea, the study says "To defend [the US], the 5-km/s interceptor would have to be fired with zero decision time." That the study authors offer no technical reason to reject the zero-decision-time option presumably implies that even the rudimentary 5-km/s I-2 interceptor could do the job.

The article authors assert, "Taking all relevant factors into account, . . . we reached the conclusion that defending the 50 states against solid-propellant ICBMs, from either North Korea or Iran, would not be feasible." But again, the study refutes this claim. Regarding North Korea, a statement on page 124 says, "Even the 6.5-km/s interceptor could be used to defend" the US. And farther down that same page, "The giant 10-km/s interceptor . . . could be used with about 30 s of decision time." Neither statement agrees with the article's conclusion that no defense is feasible.

The article's pessimism with respect to solid-propellant ICBMs isn't justified for Iran, either. According to the APS study, "It appears that by

basing a 10-km/s interceptor in the Caspian Sea and a second one in Afghanistan or Turkmenistan, all 50 states could be defended" (page 94) against missiles launched from central Iran. However, the study further states, "If the launching site for solid-propellant missiles destined for [Washington, DC] . . . were moved about 200 km to the southeast, this defense would be precluded." That statement is transparently incorrect. If one extrapolates from the study's figure 5.17, the base in western Afghanistan would clearly be able to intercept effectively. Thus, the study should not be read as implying that defense against Iran is impossible.

These are technical, rather than political, reasons to question the study's overall pessimism. Still, because the study contains some optimistic assumptions that might yet be tightened, even a revised version would not necessarily conclude that boost-phase defense is possible. These persistent ambiguities warrant further study.

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The article about the APS study on boost-phase missile defense gave considerable information on the physical challenges of such defense. However, many more questions need to be asked and answered.

It may technically be possible to build a system to stop one missile, but how about 5, 10, or more? Where will those missiles be coming from? Who is going to have such missiles in quantity?

Can anyone guarantee that *all* incoming missiles will be stopped? What will such a total system cost? Are the potential lives and property saved worth that cost?

This and other space-based projects, many of which later turn out to be boondoggles, are supported by NASA, the military, and industries looking to generate job protection and company profits for years to come. The proposed manned trip to Mars, the permanent base on the Moon, the orbiting space lab now under construction, robots exploring the Mars surface, are or will be a waste of money. If water existed on Mars millions of years ago, what relevance has that to us on Earth today, or even in the distant future?

I think the excessive costs of space projects versus their minimal value gained needs a very careful

reevaluation. I believe that very little has been gained from research in space; most of the benefits have been from research on the ground *for* the space program. Exceptions include satellites for weather, communication, Earth mapping, astronomy, and military information.

Congress will not stop spending on wasteful projects. The members get too much election campaign money from lobbyists. Citizens with some technical knowledge and common sense need to get together and demand a change in the funding of these projects, with members of the physics community taking a lead role. There are far better places than space to spend money for research, development, and education.

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Kleppner, Lamb, and Mosher
Kreply: The APS study concluded that a boost-phase defense using airborne interceptors (ABIs) incorporating technology that would be available within the 10-year period considered could be useful in limited circumstances. Dean Wilkening's analysis agrees with the study's in most respects, but his assessment of the utility of ABIs is more positive.

One reason the assessments differ is that Wilkening assumes an airborne X-band radar system will be available. No such system yet exists. The study judged that the time required to field such a system would be greater than the 10-year period considered. A second reason is that his interceptor has a higher acceleration than the study's comparable interceptor I-2 and has a 20-second burn time compared to the 40-s burn time of I-2. Because Wilkening's interceptor has a higher average velocity, it can reach a greater distance, but there are penalties for such a high acceleration. Wilkening's analysis appears to neglect one of these: The interceptor's final stage (kill vehicle) must have more velocity change ("divert") capability because it is released after only 20 s, when it has less information about the intercontinental ballistic missile's flight and must maneuver for a longer time. Wilkening's kill vehicle has a total divert capability of 2 km/s, which is what the study estimated would be required for a kill vehicle released after 40 s. Additional divert capability increases the mass of the kill vehicle and its boosters and reduces the final speed of the intercept-