Missile Defense Testing and Development

One of the persistent questions raised about the U.S. program has been whether there is sufficient information from testing to allow us to move forward with the systems we are building.

The suggestion is sometimes made that we are departing from best practices in testing, and somehow pressing forward with a system before it is ready. This actually misrepresents both what we are doing, and how systems are normally tested.

The full range of missile defense testing—from our extensive modeling and simulation and hardware-in-the-loop tests to our ground and flight testing—makes us confident that what we deploy will work as intended. We do not rely solely on intercept flight tests to make final assessments concerning system reliability and performance. Our flight tests are important building blocks in this process, but the significant costs of these tests combined with the practical reality that we can only conduct a limited number of these flight tests mean we have to rely on other kinds of tests to prove the system. Assessment of our capabilities will be based on new test events as well as data collected from flight- and ground-tests and simulations over the past several years.

By hooking it all up and putting what we have developed in the field, we will be in a better position to fine-tune the system and improve its performance. Testing system operational capability in this program is, in many ways, different from operational testing involving more traditional weapon systems. All weapon systems should be tested in their operational environments or in environments that nearly approximate operational conditions. This is more readily accomplished for some systems, and is more difficult to do for others.

But to suggest that somehow all weapon systems should be "fly before buy" is to ignore the experience of many complex systems. How do you realistically test an enormous and complex system, one that covers eight time zones and engages enemy warheads in space? The answer is that we have to build it as we would configure it for operations in order to test it. That is exactly what we are doing by building our test bed and putting it on alert this year.

Test Failures

The basic feasibility of our missile defense programs is well established. The fundamental feasibility of hit-to-kill systems was proven in the 1980s. Since that time we have had many successful intercepts with a variety of interceptors—the Homing Overlay Experiment, Exoatmospheric Reentry Intercept System, the Ground-based Interceptor, the Theater High Altitude Air Defense System, the Standard Missile 3, and the Patriot Advance Capability 3 missile. Each of these systems has had test failures as well as successes, but such failures should not raise questions about whether the eventual system will work as designed. Test failures are a part of system testing and development. We learn from failures, and expect some throughout the course of missile defense testing and development.

It may seem counter-intuitive, but the rate of failure during development testing is completely unrepresentative to the expected system performance at deployment. Flight testing is intended to discover issues in the design, manufacturing or environment that can only be understood in a complete system integration test. Developmental flight tests are not intended as demonstrations of the finished product, nor are they tests of the performance of the system under combat conditions. Development testing is intended to test specific issues of integration or environment to feed back into the final design.

It is common to conduct a flight demonstration of the final system, in nominal performance, at the end of development. Such tests are representative of the full system performance, given the understanding of the system that has been provided by hardware testing and simulation throughout the program. But it is not uncommon to begin production well before such a demonstration.

Consider the Polaris submarine-launched ballistic missile program of the 1950s. Development testing on the Polaris missile included only two test flight successes. Attempts at an end-of-development flight test demonstration included five failures. After the failures, the design team was under great pressure to return to the design stage, but they felt they understood the reason for each failure. When the first successful flight demonstrations occurred in April of 1959, the U.S. had already produced the SLBMs that would be put in the first Polaris-launching submarine, and the missiles were at sea six months later.

An Analogy for the Role of Testing—The Wright Flyer

A timely example of learning from failures, given the perspective of 100 years, is the Wright brothers and their development of the airplane. They experienced both success and failure before they achieved the first manned, powered flight in history. Their first glider was a success, while their second glider was a dismal failure. After their initial disappointment, the Wright brothers went back to the drawing board and continued to test, develop, and improve their design. In 1902, after design modifications, the Wright brothers flew several manned gliders with few problems. The minor problems they did encounter led to further refinement of their design. Having achieved manned flight, the brothers then set about developing a powered aircraft. In 1903, on their third attempt at flight, the Wright brothers met with success. Their twelve-second flight marked the birth of aviation.

Efforts to overcome the failures encountered during the testing and development of the airplane moved the design in the right direction one step at a time. In the same way, overcoming failures during the development of a missile defense system will push the design in the right direction.

"Realistic" Test Conditions

Initial system tests do not—and should not—resemble a realistic operational environment. Beginning with the full range of realistic conditions is not an effective way to develop a complex system. Rather, individual parts of the system should be isolated and tested alone and integrated incrementally. Once the entire system is working under simple conditions, complexity should be added to the test scenarios. This way, we can ensure that problems are properly identified and corrected. If the system were built in its entirety and tested initially under complex conditions, there may be no way to identify the source of problems, and, consequently, no way to fix the problems.

There is another analogy to the Wright brothers and their test and development strategy for the airplane. After their second glider failed in 1901, the Wright brothers took pause and approached their glider design more systematically. They did not build an entirely new glider in an attempt to solve their problems. Instead, they built a wind tunnel and wings in various shapes, and tested each wing in the wind tunnel to observe how the shape affected lift. They broke the system down into parts and tested each part separately in a simple, controlled operational environment. They developed a good understanding of how the wing shape affected the entire system, and after they had this foundational understanding, the brothers built another glider. The Wright brothers then focused their attention on developing a movable glider tail. They continued to test in the wind tunnel as well as verifying their wind tunnel results with actual glider flights. The next step was development of powered flight. The Wright brothers set about modifying their airplane design to accommodate a propeller and engine with the same systematic care they gave to their gliders. Finally, in December of 1903, they achieved the first manned, powered flight. The brothers had to send the airplane down an inclined track in order for it to gain enough speed to become airborne, and the flight lasted for twelve seconds. This was a far cry from the operating environment of any useful aircraft—but it was the beginning.

The development of the airplane occurred one small step at a time. The Wright brothers simplified operating conditions as necessary to improve their design, gain deeper understanding, and achieve future success. This proven strategy is the same approach used today in developing a successful missile defense system.