Tactical Missile Design

A world-leading expert weighs in on the engineering gaps

Defence IQ

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Where are the current international capability gaps in missile defence?

I would say that the greatest gap in the current capability for missile defence is the cost asymmetry of defence versus offense. It is usually much easier and cheaper to develop an offensive missile than an effective missile defence system. Possible future threats such as manoeuvring re-entry vehicles, multiple re-entry vehicles, decoys, and cruise missiles will probably be even more difficult to counter in a cost effective manner. A missile defence system should be a complement to an offensive system that can take out threat missiles before they are launched. It is important to have a sword to complement the shield.

In what significant ways have the design aspects of today's missiles progressed in the past decade and what is driving development?

Much of the missile development of the past decade has been focussed on the areas of missile defence and precision strike missiles. An example of a transformational capability is network-centric warfare. The widespread application of GPS/INS/data link technologies to missiles in network-centric warfare has greatly enhanced their target acquisition, accuracy, lethality, and adverse weather capability. Another example of a driver in missile development is the use of COTS electronics, for lower cost with high computational capability. A third example is the application of multi-mode warheads for precision strike missiles, to reduce the number of types of missiles and to reduce the development, production, and logistic costs. A fourth example is compressed carriage, to improve the firepower for launch platforms such as the F-35, which has a small volume weapons bay. Finally, increased emphasis on target detection, accuracy, and low collateral damage are driving the development of high resolution seekers that also low noise.

The main technological shortfall today may be said to be effective system integration, particularly as other weapons systems become more available or more complex. How has this impacted the domain and what case studies could you point to of any particularly successful integration programmes?

Arguably today we have more system integration problems than technology problems. As you said above, systems are becoming more complex, which leads to more system integration problems. An example of how the emphasis on system integration has impacted the domain is the impact on the culture of selecting new system engineers. Young engineers, without sufficient experience, are being selected for system engineering, because there is currently a large shortage from retiring system engineers. System engineers have traditionally been the most experienced engineers, typically rising from the ranks of technical/subsystem specialists, to become lead subsystem engineers, to finally evolving into system engineers.

A classic example of a successful system integration programme is the F-14 aircraft/AWG-9 fire control system/Phoenix missile. It was effectively developed as a system-of-systems. A current example of what appears to be a successful system integration programme is the Israeli David's Sling/Iron Dome missile defence system. Another current example of what appears to be a successful system integration programme is the F-35 Distributed Aperture System (DAS), which provides the pilot with a greatly enhanced visual situational awareness.

For many nations, particularly those in Europe, budgets remain restricted, so there is an ethos of doing "more with less". How are you seeing this approach being managed when it comes to missile development and what would your advice be for those dealing with programme management under limited resources?

First, I would strive to avoid the typical cost growth problems. These often occur from programme funding instability and requirements creep. One way to minimize cost growth is to plan the EMD programme at its beginning as a low risk and short duration programme. Also, competition should be conducted when possible. From my experience the benefits of competition include reduced cost, increased quality, and reduced risk. Finally, the programme manager should not make the mistake of minimizing the number of planned flight test missiles in order to try to reduce EMD cost. Problems that are not uncovered during EMD flight test will be very expensive to correct later on in the programme. Another consideration to minimize cost is to adapt a more modern missile to the mission of an older, retiring missile. For example, Hawk was a good air defence missile, but it is getting old and is no longer in production. One relatively low cost approach to replace the retiring Hawk is to adapt the AMRAAM air-to-air missile to a surface-to-air mission, such as the NASAM and SLAMRAAM programmes.

And you have a new book out on the subject?

I'm very pleased with the success of my year 2012 textbook, *Missile Design and System Engineering.* It's much larger in scope than my year 2006 book, *Tactical Missile Design, [Second Edition].* The new book has 88% more pages - with much more written material, figures, videos, and comparisons of missiles. Much of the new material is in the area of system engineering, with particular emphasis on the system integration of the missile with its launch platform and fire control system. Also, the book has extensive use of simple closed-form, physics-based analytical expressions - to provide better insight into the primary driving system parameters.

Finally, about every two months I offer a one-to-five day short course based on my textbook, plus additional new material. Information on the short course and textbook are available on the web site http://genefleeman.home.mindspring.com.