Introduction

Ms. Fox began by noting that a basic US strength – a modern, highly capable military – is something that the American people expect. They are right to expect such a military, which is different from taking its military for granted. However, the military is now suffering from a lack of investment. Ms. Fox indicated that she would be discussing:

- The impact of the declining defense budget on sustaining America's technical edge
- The over-constrained DoD environment as it relates to necessary innovation
- Some suggestions about what could be done to mitigate the impact of the current budget constraints

The Sequester

- On March 1, 2013, the Congressionally mandated Sequester cut $37 billion from that fiscal year’s defense budget
  - Some believed that the US would lack an effective military on March 2nd
  - Others said that the Sequester would not be a problem for DoD
  - In fact, the devastating impact on DoD would not be seen right away
- Readiness (a concept that is not embraced in Washington, DC since it has no constituency) suffered from major impacts in both training and maintenance
  - The military must train its people to do difficult things, using complex equipment that needs to be maintained
  - Training: Sequester cancelled much local and national-level training
    - Result: great swaths of military personnel have missed that component of their development and won’t ever be able to get it back
o **Maintenance**: Sequester required the furloughing of people at the maintenance depots
  ▪ Result: a maintenance backlog, and now there is no funding for overtime pay to mitigate that backlog

**Modernization** impacts appeared throughout the acquisition process
  o A study on the costs in the acquisition process showed that the biggest impact on acquisition costs coming from budget downturns
  o In those situations, DoD would use *slips and slides* that stretched out programs including slipping forward milestones
    ▪ Doing so broke contracts, forcing costs to go up and creating inefficiencies
    ▪ DoD is still paying for these problems caused by Sequestration

**A Bi-partisan Budget Act** provided the longed-for budget stability for FY14-15
  o But DoD still cut $75B over two years, which was a very big cut
  o The President’s FY2014 Budget was important because all subsequent budgets must be measured against it
    ▪ FY14 was designed to support the Defense Strategic Guidance (DSG)
      ▪ Remarkably little has been said against DSG and it has been reaffirmed in last year’s QDR
    ▪ DoD built its program to align with the Guidance and then figured out what the costs would be
      ▪ However, the Bipartisan Budget Act cut $75B from that budget – the budget necessary to achieve the strategy

**DoD could still see the budget go down further – lower than FY14 but $115B higher than the Sequester act requires for FY16**
  o The current budget before Congress now adds $12B
  o Even after all of this review and study, Sequester will return in FY16 with another $35B cut in that year alone

**Continuing Impact of the Sequester on the Force**
  o A balanced force involves *Readiness, Modernization* and *Cost of Ownership*
    ▪ Cost of Ownership is usually associated with ships, aircraft, tanks, etc.
      ▪ But must also consider paying the people who will operate them
      ▪ Pay costs are fixed by the size of the force
  o Ideally, DoD budgets would cover and balance all three elements as depicted in first triangle below
  o DoD also needs innovation to maintain the US military's technological edge
  o Triangle representations below show how the situation is out of kilter
    ▪ DoD proposed some reductions in force and slowing the growth of salaries with other small changes to items such as health care co-payments
    ▪ Congress walked back many of these changes and denied many of the force structure cuts (in numbers of forces, ships, etc.)
    ▪ Result: The bottom of the triangle stayed fixed but the budget did go down, creating the second triangle
    ▪ Sequester FY16 will force the squished third triangle
- Problem: Potential adversaries are investing in their force structures, as well as fielding new, rapidly expanding capabilities
  - Cuts in the budget risk DoD’s ability to technologically stay ahead of these potential adversaries
- The triangles above don’t show an environment conducive to developing great new ideas
  - The Services are holding on to all their operational demands – no task has come off the list
    - Still must worry about Russians, terrorists, the Middle East, etc.
  - With the Services trying hard but struggling, where does innovation fit in?

**Innovation**
- There is an expectation in Washington that DoD should know exactly what the costs will be for a new system and how long it will take to field it
  - The Nunn-McCurdy Process requires that if a program exceeds the predicted timeline by too much, DoD must reassess the whole program
Problem: if a program does not live up to these early-on predictions, then it is considered a failed program

Lots of innovation initiatives are going on within DoD

- DoD is aware of the problem and it is trying to protect its S&T funding since it recognizes S&T as its seed corn

Innovative companies’ views on innovation differ, for example Google has 9 Principles of Innovation, some of which DoD shares:

- Have a mission that matters
- Bet on technical insights
- Fail well

DoD innovation in late 1970s showed different views: Lockheed Martin (LM) and Northrup Grumman (NG) begin to design a stealth aircraft

- LM very quickly designed the F-117 using the computational models it already had for designing ways to reduce radar cross-sections
  - Problem: aircraft was hard to fly; had maintenance issues; and the design only allowed for so much deflection
- NG used advances in computational fluid dynamics to design curved surfaces that allowed for reducing cross sections even more
  - With this design builders could reduce radar cross sections much more and NG could build the B-2
- In the end, B-2 was not considered a successful program; some would call it a failed program
  - After 18 years DoD bought only 20 planes, versus the 132 originally planned, and the cost had risen to $2B each
  - But the program “failed well”
    - Stealth programs that came along later benefitted a great deal from the development done to build the B-2

Innovation today

- DoD is not likely to have a program like the B-2 today because of the budget problems and the acquisition expectations
  - However, not all programs of record should continue with overruns
- Problem: Requiring that DoD know exactly how much a program will cost and how long it will take from the very beginning stifles innovation

Sources of Innovation

- Innovation can come from anywhere
- In the past, 2/3’s of innovation came from DoD; 1/3 from commercial sources
- Now the percentages have flipped with commercial sources taking the lead
  - DoD needs to figure out how to make use of these advances
- A possible model: During the Cold War the Navy had a Tactical Development and Evaluation (TD&E) structure, which used a very flat organization
  - Anyone could suggest a new tactic and submit it to TD&E
  - TD&E would come up with some money for experiments and would provide analysis help for suggested tactics in already planned exercises
Ideas usually came up from junior officers and enlisted ranks
No such opportunities exist today
- Something similar was happening on the battlefield for the Army, but such activity is not going to help sustain DoD’s technical edge
- Problem: There is no way to try out new ideas, given the lack of funding for extending or even holding exercises

- Need to bring back some sort of equivalent process of suggestion and experimentation
  - Need to be able to experiment in a safe place
  - Will be hard to do with current budget constraints

**Innovative Company Ways May Not All Work for the Military**
- Google’s ship & iterate system (also used by other tech companies) won’t work for DoD, as in the example of the Joint Strike Fighter (JSF)
  - Concept: Design was so advanced that it would not need much testing
  - Idea was to start slowly with only a small number of aircraft built while still experimenting and testing
    - Would allow a little experimenting and developmental testing leading to some modifications
    - LM wants to speed up the rate of production
      - Must overcome the instability in the program based on the high level of concurrent testing
      - Billions of dollars have been spent already but testing will go on for years
      - Now need to cut back
- Possibly could work for DoD if built a few prototypes that get sent to the fleet/field to try out for a relatively small amount of funding
  - Findings can be cranked back into the development
  - Only then should there be a discussion about the exact timing and costs that will be needed for the entire program
  - Problem: Such a method would require a number of changes in regulations and procedures to use

**Mitigation of Budget Constraints**
- Efforts are currently going on at APL to develop Practicality, Thoughtfully, and Broadly

**Develop Practically**
- Example: Technology of Autonomy (the future of warfare)
  - There are many ideas about autonomy available already
  - Autonomous swarms and other concepts could be developed
  - To develop practically requires much up front thinking about what should be developed
- Need filters to sort through all the available ideas to determine what should be built
- One filter to consider: man vs. machine
Machines are good at some things but not at everything - as can be shown in lots of data that already exists

- Google Maps is a perfect example of what machines can do with a lot of data that people would not be able to manage
- Persistent stare capabilities are better done by machines than by humans who get bored, distracted, or tired
  - People are best at pattern recognition tasks but cannot maintain the necessary stare function

Humans are much better at identifying intent (based on context, body language, facial expressions, etc.) than are machines

- Example: Spell checkers aren't good at identifying what people want to say and often autonomously change the meaning of a sentence
- Machines are unlikely to get better at this type of activity any time in the near future

Bottom line: If DoD has no money for new initiatives, it needs to consider the concept of what can be done best by machines vs. by humans

- Legal and ethical norm filters
  - It is very clear that the laws of armed conflict call for:
    - Proportional responses
    - The capability to discriminate types of targets
    - Humans in the loop
  - Avoiding those issues, both the Navy and the Army are building autonomous cargo delivery systems
    - A good use of autonomy since such activities reduce risks to human operators and involve complex route planning, which they do best

Bottom line: Autonomous operations could be game changers in the logistics chain and persistent stare activities without pushing the man/machine boundaries

Develop Thoughtfully

- Example of the wrong way: Google may not have been thoughtful when developing their Google Glass project
  - The technology was immediately considered cool and desirable
  - Further reflection brought up problems of privacy for those not wearing Google Glass
    - What was being recorded?
    - What would be done with it?
  - While privacy issues were the main complication, Glass also had maintenance problems and so the devices were withdrawn

Cultural Norms: Some would say that the answer to part of these complications is to get rid of the human policies involved, however they must be considered

- The technologies involved in autonomy would not be able to meet existing laws of armed conflict
  - Some consider this a positive element since machines would not get upset at decision-making points
The concept is being debated and surveys show that most people are concerned about the prospect of robot armies.

Some believe that it is necessary to convince those who are concerned that the laws are outdated or unimportant.

- There is some fear that having autonomous armies will make countries more willing to go to war.
- Responsibility for damage is another major matter of concern with autonomous activities if something goes wrong.
  - Especially true in cases of lethal activity.
  - What if a robot kills someone accidently? Who would be responsible?
    - The software designer?
    - Commanders who sent the autonomous weapon system?
    - The President?
- Until questions about responsibility are clarified, lethality may be a hard bar to cross for developing autonomous systems.

Based on decades of movies and books many American believe that vast numbers of robots lead inevitably to a dystopian world.

- Things always seem to go wrong when the robots take over.
- Hard to convince people that the real systems would not be like those seen in movies, books, etc.

Bottom lines:

- People first will have to be convinced that autonomous robot systems are a good idea and that policy changes have been considered.
- DoD will need to show that something yet unidentified has been built into systems to handle the lethality issue, but that probably could be done.
- Then there are the issues involved in just trying to build such devices.

**Develop Broadly**

- Concept: Develop technologies that might not be needed immediately but would be on the shelf for final development and production if the need arises.
- This tech-on-the-shelf strategy has been proposed by Deputy Secretary of Defense Robert Work.
  - Called the Third Offset Strategies (there have been other important offset strategies in history).
    - Need multiple strategies because of all the various threats that the US is facing that require a spectrum of capabilities.
- There may be no money to field some of these strategies but there are efforts to protect S&T leads.
  - Need to capture new concepts and put them on the shelf for potential future requirements.
  - Really could use a situation seen in the movie Batman.
    - When Bruce Wayne goes to Wayne Industries basement he finds and then modifies existing capabilities to fit his needs.
    - Body armor designed for the military was refashioned into a Batsuit.
• Specialized military vehicles that didn’t quite work for what had been intended became the Batmobile
• DoD needs to build prototypes to put on the shelf to be used for a potential future requirement or when the money comes back
• Things to consider:
  o DoD needs to avoid building systems that are easily surpassed by other technologies, new CONOPS, etc. until it is no longer relevant
  o Need to avoid building whole systems that don't integrate with other systems
  o Solution: Design modular systems whose sub-systems can be swapped out and modernized as needed after testing in the fleet
• Need a dynamic shelf – send prototypes to the fleet/field for testing
  o Will require some funding to permit field testing and for oversight
  o Unless DoD can figure out a way to do all of this, it may not be ready to face new requirements

**Conclusion**
• Maintaining the US technical edge is a challenge especially under budget constraints
• Problems can be overcome if DoD finds new ways to do the things that have been constantly done the same way over time
• Under SecDef for Acquisition, Technology and Logistics, Frank Kendall, has noted that every downturn in American military history has been followed by an upturn
  o DoD must be ready for those upturns and be ready to field new systems
  o The US can then maintain its technological edge, which will build up DoD capability triangles

**QUESTION & ANSWER SESSION**
**Re: Internationalization**
• There is a growing realization that DoD must rely more and more on its international partners
  o Doing things alone will mean that something gets missed
• Need to find ways that DoD can work with others despite classification and regulation concerns
• There have been breakthroughs involving the sharing of equipment
• Information is now spread all over
• The Missile Defense Agency does help bring all the elements together but only in its own area
• DoD must have more tactically-centric organizations and work more broadly so that all the potential partners can work together

**Re: Cost of Ownership – Personnel Costs**
• It is very important that DoD gets it right in handling pay and benefits for its people
  o The military’s capability remains high because of the quality of its people
  o Percent of the budget spent on people has gone down some
• Two elements to the problem:
Getting the force smaller is more important than paying the people less
  • DoD tried for a smaller force but it was largely denied by Congress
Cost of paying/caring for people has gone up dramatically since 2001
  • Personnel costs then had fallen to a level that was seen as too low
  • Salaries were raised and there was an effort to link salaries to cost of living estimates
    • But Congress continually added more than what DoD asked for
    • Reached a point where personnel costs went up 40% relevant to the costs of everything else
    • Problem: Can’t have a highly paid force that lacks equipment/training
Efforts have been made to slow the growth of personnel costs, not to cut pay or benefits
  • DoD established a Retirement Commission to develop new ideas to slow growth, but had little success in making changes
  • Biggest part in the base of the Triangle comes from the size of the force
    • Given the range of world problems, it is understandable why people don’t want to cut back on the size of the force but something needs to be done

Re: Dumb Weapons Systems
  • The American people and military no longer tolerate weapons systems that cannot control the amount of collateral damage involved in a strike
    • As soon as DoD had precision guided munitions (in Kosovo / OIF), the issue of collateral damage became part of the criteria used to evaluate targeting
    • But even TLAMs have limitations – can’t call them back after launch
  • This gets into the debate about lethal robots – a new concept
    • Can’t convince people that they won’t take over the world
    • Can’t not develop them but must figure out how to handle the problems they could create
      • Must be able to empirically prove what the system will do
  • Commanders want to know exactly what the system will be doing 100% of the time
  • Problem can be managed if DoD learn to understand the systems
    • DoD needs to have a safe range where it can test autonomous systems
    • Need to design in checks for all the stages of autonomous systems

Re: Campaign Modeling
  • A useful capability but not a substitute for real testing and experimentation
  • Campaign modeling is very complex with lots of variables
    • Errors don’t cancel each other out – they add to each other
  • Probably has been used too much in the past
  • Such tools can be used for some purposes but they must be used by people who know the limitations of the modeling tools involved
  • DoD needs a broad set of tools and this is just one of them
Re: Extensive Competition
- In the JSF example there was concern about sustaining compliance with acquisition regulations
- Need ways to condense the development cycle, but must be realistic
- Problem: As soon as DoD gets better at something there is a desire and an expectation for more
  - Those in DoD who accepted all the promises about the program are to blame for causing it to be considered a failed system
  - The JSF Program was really not that bad given how complex the system was when compared to other programs
- DoD and Congress shouldn’t be surprised at such situations if expectations are more like hopes and dreams
  - Need to look at history of earlier systems and the data involved in systems
  - In the end JSF may actually be seen as a good system

Re: Development Complexities
- Example: the Ground Combat Vehicle was designed to have more lines of code than the JSF
- Planners always think it will be easy so they start late
  - There are always software challenges and they must be expected
  - Must get the best software engineers involved early – not wait until problems crop up and the system needs a rescue
- The country needs more well-trained IT and cyber personnel
  - Best ones always being lured away from DoD into industry
- But there are limitations to commercialization
  - Is it really likely to be the answer for developing new tanks?
  - Commercial sources may be able to help shorten development time and provide better success
- DoD planners must be realistic about what can be done

Re: Discipline in the Development Process
- At about the 6.1 level of S&T development DoD may not want all that much discipline to test new ideas but it does need some
- Breakdowns often occur when moving control of projects from DARPA to one of the Services
  - Services may not have adequate funding for carrying the program further
- DoD probably does not build enough prototypes
  - But DoD is not well-organized for doing so now
- Developing ideas and doing the analyses are the fun parts while implementation is the hard part

Re: Selling Programs
- Often failures come from expectations of high performance
- There are no magic answers
• Things are somewhat better: There have been no Nunn-McCurdy program failures under Secretary Kendall in the last 2 years
• But there are still things that need to be done or done more such as:
  o Prototyping and building technologies to put on the shelf (which require the use of different kinds of funding)
  o Avoiding committing DoD to years of investment
  o Recognizing that there are lots of points along the way to say yes or no on program development
• Need a strategy to build support for DoD’s requirements
• DoD needs help from all levels and organizations

Re: Relations with FFRDCs/UARCs/Other Universities
• DARPA is doing a great job but there need to be more offices in DoD that consolidate and explore new ideas from other sources
• Must recognize that commercialization is not the only answer for DoD since organizations like Google and Apple won’t be building weapons systems
• Those who want to work with DoD must also be aware that budgets are shrinking
• More DoD involvement with universities would be good but it is not clear how that can be done
  o More conferences are a possibility but such sharing reaches only a shallow level
  o Need processes and places where ideas can be sent

Re: DoD Acquisition Process
• Really is more good to it than bad, which is not the normal view
• There are horror stories such as the SBX, a very big radar that needed to be floated across the Pacific – something it was not designed to do
  o It was not designed for the users/purposes it eventually was assigned to
• Need to harness innovative ideas
• The whole acquisition process should be better and easier
  o Must review all the things a program is expected to do
  o There are no incentives for a program manager to identify when something about a program is not good
  o The current system only promotes moving on to the next milestone
• Under SecDef Kendall is pushing for change
  o Problem: Congress doesn’t trust DoD on acquisition issues because of its poor track record
• It may be possible to fast track some programs if they are using elements that are already well-known and well-tested
  o Already being done somewhat but need to do more in such a constrained budget environment
Re: Acquisition Process Improvements

- There is no one law or villainous process that can be changed to make a big improvement
- Biggest problem: expectations
  - DoD has its own expectations and needs to defend them to Congress
  - Congress expects that DoD will be able to tell them exactly how long a program will take and how much it will cost from the start
- DoD needs to be honest with itself and then be ready to sell its position to Congress

Re: Best Practices for Scientists Trying to Communicate with the Public

- The world is now so complex that understanding and communicating the intersection of policy and technology is crucial
  - Policy-makers don't usually have science/engineering degrees
  - Policy-makers often can't wait for answers before making choices
- Tech people need to provide policy-makers with digestible ways to explain their programs – with help from communicators
- Recommendation: Find ways to bring policy-makers necessary information on complex programs in packages that can be absorbed in limited amounts of time
  - Then they will need to be able use that information to defend these programs before Congress – very hard to do
- Need a comms bridge with some of the people charged with doing the communicating required to learn about the technical issues
- When you can bring people like the SecDef or the President good technical/analytical information, they really appreciate it and make good use of it