



## Mr. Cody Reese

First off, you might notice that unlike my panel colleagues, I am not a Marine colonel nor do I expect to be one anytime soon. But I definitely appreciate the work they are doing. The first commanding

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*Mr. Cody Reese graduated from the University of California, Berkeley with a B.S. in mechanical engineering in 2002. Upon graduation, he served at the Naval Facilities Expeditionary Logistics Center under the Professional Development Center intern program. Following the receipt of his California Professional Engineer license in 2005, Mr. Reese took a position in the Amphibious and Expeditionary Systems Department at the Naval Facilities Engineering Service Center (NAVFAC ESC). At the Engineering Service Center, he has worked on projects ranging from autonomous crane systems for cargo transfer in high sea states to expedient airfield damage repair equipment. In 2009, Mr. Reese accepted his current position at NAVFAC ESC as Technical Direction Agent (TDA) for the Office of Naval Research (ONR) Code 30 Logistics Thrust. As TDA, Mr. Reese assists the ONR Logistics Thrust Program Manager with the development and execution of the logistics science and technology (S&T) program. Mr. Reese leads a team of subject-matter experts who have a broad range of knowledge and experience in diverse expeditionary logistics disciplines including the following: expeditionary energy and power, autonomic logistics, water purification and distribution, logistics sustainment support for small-unit distributed operations, and sea-based logistics. The end users of the technologies include the Marine Corps and the Naval Expeditionary Forces. Mr. Reese is highly involved in concomitant duties in support of the command and the engineering profession. For the past 6 years he has served as senior staff for the Society of American Military Engineers, Seabee Engineering and Construction Camp. He has served for the past 4 years as the command's Combined Federal Campaign chair and as a member of the command's lauded recreation committee. He was recently inducted as a cadre member into the NAVFAC 2011 Leadership Development Program.*

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officer I served under at the Naval Facilities Engineering Command (NAVFAC) Engineering Service Center was Navy Captain Mark Samuels. He was an excellent public speaker; at the beginning of a presentation he would always tell a poor joke that would enhance his presentation. So, I am going to try that technique today and see how it works. I will tell one related to energy and climate change. What do you call a fish with no eyes? A fsh. See? Lame.

As Colonel Ted Smyth said, I work for the NAVFAC Engineering Service Center. While the Center is doing fantastic things for Naval facilities engineering across the board, I have been assigned full time to support the Office of Naval Research (ONR). Basically, I get to go all kinds of good places. I have the coolest job in the room, and I think you will agree with me at the end of this. I am basically a science and technology scout for ONR Code 30 Logistics Thrust. ONR 30 is the Expeditionary Maneuver Warfare and Combating Terrorism Science and Technology Department, and as such it is focused on the expeditionary Navy and Marine Corps, the guys with boots on the ground. Within that, there are different technology thrusts: maneuver, fires, C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance). I support logistics, which is everything else to include energy, water purification, asset transport, and infrastructure. This year, in the logistics thrust area we are managing over 25 efforts focused on improving expeditionary logistics. In the remainder of my talk, I am going to delve into some of the cool technologies that we are looking at.

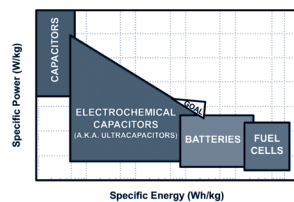
As my panel colleagues have said, there are several different ways to reduce energy demand. To start with, there are behavioral initiatives, which I am not going to go into. The Marine Corps ethos is driving that pretty hard, and I think that is going to have a huge impact. Then there are technological options. There are specific device improvements that have a direct energy benefit, and there are those where the effect is indirect. A lot has been said about vehicles and convoys. I am not going to talk about specific vehicle improvements, although rest assured, ONR's maneuver thrust has that covered. They are working heavily on Medium Tactical Vehicle Replacement (MTVR) fuel efficiency and hybrid vehicles.

The bottom line is that nearly every research and development effort in the logistics thrust reduces Marine Corps energy demand in one way or another.

That being said, I get to basically present whatever I want out of the logistics portfolio, so naturally I will choose my favorites. I am going to start with power and then move on to water and cargo delivery. I am going to focus mainly on technologies at the applied level. We definitely support the basic research that supports these applied-level things, but it is not quite as easy to see the actual benefit that a carbon nanofoam is going to have on MTRV energy reduction. So, I will focus on those that have obvious applications.

Let us start with a hybrid power source with a high energy density (Figure 1). This is basically the union of an alter-capacitor and a lithium-ion battery in one box. It has the same form factor as a BA-5590. It has the potential to double the specific energy of that battery. So basically you have a battery that has twice the power of the one that you now have. The indirect energy benefit is that you now have to bring fewer batteries to the fight. Batteries are heavy, and hauling them around the theater takes a lot of fuel. In addition, with fewer batteries we can reduce battery manufacturing and disposal. Although the manufacturing is not quite a Marine direct cost, disposal certainly is.

- **Hybrid power source (capacitor high-power unit + battery)**
- **Lithium-ion battery negative electrode**
- **Activated-carbon capacitor positive electrode**
- **Same form factor as BA-5590X**

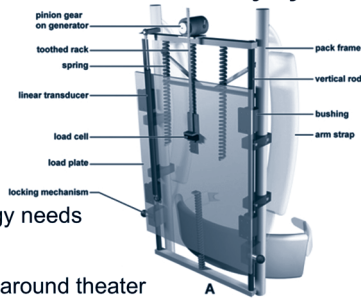


- **Direct energy benefit**
  - Potential to double the specific energy of BA-5590 batteries
- **Indirect energy benefits**
  - Fewer batteries transported to and around theater
  - Reduced battery manufacturing and disposal

Figure 1. Hybrid Power Source with High Energy Density

Now let us look at power management for military radios. We are basically adapting a power management integrated circuit that is found in a lot of commercial laptops, cell phones, and those types of things. It functions through selective power control to individual circuits in the radio with no adverse performance effects. Basically it just shuts down subsystems that are idle and consuming power within a specific device. It has the potential to reduce the power consumption of that device by 30%. With that, a radio squad can reduce its battery requirements for a 4-day mission by 12 pounds, which again leads to fewer batteries transported around theater and reduced manufacturing and disposal.

- **Suspended backpack with integrated generator**
- **Oscillating motion between pack and frame**
- **8–45 watts while walking-running with an 80-lb load**
- **Reduces load-related forces that cause skeletal injury**



- **Direct energy benefit**
  - Soldiers self-supply electrical energy needs
- **Indirect energy benefits**
  - Fewer batteries transported to and around theater
  - Reduced battery manufacturing and disposal

**Figure 2. Harvesting Electric Power from Walking**

My next concept is a device that harvests electric power from walking (Figure 2). This has been tried a couple of different ways before; our approach uses a backpack that effectively oscillates up and down as you walk. Depending on the load you are carrying and the speed at which you are moving, you can generate anywhere between 8 and 45 watts—a significant electrical output. As a secondary benefit, the backpack reduces load-related forces that cause musculoskeletal injury. I have run around with one of these on my back; it is actually pretty amazing. So obviously the direct energy benefit is that the Marine self-supplies his electrical needs. The indirect energy benefits are the same as reported previously.

Fewer batteries need to be transported to and around the theater, and manufacturing and disposal costs are reduced. Since you need fewer batteries, your pack is lighter than it would be otherwise. Although the pack weighs a little more, it pays off since you need fewer batteries. If you couple that with batteries that are twice as powerful and with radios that need 30% less power, this can definitely provide the guys on the ground with their own source of self-sustaining power even for the cases where other renewable energies might not be appropriate.

Now let us turn from power to water purification, which is something I really like working on. This next one is a platform-enabling technology that has applications across the different scales and levels of water purification systems used by the Navy and Marine Corps. It is effectively a pretreatment and uses a continuous-flow clarification process that operates on the sheer forces within a fluid with a very low-pressure drop (around 3 psi). It is not a centrifuge; it is basically just a curved rectangular channel with one input and two outputs.

- **Pretreatment for various water purification systems**
- **Continuous-flow clarification**
- **Utilizes hydrodynamic forces**
- **Low-pressure drop**



- **Direct energy benefit**
  - Less energy required for water purification
- **Indirect energy benefits**
  - Reduced burden on logistics supply chain for replacement filters
  - Reduced need for filter manufacturing and disposal

**Figure 3. Small-Scale Fluid Particle Separator**

As you can see in Figure 3, it is pretty small. Figure 3 shows a tank of water that has been spiked with carbon particles measuring from 5 to 30 microns. The water initially goes in dirty, but by three quarters of the way around, the sheer forces cause the

carbon particles to band together in one particular region of flow. The water containing the particles can be diverted out one of the output ports, while the “clean” water goes out the other port. This is the closest thing to magic I have ever seen; it is amazing to watch. Its orientation does not matter; you can shake it while it is running. We are looking at using this on everything from small water purifiers all the way up to replacing the prefiltration systems on shipboard-level systems. The Navy has discovered that when they operate in remote regions, prefilter fouling for their reverse osmosis systems can go through the roof. They need six times as much prefiltration than they currently have. If we could use this instead, we could save a lot of room on the ship. In the expeditionary environment, we could save a lot of resupply of small filters for these water purification systems.

Advanced energy recovery is another of our water-related concepts. It takes a lot of power to actually pump water through a plastic membrane to get freshwater out the other side. Typically, energy recovery systems are optimized for large-scale plants such as industrial water purification systems that process millions of gallons per day. Currently, none are really adapted to small expeditionary systems where you may be operating on fresh- or saltwater in any climate or place. So the reverse osmosis systems with energy recovery that we are looking at are scalable for the small range (40 gallons per hour). They allow for variable recovery ratio depending on the specific operating conditions. They have been shown to improve the efficiency of an actual system by as much as 60%. If we couple that with some of the less-resource-intensive prefiltration, we can have a huge impact. An indirect energy benefit is that it reduces fuel transport requirements.

This next concept is sort of a baby step in the direction of autonomous resupply. This is an upgrade to the existing CQ-10 Alpha SnowGoose unmanned aerial vehicle, which is a parafoil-based system (Figure 4). The parafoil is launched by towing it behind a Humvee on a trailer. We are upgrading it by adding a three- or four-blade autogyro that will prespin the rotors at zero pitch and then go full collective and launch up in the air. The system autogyros from that point on. It is a very simple autonomous system, and

it is extremely easy to operate. It can deliver up to 2400 pounds and can cover a 93-mile radius in 24 hours. How does this save fuel? Instead of using the parafoil, the alternative would be to send an MTRV with an armed escort that might have to drive 200 or 300 miles round-trip through the mountains to cover the same 93-mile radius. Thus, it offers an energy-efficient way to provide direct resupply for small expeditionary units. As a secondary benefit, it reduces maintenance needs for your vehicle fleet.

- **Autogyro upgrade of CQ-10A SnowGoose Unmanned Aerial Vehicle**
- **Self-launch with near-VTOL performance**
- **500-lb payload**
- **Supply up to 2400 lb/24 hr in a 93-mile radius**



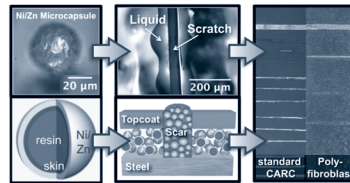
- **Direct energy benefit**
  - Reduced fuel consumption for small supply delivery in rough terrain
- **Indirect energy benefit**
  - Reduced ground vehicle and helicopter maintenance

**Figure 4. CQ-10 “Bravo” Cargo Unmanned Air Vehicle System**

My next concept is a local favorite. It was originally developed right here at JHU/APL: it is a self-healing galvanic protection additive called polyfibroblast (Figure 5). It is basically uncured paint in a zinc microcapsule, and it is compatible with existing MIL-SPEC paints. It can be mixed in with current paints and applied without retraining or refitting the equipment. Essentially, when a scratch is made through the paint surface, it ruptures the zinc microspheres and the paint resin flows out and fills the cracks. In addition, the zinc provides a galvanic protection for the actual surface. You can also add fluorescent dyes to indicate damage so you can tell where the stuff has been used and where your vehicle has been damaged. While it has no primary energy benefit, it definitely reduces vehicle maintenance. The cost of corrosion for the Marine Corps

in 2007 was something like \$600 million; a lot of that is due to the cost of rotating vehicles through maintenance cycles. Anything you can do to reduce that is going to save energy and dollars.

- **Uncured resin encapsulated in microscopic zinc spheres**
- **Stored fresh paint fills scratches**
- **Zinc sacrificial anode protects surface**
- **Fluorescent dye indicates damage**
- **Compatible with existing MIL-SPEC paints**



- **Indirect energy benefits**
  - Increased operational life of asset
  - Reduced maintenance energy required over equipment life cycle

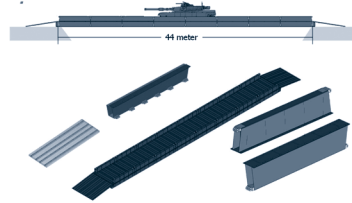
**Figure 5. Polyfibroblast: A Self-Healing, Galvanic Protection Additive**

The last technology effort I am going to cover is the modular composite bridge (Figure 6). The Marines and Army currently deploy 10 to 15 different types of bridging for theater aspects for different scenarios. Each bridge has its own deployment issues, maintenance, and training. The whole process is very energy intensive. What we are looking at is a system of basically giant carbon-fiber Legos. This is the bridge that every 5-year-old dreams about. The kit has five or six basic components: a pier section, a ramp section, a beam, a bank seat, and a deck. You can combine these in multiple different ways to make short bridges, long bridges, pier bridges, or line-of-communication bridges. You can put railings on the bridges. The actual energy benefit of this is somewhat sneaky. Instead of shipping 15 different bridges to the theater, you can ship two full bridge kits and save a tremendous amount of logistics transport. Space is at a premium on our amphibious ships and on our ground transport vehicles. Shipping the equivalent of a medium girder bridge will take seven ISO containers instead of the 20 ISO containers that would be required to ship the existing medium girder bridge. Even though these modular bridges will

be slightly more expensive to procure, the energy savings and the overall life cycle cost savings are significant.

- **Modular system of bridge building blocks**
- **Multiple bridge geometries**
- **Improved performance**

- Increased strength
- Reduced weight
- Lower maintenance
- Health monitoring



- **Indirect energy benefits**
  - Less large and heavy material transported to and around theater
  - Reduced maintenance energy

**Figure 6. Modular Composite Bridging**

Rest assured that we are also investing in the fundamental materials science that lies behind all this stuff. We are conducting research on nanocarbons. We are looking at composites for large structures and nanocomposite electrodes for solid oxide fuel cells. We are investigating self-lubricating coatings and alloys to enable maintenance reduction. We are looking at solar energy, including stretchable photovoltaic materials. These materials can stretch and crumple. They can get shot through, get damaged, and still function pretty well.

In addition, we are looking at ways to optimize the logistics supply chain. How do we do packaging? Are containers the right thing? Austere cargo handling is a big issue. Is there a more efficient way to move a 55-gallon drum full of water than to find enough Marines to lift it? There are opportunities for automation in the packaging process. We are also working on the micro-grid concepts that you heard about earlier to include energy storage buffers and load-source management technologies. The things we really look for are platform-enabling technologies that can be scaled across many different systems and become game changers through their secondary or tertiary logistics effects.