



Smart logistics for future armed forces

by Torben Schütz and Zoe Stanley-Lockman

In recent months, the first 3D-printed unmanned aerial vehicle (UAV) was deployed to a combat zone, fighter jets completed successful test flights using 100% biofuel and power-generating gloves capable of keeping troops warm in cold climates were tested. New technologies are changing the face of warfare – as well as its logistical tail. Recent innovations with military logistics applications have the potential to free up much-needed resources, rebalance force composition and offer operational benefits such as more distributed manoeuvre. Now the question is: for the first time since the Industrial Revolution, can emerging technologies reverse the trend of the ever-growing logistics tail of modern armed forces?

Not only are logistics expensive, but with long wait times for spare parts, incomplete information and convoys as easy targets, they also translate into operational risks. US Secretary of Defense James Mattis once famously stated the need to ‘untether’ forces from fuel requirements: emerging technologies have the potential to impact the production of goods, the means of transportation and the volume of transported goods, partially fulfilling General Mattis’ request.

Since European armed forces have more than once struggled to mobilise and sustain combat forces in recent memory, rebalancing the ratio between combat and logistics forces (‘tooth-to-tail’ ratio) and

strengthening logistics forces are top priorities to increase operational readiness and get ‘more bang for the buck’. This is digested in different ways in Europe: while Western European states have begun to answer the call to increase tanker/transport fleets as iterated in the December 2013 Council conclusions, others are working toward multi-nationalising logistics hubs. While these help fill *current* capability gaps, how can new technologies offer solutions to ameliorate the tooth-to-tail ratio for *future* forces?

Perhaps most importantly, logistics is an area ripe for defence cooperation. Be it fuelling destroyers deployed to anti-human trafficking missions in the Mediterranean, distributing medical supplies to troops in the Sahel or supplying forward operating bases in Afghanistan, effective logistics is a common denominator along the whole spectrum of military activity. As the EU offers defence research and development (R&D) funding for the first time, logistics innovation offers interesting technological niches that already garner interest from industry – namely green technologies, artificial intelligence (AI) and robotics – and that could allow European armed forces to modernise together.

Driven by digitalisation and globalisation, civilian logistics companies are currently ahead in the development of technologies, processes and methods to cope



with recent innovation in logistics and its application in the real world. Commercial companies have also helped transform logistics through vital R&D investments. While some requirements are uniquely military, many technologies and processes for military logistics can also be borrowed from the commercial realm. Such dual-use R&D funding could also be mobilised to help transform logistics tasks for other crucial security programmes in the development aid and natural disaster relief realms.

Green technologies

With fuel and electricity needed to power equipment necessary to any military mission, energy generation, storage and usage constitutes a large part of today's logistical effort. Between the Second World War and the First Gulf War, energy consumption per soldier quadrupled in consequence of operating more platforms fitted with electrical devices and defence electronics such as radios and computers, as well as equipment like air conditioning systems to keep electronics operational. R&D of 'green' technologies has flourished as means to reduce fuel consumption. Solar cells, hybrid electric vehicles are already tested by or in use with the German Bundeswehr, Belgian Special Forces, French security agencies and the UK Ministry of Defence. Methanol-based fuel cells are used to reduce fuel usage, for example by establishing microgrids for forward operating bases, and to lower costs, keeping electronics powered for twice as long as offered with battery life.

Such green technologies should not be seen as substitutable goods for existing energy sources. Their proven operational benefits are threefold. First, with fuel cells weighing on average one-quarter of the weight of batteries and charging equipment for electronics they replace, the lighter load translates to greater mobility. Second, they last longer in the field and recharge faster than other charging devices, allowing forces to stay in the field longer and decreasing turnaround time between missions. Third, their low acoustic and thermal signatures make it harder for adversaries to detect forces and operating bases, thereby enhancing troop safety. Similar operational benefits may be offered by other green technologies, including photovoltaic (e.g. solar) energy or hybrid electric drive. With the potential to decrease demand for polluting resources and cumbersome batteries, taking up green technologies could allow militaries to enhance effectiveness through cost savings and additional operational benefits.

Other ways to generate energy could also 'kill two birds with one stone' down the road. For example, piezoelectricity, generating energy from motion, could include smart armour for personnel and vehicles

that not only generates electricity through motion and/or when hit, but also instantly analyses the direction of an attack and sends information about enemy locations back to others in the unit. Waste generation, often a burden in bases, may eventually be used to generate energy itself. Generating water as a by-product, hydrogen energy would also lower heavy transportation requirements of much-needed water. Although these power generation alternatives are significantly more expensive to research, develop and produce than some of the other promising green technology solutions, their feedback loops render them attractive for future forces.

Additive manufacturing

The provision and delivery of spares is also essential to keeping equipment operational. Additive manufacturing (e.g. 3D and 4D printing) offers new pathways to flatten supply chains and speed up delivery time. Raw materials and the printers themselves will still have to be transported, meaning the volume of items transported isn't expected to decrease dramatically, yet its ability to reduce waiting time for spare parts enhances operational readiness.

The most tangible additive manufacturing examples stem from the US Marine Corps' experience, which includes the deployment of a 3D-printed UAV, at least 40 printers to the Middle East for radios, specialised wrenches, mortar systems and medical equipment, and even experiments of a portable 'expeditionary fabrication lab' (X-FAB) unit comprised of 3D printers, a 3D scanner and CAD software for automated design and documentation.

On the European front, Germany is testing military applications of additive manufacturing, yet so far predominantly in laboratories or prototyping for single components. The French armed forces completed a test flight in 2014 with 3D printed parts on a Tornado aircraft. Two years later, Airbus unveiled a prototype of the Thor UAV with 50 3D-printed parts. The UK Royal Navy has also put forth concepts that include 3D-printed hulls for submarines and a 3D printer itself installed to print unmanned vehicles aboard future frigates. Printing and welding parts and components – or even platforms – requires digital models that can then be reverse engineered. To this end, the Royal Dutch Navy has been an early adaptor, using 3D scanning to complement printing activities and expedite the production process further.

The European Defence Agency (EDA) is spearheading initiatives further along in the research and development process, already prototyping and testing 3D printing facilities in standard containers as well



as their transport via tactical transport aircraft. Be it printing the smallest part or an entire platform, the breadth of opportunities offered by additive manufacturing also means that European militaries could choose the scale and ambition of cooperation. What is more, cooperation in additive manufacturing could remedy some of the issues that specialisation has created for countries procuring similar equipment.

Beyond the technological interest in additive manufacturing for the armed forces, the organisational elements have pros and cons. On the one hand, 3D printers can be attached to combat units of various sizes – currently down to the battalion level – or even fitted onto certain equipment like designs for future principal surface combatants. Such decentralisation of spare part production enhances the mobility and readiness of troop formations, since they become less dependent on the logistical tail. Yet on the other hand, the specialists required to operate the printers have different skillsets than those deployed in the field. To this end, the US Navy's 'Print the Fleet' project – albeit small in scale – may be instructive in that it equally emphasised incorporating 3D-printed technologies and training non-engineers to utilise them.

Artificial intelligence and nervous systems

Networking nodes in a system together is a major operational challenge for armed forces in Europe and around the globe. AI algorithms that can prioritise and manage transportation and distribution tasks have the potential to transform logistics. While automating military logistics is not a new phenomenon, especially in the US, automation lost momentum after the last 'AI winter' in the late 1980s and early 1990s. Already in the 1990s the US Army and the Defense Advanced Research Projects Agency (DARPA) recognised this with the 'DART' system, which started as a glorified Excel spreadsheet database used in the wake of the Operations Desert Shield and Desert Storm. Ever since, spreadsheets have been used as logistics management tools – but often in *ad hoc* ways.

In theory, spreadsheets have transformed logistics management. But in theatre, this transformation is far from complete: for lack of centralised, standardised management systems, combat troops have reported that simply using common sense is more reliable than forecasting equations offered in spreadsheets.

Logisticians are seeking ways to optimise the ways that information is collected, analysed and distributed. One key development to this end is that sensors have become more affordable and effective. Their

abundance means that tasks currently performed by humans can be automated. Ministries of defence are also investing in block-chain technologies to de-centralise digital ledgers, yet the proliferation of military 'apps' is unmatched in results as of yet. Going a step further, big data, AI and machine learning technologies can network them together for more complete information.

AI, big data and deep learning may minimise the manual input needed to move from less reliable, automated systems to more accurate, autonomous systems. Creating a 'nervous system' for military logistics – one with a central location to send signals when inspections are needed or precisely which parts require repair – allows a unit to operate more effectively due to more complete data links between systems and disaggregated forces. New computer programmes developed in the past year have, for example, freed up four hours per day of airmen who previously had to plan air-to-air refuelling by hand. Such examples offer hope for efficiency gains, and also demonstrate that information flow processes can leapfrog development stages from analogue to auto-flow.

This aggregated data could also automatically send fuel requirements of a unit to local production cells. Artificial intelligence systems could also divine when information needs to be sent up to higher echelons, increasing inter-unit cooperation in a systematic manner. Furthermore, such systems could also enhance interoperability between service branches, and, if pursued in a multinational context, between allies and partners throughout their military organisations.

Having more complete information about the allocation of resources because of artificial intelligence systems that aggregate and disseminate information on similar experiences increases military readiness. Known in the civilian sphere as 'anticipatory logistics', the possibility of gathering 'lessons learned' in real time could help to lift the logistical 'fog of war'. In order for these measures to enhance flexibility and responsiveness of logistics supply chains, information circulation would have to be faster and production decentralised. This would enable faster reactions on the ever-changing tactical and operational situation in terms of production, transportation and distribution.

Robotics and unmanned systems

From inspections to delivery, unmanned systems are already in use to help reduce the logistical tail. Borrowing tactics from companies like Amazon and DHL, unmanned aerial vehicles have reduced the average inspection time for aircraft from 2 hours to 15

minutes. Taking stock of where goods are stationed, unmanned vehicles also help minimise inventories, therein reducing the required manpower for convoys and thus the supply of combat troops. Unmanned cargo helicopters have been deployed for resupply since 2011: 37 US Marine Corps K-MAX helicopters were able to deliver over 1,800 tons of cargo and fly 1,730 resupply sorties in Afghanistan.

Robotics and unmanned system then lead to fewer humans active in resupply missions, which decreases the danger for deployed personnel. Furthermore, unmanned systems of various sizes and payloads make for flexible supply possibilities – from large drops for forward operating bases to small drones performing on-demand deliveries to platoons on patrol. However the introduction of the unmanned does not necessarily mean the replacement of humans: one tangible example is fitting vertical take-off and landing (VTOL) UAVs on top of supply vehicles to have them deliver goods as-the-crow-flies while a driver steers the vehicle along main roads, not having to make detours or traverse more difficult terrain.

Risks in opportunities

While these advantages are worth exploring, there are also risks associated to such changes, including potentially making armed forces more susceptible to cyber-attacks. A larger risk of severed lines of communication would unfold if convoys are no longer protected by humans. A too stark focus on ‘just-in-time’ deliveries endangers the exploitation of sudden tactical changes. ‘Just-in-time’ in its extreme can never be the objective in the military, since chance and the fog of war can alter plans easily. However, abundant reserves to enable exploitation of chances can, of course, be factored in.

Given the proliferation of civilian technologies related to logistics and the validity of the rule of growing logistic tails with increasingly complex weapon systems, it is likely that advanced countries will make use of such innovative technologies to improve the logistical systems of their armed forces. For example, governments may be reluctant to reap the benefits of additive manufacturing for the armed forces given fear that supporting security and military-related applications could lead to the proliferation of sensitive technologies to bad actors around the globe – as was the case with the US Department of State pursuing legal action against individuals that 3D-printed firearms. Hence, to ignore these changes might result in strategic disadvantages for Europe compared to potential adversaries. Through close cooperation with the US armed forces, which clearly lead in this domain, the West should aim to retain this advantage.

Tall tales or small tail?

As is always the case for modernisation, armed forces will have to strike a balance between pragmatic, less costly solutions and investments in shiny gadgets. The interest in green technologies, artificial intelligence and robotics is that they lie in between: shine as they may, cost-effective, pragmatic solutions are not out of sight. Be it incrementally retrofitting aircraft with artificially intelligent avionics or 3D printing items aboard frigates, such changes increase the speed and volume of logistics.

No single ‘silver bullet’ should be expected to radically change how logistical tasks are performed. The most significant changes are those that capitalise on the areas where new technologies make sense organisationally and operationally – as informed by feedback loops between supply chain specialists and those on the frontlines themselves. Defence procurement will be tested, too, to utilise civilian-driven technologies, whose prices will be driven down and technology cycles shortened by market forces.

Therefore the goal – and the advantage – of more efficient and distributed logistics operations would be to unlock the potential to reinvigorate combat troops within the armed forces. Through successful implementation, enhanced operational readiness and mobility would be within reach if freed resources are fed back elsewhere into the system. While such advantages should generally be motivation enough, it becomes ever more clear that improvements in mobility and distribution of troop formations are necessary if they want to survive on the battlefield of the future, where more and more adversaries are increasingly able to reconnoitre and engage concentrated forces.

The proliferation of reconnaissance-related technologies (ranging from commercial drones to satellites) and precision-guided munitions will require forces to disperse ever more. Hence, the reality is that armed forces will be forced to reconsider logistics in a changing modern combat environment, regardless of their current technological, doctrinal or organisational preferences. And in this process, some elements of this revolution in military logistics might reduce the flow of goods from the industrial base to troops, reversing a 200-year old trend.

Torben Schütz is a Managing Director at the Berlin Office for Defence Information.

Zoe Stanley-Lockman is an Associate Analyst at the EUISS.

