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Strathclyde University:

Navigating the Murky Waters of the Military Industrial Academic Complex

A follow-on case study to *Weaponising Universities: Research collaborations between UK universities and the Military Industrial Complex.*

Published by CAAT and Demilitarise Education September 2024

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Overview

This report follows on from one published earlier this year by Campaign Against Arms Trade (CAAT) and Demilitarise Education (dED_ucation), "**Weaponising Universities: Research Collaborations between UK Universities and the Military Industrial Complex**", also by Okopi Ajonye. This report discussed the background to the growth of the "Military-Industrial-Academic Complex" (MIAC) in the UK, and the key technologies for which the government and the arms industry are seeking academic partnerships, along with case studies of three universities: Imperial College London, Southampton University, and Lancaster University. This was followed by a discussion of ways in which the growth of the MIAC is being resisted by staff and students at various universities, and of how universities might seek to move away from reliance on arms industry and military funding.

The current report provides a case study of Strathclyde University. It is intended as a stand-alone report, but readers seeking more background on some of the concepts discussed in this report, such as the MIAC, Emerging & Disruptive Technologies (EDTs), Militarised Environmental Technologies (METs), or ideas such as General and Complete Disarmament (GCD), are encouraged to read *Weaponising Universities*.

The University of Strathclyde (UOS), located in Scotland, was formally established in the year 1964 by Royal Charter.[1] Similar to other universities, UOS has financial, research, and academic links to the military-industrial-academic complex (MIAC). Previous investigations revealed that UOS has invested in arms companies such as BAE Systems and Thales to the sum of £514, 200, and £615, 853 respectively.[2] Demilitarise Education's (dED) research reveals that UOS has also received considerable research and academic funding from the military, military-serving laboratories, and arms companies since 2016, as shown below.

Table: Research and Academic Funding

Military, Military-Serving Labs, and Arms Companies	Value
Rolls Royce	£13,440,192.21
Defence Science and Technology Laboratory (Dstl)	£11,535,245.94
BAE Systems	£3,504,836.45
QinetiQ	£2,654,941.12
Atomic Weapons Establishment (AWE)	£1,264,114.60
Ministry of Defence (MOD)	£1,035,234.34
Babcock International	£657,262.87
Thales	£338,563.87

UOS is also notable for being an academic member of ADS Group, the main trade association in the UK for the aerospace and defence sector.[3] By emphasising that the research portfolio in UOS is "complemented by relevant teaching programmes at undergraduate, postgraduate, and post-experience levels, that contribute to the skills agenda of the ADS sectors",[4] ADS Group not only claims that research in UOS is

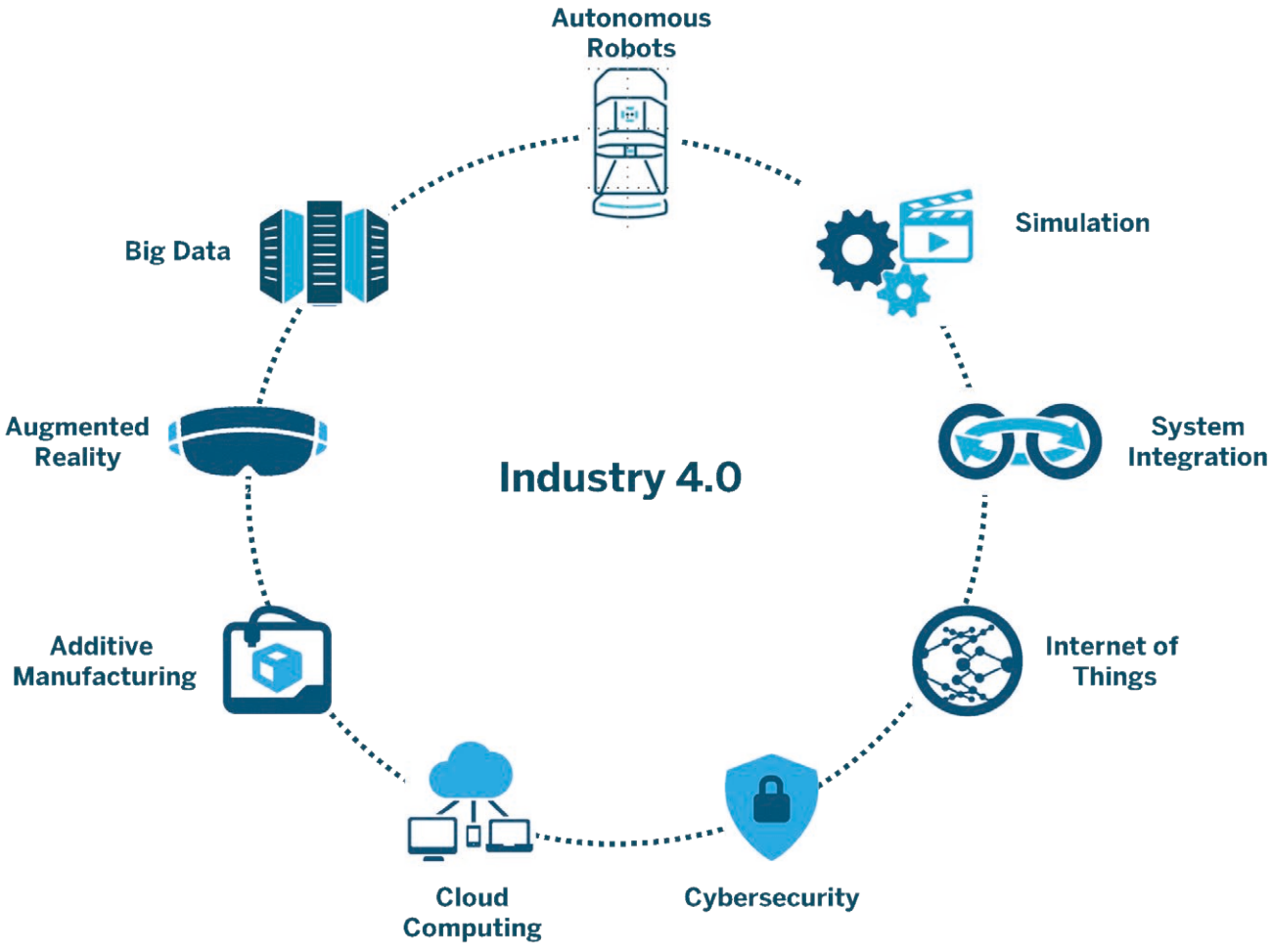
1 University of Strathclyde, Glasgow (undated). 50th Anniversary. https://bit.ly/46tH4AB
2 Briggs, B. 2021. Uni members of COP26 network invest £5.2m in fossil fuels and arms. The Ferret. https://bit.ly/4fy4WHi
3 ADS Group (undated) University of Strathclyde https://bit.ly/3YxeJaM
4 Ibid (undated)

relevant to those sectors, but that education provided by UOS is tailored to meet skills requirements of the arms industry.

Research agendas of the MIAC are often aimed at improving the economic performance of the arms industry and strengthening nuclear, conventional, and future weapons capabilities. This case study will delve into the role of UOS in this MIAC.

Industry 4.0, Conventional Weapons Systems & Lasers

The UK government has long pressured universities to generate knowledge that can drive economic growth as well as the competitiveness of various industries, including the arms industry. One such area to which academia is contributing is "Industry 4.0". Building upon the foundation laid by the "third industrial revolution", which saw information technology (IT) emerge as a driving force in the economy, Industry 4.0 aims to apply digital technologies, such as artificial intelligence (AI) and the Internet of Things (IoT), to industrial operations.[5] By providing research and development (R&D) to apply such technologies to the manufacturing operations of arms companies, universities can boost the competitiveness, profitability, and export growth of the arms industry, as well as the global insecurity, instability, and economic and environmental decline associated with the industry. One of the following cases will therefore describe how UOS is applying digital technologies to the manufacture of one category of conventional weapons systems – warships – as well as the potential consequences of these academic contributions for the arms trade.



5 Shaw, H. 2024. What's the Difference Between Industry 4.0 and Industry 3.0? Rowse. https://bit.ly/4dx2gIp

UOS is not only involved in applying digital technologies to warships but also "green" technologies. Such "green technology" reflects the military's concern with adapting military systems and infrastructure to a changing climate, and maximising warfighting capabilities in the process. These technological adaptations can hence be understood as "militarised environmental technologies" (METs). One case below will investigate and problematize UOS's role in providing METs for BAE Systems.

In addition, UOS has been associated with a facility that houses powerful lasers that sustain nuclear weapons knowledge, with potentially serious implications for non-proliferation. As the following section will show, besides contributions to nuclear and conventional capabilities, UOS also plays a highly active role in supporting the development of emerging technologies for future warfare.

Emerging and Disruptive Technologies (EDTs)

As IT increasingly underpinned the economy during the third industrial revolution, it simultaneously transformed warfare, which illustrates a historical trend in which technologies leveraged for industrial processes are simultaneously utilised for military applications.[6] Therefore, the IT-driven economy triggered a Revolution in Military Affairs (RMA) led by IT. However, whereas IT previously led the RMA, today the RMA is led by dual-use Emerging and Disruptive Technologies (EDTs), including AI.[7] Therefore, one case below will illustrate how another EDT – quantum technology – that is being applied to the economy is also shaping the current RMA. This case will show the role of UOS in adapting this technology to military use.

The perceived myriad advantages of EDTs for warfare have made such technologies objects of considerable interest to the military. Several EDTs are outlined in the MOD's Defence Technology Framework (DTF), which identifies technologies with transformative potential for the UK military. One of the following cases will show how UOS is conducting research on sensors with military applications that neatly reflects those illustrated in the DTF. More cases will describe and scrutinise UOS's participation in partnerships to develop technology to aid unmanned systems and develop hypersonic weapons, another critical EDT for the military.

6 Sheehan, M. 2014. The changing character of war. In (Eds.) Baylis, J. Owens, S. Smith, P. The Globalization of World Politics. An Introduction to International Relations. (Oxford University Press, 6th Edition) p. 221

7 Raska, M. 2021. The sixth RMA wave: Disruption in Military Affairs? Journal of Strategic Studies 44 (4) pp. 456-479. p.458

Key Research Partnerships

Table: Key partnerships at UoS

Areas of Expertise Under Investigation	Key Military/Industrial Partnerships	Value of Partnership
Industry 4.0	BAE Systems	Unknown
Militarised Environmental Technologies	BAE Systems	Unknown
Lasers	Atomic Weapons Establishment (AWE)	Unknown
Quantum Technology	QinetiQ, BAE Systems	Unknown
Sensors	Defence and Security Accelerator (DASA), Leonardo	£2.3 Million
Communications, Unmanned Systems	BAE Systems	Unknown
Hypersonic Missiles	Team Hypersonics	£1 Billion

Industry 4.0 and Shipbuilding

UOS has a longstanding collaborative relationship with BAE Systems centred on R&D for the company's warship sector and addressing BAE's workforce needs. For years UOS has worked with BAE Systems to develop a "stream of the best engineering talent into BAE Systems Naval Ships".[8] This illustrates a critical function of the MIAC as shown by UOS's membership in ADS Group: to build and maintain a robust pipeline of skilled scientists to work in the arms industry; particularly to address skills shortages in the industry.

By 2022, this relationship with BAE Systems expanded to include researchers from the Australia-based Flinders University who together with BAE Systems and UOS researchers signed a Memorandum of Understanding (MoU) to collaborate for R&D into "advanced manufacturing, digital tools and Industry 4.0 in shipbuilding".[9] According to BAE's announcement of these research ties, innovative research outputs from the MoU are to be applied to the Hunter Class Frigate program, based at the Osborne Naval Shipyard, and the future shipbuilding program based in the BAE Systems Govan shipyard on the River Clyde.[10] The Govan shipyard is notably a site of production of the Type 26 frigate Global Combat Ship (GCS) for the Royal Navy,[11] and that stands at the forefront of BAE Systems' warship exports, and strengthening the exportability of warships is a key priority for BAE Systems. As noted in the MOD's National Shipbuilding Strategy, "ships will be designed with exports in mind from the outset" and "the exportability of a ship will be a key requirement that industry must meet".[12]

Prior to this collaboration with Flinders University, and as a strategic academic partner of BAE Systems, UOS has explored the application of digital technologies to the design of complex naval warships, aiming to boost BAE Systems' manufacturing capabilities and the global export of its products.[13] This collaboration has shown dividends and may have contributed to the company's export growth. BAE Systems Naval Ships, who was the industrial partner for this project, has been credited by BAE Systems for its contribution to the economic and social development of Scotland through securing exports of the

8 British Institute of Non-Destructive Testing 2017. Strathclyde signs strategic agreement with BAE Systems. https://tinyurl.com/mpnksd76
9 Sproull, R. 2022. New research ties will advance modern manufacturing. BAE Systems https://bit.ly/4fsuANN
10 ibid 2022
11 SCA Group (undated). Type 26 Global Combat Ships – Govan & Scotsoun. https://tinyurl.com/mr2t5run
12 Ministry of Defence (undated) National Shipbuilding Strategy. Fact Sheet.
13 SRPe. (undated) Advanced Digital Manufacturing Techniques for Complex Warships. https://bit.ly/4dszBnB

Type 26 GCS.[14] In 2022, exports of ships and submarines overtook weapons technology to become the UK's second most valued military export capability.[15] UOS's research in digital technologies for shipbuilding hence plays a role in supporting and promoting the growing arms trade; specifically in warships.

Greening Warships

UOS is also applying green technologies to shipbuilding for BAE Systems. Along with the University of Southampton, UOS is working with BAE Systems to improve the energy efficiency of the company's warships.[16] Such research can contribute to the Royal Navy's ambition to possess one of the greenest fleets in the world.[17] Objectives to meet this aim goes beyond greening technology on warships to applying green infrastructure at various military dockyards and bases. For example, a Forward Logistics Centre in Portsmouth Naval Base is entirely solar powered.[18]

Such plans for a green fleet bear similarities to the U.S. Navy's "Great Green Fleet" which was supplied with fossil-free alternative fuel[19] and intended to signify the military's step towards energy efficiency and the incorporation of METs. Furthermore, U.S. military planners understood the significance of framing these environmental efforts in terms of their contributions to combat efficacy to ensure their adoption.[20] Similarly, the UK military has often emphasised the contribution of green technologies to operational efficiency and effectiveness. For example, according to the Defence Operational Strategy, the Ministry of Defence (MOD) "will seek to maximise operational advantage through its energy choices" and "harness new energy technologies in a way that enhances military capability".[21] Therefore, such green initiatives appear to be driven more by ambitions to enhance warfighting effectiveness rather than purely environmental concerns, which can fuel accusations of the Royal Navy being 'greenwashed'. For example, according

14 Scottish Affairs Committee 2022. Written evidence submitted by BAE Systems.
15 JEDHub. 2024 Annual Economic Report. Capturing and quantifying the contribution of the defence sector to the UK economy. p.21
16 BAE Systems Annual Report 2023. BAE Systems plc. p.23
17 Royal Navy News. (undated) Royal Navy aims to create one of the world's greenest fleets. https://bit.ly/3AiKY33
18 Ibid (undated)
19 Environmental and Energy Study Institute 2016. U.S. Navy Deploys "Great Green Fleet" in Bid to Reduce Military Energy Use. https://bit.ly/3LOw9bh
20 Klare, M.T. 2019. All Hell Breaking Loose. The Pentagon's Perspective on Climate Change. (Metropolitan Books).
21 Ministry of Defence (undated). Defence Operational Energy Strategy 2023. Policy Paper. GOV.UK https://tinyurl.com/2krh6rvz

to the MOD's Greening Government Commitments (GGC) for 2025, greenhouse gas (GHG) emissions from military equipment such as warships are excluded from these commitments despite such equipment accounting for two thirds of the MOD's GHG emissions.[22] Therefore, the GGC only covers military bases and installations,[23] such as the aforementioned 100% solar-powered Naval Base in Portsmouth. Such exclusions therefore suggest that the MOD's drive for a "green" fleet may not yield substantial green impact. Such scepticism is reinforced by the U.S Navy's experience with its own Green Fleet. As much as 90% of the fuel of the Great Green Fleet was still composed of ordinary petroleum, so the initiative resulted in minimal reductions in emissions.[24]

Orion

As a nuclear weapons state (NWS), the UK has neither signed nor ratified the Treaty on the Prohibition of Nuclear Weapons (TPNW), which prohibits developing, testing, producing, acquiring, possessing, stockpiling, using or threatening to use nuclear weapons.[25] The UK however has signed and ratified the Comprehensive Nuclear Test Ban Treaty (CTBT), which prohibits nuclear weapons test explosions.[26] Therefore, in order to verify the continued functioning of its nuclear weapons under the constraint of the CTBT, NWS such as the UK have developed methods to simulate the physical conditions of nuclear explosions without creating actual detonations. One of such methods is to model the physical conditions of nuclear weapons explosions through the use of lasers.[27] The Atomic Weapons Establishment (AWE), the MOD-serving lab that produces and maintains the UK's nuclear weapons, operates a facility for such work: the Orion Laser Facility, which is equipped with one of the world's most powerful lasers. UOS was one of several universities that have been granted academic access to Orion. A professor from UOS led a team that used the Orion Laser Facility for investigations into quicker and more efficient means of triggering nuclear fusion.[28] As raised by a report into UK universities and the AWE, such academic cooperation with the AWE and Orion is problematic given the dual use applications of such research.[29] Since nuclear material is dual-use, nuclear fusion has civilian applications but is also one of two means of triggering a nuclear explosion.

Furthermore, such facilities, which are intellectually aimed at retaining and expanding knowledge of nuclear weapons science,[30] directly undermines global goals for nuclear disarmament. One of such obstacles to realising nuclear disarmament is that even if nuclear weapons were eliminated, the knowledge to make them will persist.[31] The existence of the Orion Laser Facility hence ought to reinforce support for the TPNW, whose article 1(1)(a) can close the "testing loophole" of the CTBT by prohibiting non-explosive testing.[32]

22 Parkinson, S. 2023. UK military GHG emissions and the Greening Government Commitments. Technical Paper. https://tinyurl.com/aazfnfmc
23 Ibid 2023.
24 Klare, M.T. 2019. All Hell Breaking Loose. The Pentagon's Perspective on Climate Change. (Metropolitan Books).
25 United Nations Office of Disarmament Affairs (undated). Treaty on the prohibition of nuclear weapons. https://tinyurl.com/2ce2zycs
26 Foreign, Commonwealth & Development Office 2023. Comprehensive Nuclear Test Ban Treaty 25th Anniversary. GOV.UK. https://tinyurl.com/y4z4u3x7
27 Williams, H. 2023. How to Get Away with a Nuclear Weapons Test. Center for Strategic and International Studies. https://tinyurl.com/w8nyx8xk
28 AWE Nuclear Security Technologies 2024. Academic access to Orion. https://tinyurl.com/3hfzzryd
29 Langley, C. 2014. Atoms for Peace: The Atomic Weapons Establishment and UK Universities. Nuclear Information Service Medact. p.14
30 Franceschini, G. Schaper, A. 2006. Nuclear Weapons Research and Modernization Without Nuclear Testing. Peace Research Institute Frankfurt 77. p.1
31 Hanlon, M.E. 2010. Is a World Without Nuclear Weapons Really Possible? Brookings Institute. https://tinyurl.com/yc8ru5e4
32 Evans, C.P. 2020. Remedying the limitations of the CTBT? Testing under the Treaty on the Prohibition of Nuclear Weapons" Melbourne Journal of International Law 21 (1)

"Quantum Warfare"

Quantum technology, though often nebulously defined, is an EDT fundamentally rooted in applying quantum physics to real-life and practical situations.[33] Quantum technology is typically divided into three types: computing, sensing, and communications.[34] Strategic competition between the U.S., NATO states, and China and Russia heavily influence the UK's prioritisation of these technologies. The UK aims to not only become an AI superpower but also a quantum technology leader. The UK's National Quantum Strategy intends the UK to become "a leading quantum-enabled economy by 2033".[35] Despite this broader economic aspiration, the military and security sector is anticipated to spearhead research and adoption of quantum technologies.[36] The UK's Minister of State for the Armed Forces declared that quantum technology would profoundly transform warfare and emphasised the necessity of industry, the military, and science to collaborate to effectively implement this technology for the military.[37] Instances of the MIAC exploring quantum technology are rapidly emerging in the UK and proceeding apace in 2024. The role of UOS in adapting these technologies for military use appears to mostly revolve around exploring and developing quantum technologies that can significantly enhance detection and imaging capabilities on the battlefield.

QinetiQ, an arms company that is the one of the main suppliers of science and technology for the MOD, has been in partnership with UOS to investigate the workability of quantum radar concepts.[38] If effectively developed and deployed, quantum radar could usher an RMA by undermining radar signal jamming and enabling the detection of hard-to-detect objects such as stealth aircraft.[39] However, despite belief in the transformative capabilities of other quantum technologies, some U.S. military science advisers have expressed scepticism regarding the revolutionary potential of quantum radars,[40] so QinetiQ's collaboration with UOS to explore the feasibility of quantum radar concepts is likely to be instructive to such debates.

BAE Systems, in collaboration with academia, is also actively seeking to harness this technology for military purposes. BAE Systems has identified the central challenge of these technologies as understanding their capability so they can be employed to maximise military advantage and even offer additional options for "offensive capabilities", so towards this end, BAE is collaborating with universities that it has identified as leading quantum research, one of which includes UOS, who will explore quantum imaging, which is linked to quantum sensing.[41] UOS's status as a leading university in quantum technology is evidenced by its position as the only university to be a partner in all Quantum Technology Hubs funded by the Engineering & Physical Sciences Research Council (EPSRC),[42] the main government agency responsible for financing engineering and physical sciences research and training.[43]

Quantum imaging, which is the area of quantum technology UOS will explore in partnership with BAE Systems, is of interest to a certain set of military capabilities abbreviated as ISTAR, i.e. Intelligence, Surveillance, Target Acquisition, and

33 Hughes-Castleberry, K. 2021. Quantum Warfare. The Quantum Insider. https://tinyurl.com/3s6bsxnj
34 Ibid 2021
35 Department for Science, Innovation, and Technology. 2023. National Quantum Strategy. p.10
36 Brown, R. (undated). Quantum Leap. Innovators. BAE Systems https://tinyurl.com/ytx7r8cn
37 White, A. 2023. Military planes should be built with quantum tech in mind: UK Official. Breaking Defense. https://tinyurl.com/yv74fcxx
38 QinetiQ 2018 Quantum Technology University Engagement. Case Study.
39 Gagaridis, A. 2021. Warfare Evolved: Quantum Radar. Geopolitical Monitor. https://tinyurl.com/345e8hxc
40 Tingley, B. 2021. Quantum Radar Offers No Benefits to the Military Say Pentagon Science Advisers. The Warzone. https://tinyurl.com/yc3yrjzp
41 Brown, R. (undated). Quantum Leap. Innovators. BAE Systems https://tinyurl.com/ytx7r8cn
42 University of Strathclyde, Glasgow. 2022. Two international quantum networks to be led at Strathclyde https://tinyurl.com/4fbe5u4u
43 GOV.UK (undated) About us. Engineering and Physical Sciences Research Council. https://tinyurl.com/3m8pdcra

Reconnaissance.[44] Such technology is "capable of detecting gases, and of detecting objects around corners, through buildings, fog, smoke, or dust…able to build images under conditions of very low light".[45]

In a report by the University of Hamburg critical of EDTs, quantum for "C4ISR" (command, control, communications, computers (C4) Intelligence, Surveillance, and Reconnaissance (ISR)), was distinguished as capable of providing humanitarian benefits by enhancing the principle of distinction and improving the accuracy of targeting, but such technology could also diminish accountability for violations of humanitarian principles by increasing anonymity and muddying the chain of decision making.[46] Similar to AI's applications in weapons systems, quantum technology may hence weaken or erode existing accountability structures in warfare. Given the relatively nascent stage of quantum technologies, and the critical role of academia in their subsequent development, it is vital for researchers to be cognizant of such risks.

As the following examples will show, UOS is involved in additional military/industrial partnerships to develop technologies that similarly accelerate the RMA by enhancing the visibility and situational awareness of the battlefield.

Sensors

Sensors are among the technology families singled out by the MOD's DTF. One example of "Illustrative defence applications" of sensors provided by the DTF is the "identification and accurate location of targets of interest".[47] Along with other universities, in 2020, UOS was awarded contracts worth $2.3 million by the Defence And Security Accelerator (DASA), the government-led initiative to pursue innovative and disruptive technologies for the military and security sectors, to develop and improve novel sensor technology, specifically Electro-Optics and Infrared (EOIR) sensor capability. Several of the potential military applications of this technology listed as part of this announcement include "imaging in difficult environments, detecting and identifying small targets such as drones, snipers, people, weapons, and vehicles, identifying objects more than twenty kilometres away and classify friendly or adversary vehicles".[48] These features also augment the capability of fighter aircraft to drop precision-guided munitions.[49] Therefore, such applications, which are similar to those provided by quantum radars and imaging as previously described, demonstrate explicit military R&D being carried out in UOS.

Leonardo, a participant in the development of the Tempest Future Combat Aircraft System (FCAS), the planned successor to the UK's Typhoon fighter aircraft, has worked with UOS on hyperspectral imaging, which can be used to derive situational awareness from sensors equipped on fighter aircraft.[50]

AI is essential to process the massive amount of data collected by sensors.[51] Israel has been distinguished for innovatively adopting AI to analyse data collected from sensors and other sources from the battlefield.[52] However, these AI systems have generated "kill lists"

44 Krelina, M. 2021. Quantum Warfare: Definitions, Overview, and Challenges. EPJ Quantum Technology 8, 24. p.23
45 Thiele, R. 2020. Quantum sciences – A disruptive innovation in hybrid warfare. Hybrid CoE Working Paper 7. p.8
46 Favaro, M. Kühn, U. Renic, 2022. Negative Multiplicity. Forecasting the Future Impact of Emerging Technologies on International Stability and Human Security. Institute for Peace Research and Security Policy. Research Report 010. p.86
47 Ministry of Defence 2019. Defence Technology Framework. Defence Science and Technology. p.24
48 DASA, Dstl, MOD 2020. DASA Awards £2.3 million to develop novel sensor technology. GOV.UK https://tinyurl.com/3wk44h9j
49 Wilson, J.R. 2016. EO/IR sensors boost situational awareness. Military + Aerospace Electronics. https://tinyurl.com/mry9p8ah
50 Team Tempest (undated). Tempest: Innovation for UK security and prosperity. p.14
51 Stratfor Worldview 2019. Sensor Proliferation is Changing How We Wage War. Real Clear Defense https://tinyurl.com/2styewx5
52 Sylvia, N. 2024. The Israeli Defense Forces' Use of AI in Gaza: A Case of Misplaced Purpose. Royal United Services Institute. https://tinyurl.com/ywk9knx5

based on raw intelligence that military officers are not required to interrogate, which has resulted in significant civilian casualties.[53] This outcome confirms fears that AI systems can precipitate automation bias, which occurs when humans excessively rely on these systems and assume their information is infallible. Therefore, to the extent that sensors depend on AI, then the limitations and dangers inherent in AI diminish the capacity of sensors to reduce collateral damage.

MarTacNet

Advancements in sensors and AI also facilitate the RMA through automating several aspects of military operations. Unmanned systems empowered by these advancements exhibit significant capabilities such as executing tasks too risky for human operators, operating with minimal human oversight, and functioning for periods longer than human operators are capable of.[54] UOS has developed technology applicable to unmanned systems, and thus contributed to these capabilities. In 2016, the Royal Navy launched the Unmanned Warrior exercise, then advertised as the first of its kind, in which BAE Systems was a key participant alongside several other arms companies to exhibit combat and unmanned naval systems. A notable part of BAE Systems's showcase was MarcTacNet, which enabled multiple vehicles from various suppliers to effectively communicate during unmanned operations.[55] dED's research reveals that UOS received funding for Phase 1 of the development of MarTacNet. Informations and communications technology (ICT) companies – Cloudnet IT Solutions, 6Harmonics, and Fairspectrum[56] – also contributed to the development of MarcTacNet, which together with UOS's involvement highlights the growing reliance of the military on the private ICT sector and universities for innovative and disruptive R&D; particularly into EDTs. Furthermore, given that ensuring effective communications is one of the key challenges of operating unmanned systems, particularly at sea,[57] such technological contributions from UOS and these ICT companies could be effective for the deployment of unmanned systems and thus satisfy a significant military need.

Unmanned aerial systems have been shown to leave lasting impacts on human beings, leading to a psychological phenomenon termed "anticipatory anxiety", which stems from a ubiquitous fear of surveillance and/or an imminent strike.[58] Additionally, these technologies have strategic implications. The previously stated advantages of unmanned systems may also lower the political costs of war and therefore increase military risk-taking and adventurism.[59] So in conjunction with advancing industry 4.0 technologies to the manufacturing operations of arms companies, UOS has contributed to both reducing the economic costs of developing military technology and potentially lowering the political costs of armed conflict; thus raising dangers to strategic stability. While these cost reductions can incentivise armed conflict, as the following section will show, UOS is involved in the development of other seemingly revolutionary military technologies that could inadvertently lead to a dramatic escalation of military crises.

53 Abraham Y. 2024. "Lavender": The AI machine directing Israel's bombing spree in Gaza. +972 Magazine. https://tinyurl.com/me5djrdj
54 Roblin, S. 2024. Future Force: Impact of Autonomous Systems on the Defense Sector. Inside Unmanned Systems. https://tinyurl.com/3xyu53d5
55 Davis, S. 2016. We demonstrate our autonomous naval technologies in the solent. BAE Systems https://tinyurl.com/2f3d8urc
56 Ibid 2016
57 Burt, P. 2024. The Next Wave: The Use of Military Drones in the World's Oceans. Drone Wars UK. p.6
58 Ferguson et al 2017. Psychological Dimensions of Drone Warfare. Current Psychology 38, pp.1285-1296. p.1291
59 Burt, P. 2024. The Next Wave: The Use of Military Drones in the World's Oceans. Drone Wars UK. p.41

Hypersonic Missiles

Hypersonic missiles are capable of travelling at Mach 5 or "hypersonic" speeds i.e. five times the speed of sound, and manoeuvring during flight. Following Russia's invasion of Ukraine, Russia deployed hypersonic missiles, which also struck civilian infrastructure and marked the first use of hypersonic weapons.[60] In May 2024, UOS, along with other universities became eligible for a programme titled the Hypersonic Technology & Capability Development Framework to develop a hypersonic missile capability for the UK.[61] This outcome follows nearly a year after the MOD's announcement of a Team Hypersonics partnership to develop a hypersonic strike capability in collaboration with industry and academia ready to deploy in 2030, so Team Hypersonics is leading this framework.[62] In contrast to AI and quantum technologies, the UK is pursuing this EDT to "catch up" with the U.S., Russia, and China, who have hitherto collectively accounted for most of the global investment into hypersonic weapons.[63]

The hypersonic speeds at which such missiles fly sharply reduces the reaction time available to targets. This shortened timeline increases the risk of miscalculation and crisis escalation.[64] On the other hand, according to a comparative analysis conducted by the Union of Concerned Scientists, hypersonic weapons are no faster, accurate, and better able to evade enemy missile defences than existing ballistic missiles, and their greater manoeuvrability may even come at the expense of reduced flight speed and range.[65] These views contribute to broader arguments that are sceptical of the capacity of emerging technologies such as quantum radars, as previously described, and AI and hypersonic weapons to trigger an RMA and offer decisive military advantages. Such sceptics argue that these technologies may instead introduce new risks and dangers. In the case of hypersonic weapons, such risks and dangers are often linked to the kinds of "ambiguity" imbued by these weapons, both of which may provoke nuclear retaliation from an adversary. Firstly, adversaries may be unable to determine the final target of a hypersonic strike due to the high manoeuvrability of such weapons, but if adversaries believe that their strategic nuclear forces are the final target, then they may retaliate with nuclear weapons.[66] Secondly, an adversary may confuse a conventionally armed hypersonic cruise missile or glide vehicle for a nuclear armed one since hypersonic strikes are capable of carrying nuclear and conventional warheads, and as a result, may retaliate with a nuclear strike.[67] The development and deployment of a hypersonic strike can hence cause a "conventional" conflict to escalate to a nuclear one, thus endangering global security.

60 The Associated Press 2023. Why would Russia use hypersonic missile to strike Ukraine? https://tinyurl.com/ycx2m2pd
61 DES Comms 2024. DE&S to award contracts on £1 billion framework to develop UK's first hypersonic missile. Ministry of Defence DE&S https://tinyurl.com/24mev7ww
62 Martin, T. 2023. UK launches Team Hypersonics in bid to eventually develop "hypersonic strike capabilities at pace" Breaking Defense. https://tinyurl.com/mwra4n86
63 Saballa, J. 2024. UK to Deploy First Domestically-Made Hypersonic Missile by 2030. The Defense Post. https://tinyurl.com/52te4u5m
64 Bugos, S. Reif, K. 2021. Understanding Hypersonic Weapons: Managing the Allure and the Risks. Arms Control Association. p.17
65 Union of Concerned Scientists 2021. Slowing the Hypersonic Arms Race. A Rational Approach to an Emerging Missile Technology. p.2
66 Batsanov, S. Miletic, K. 2020. What are the risks associated with hypersonic weapons? Pugwash Briefing Paper, Hypersonic Weapons Series #6, p.3
67 Ibid 2020. p.3

Resistance and Alternatives

In 2009, following Israeli military actions in Gaza against civilians, UOS students undertook decisive action by voting to sever ties with BAE Systems as part of a motion submitted to the highest decision-making body for students.[68] This action followed an occupation of the McCance building, the main administration building for UOS.[69] Students had uncovered, through the Freedom of Information Act (FOIA), evidence of joint research projects between the university's engineering department and BAE Systems[70] This protest was part of a larger wave of student protests that spread across UK universities in 2009 against the war in Gaza at the time;[71] similar to the campus protests against the war in Gaza beginning from late 2023. During the protests in 2009, some engineering students expressed concerns of the impact of severing relationships with BAE Systems on their future careers, which were accommodated by one demand by student protesters to investigate alternative funding sources for the Engineering Department.[72] One potential avenue for addressing such career concerns is located in the green sector. Contrary to greenwashing the military and steering graduates into arms companies to fill skill gaps, engineering talent can be redirected towards the renewable energy sector to address critical skills shortages which, if left unaddressed, threatens UN climate targets and by extension global efforts to combat climate change.[73]

However, as shown by this report, research collaboration with BAE Systems and other arms companies and the military is not only ongoing but likely to be intensified by the military's pursuit of technologies such as EDTs and METs. Beyond alternative student careers, demands raised in protests in 2009 can hence be extended in three ways to confront new and ongoing realities. Firstly, a strategy to demilitarise UOS can

68 Ahmad, I. 2009 Victory for student movement: Strathclyde University to end complicity with Gaza conflict. Pulse Media. https://tinyurl.com/3vphrcyc
69 Thomson, D. 2009. Strathclyde University Occupied by Students. Indymedia UK https://tinyurl.com/3cw9zemt
70 Ibid 2009
71 Benjamin, A. Lipsett, A. Storm of student protest over Gaza gathers force. The Guardian https://tinyurl.com/msjbje6a
72 Ahmad, I. 2009 Victory for student movement: Strathclyde University to end complicity with Gaza conflict. Pulse Media. https://tinyurl.com/3vphrcyc
73 Amelang, S. 2023. Skills shortage delays global energy transition, puts climate targets risk – report. Clean Energy Wire. https://tinyurl.com/yjmet8zt

be broadened to include addressing the dual-use challenges posed by these emerging technologies. Secondly, protection for students and alternative funding sources in the event of terminating military-industrial contracts can be extended to the researchers, communities, and workers dependent on such contracts. Third, such planning for conversion can complement advocacy for international discussion to address the insecurity driven by the arms race, reverse the arms trade, and reduce and regulate nuclear, conventional, and future weapons capabilities such as hypersonic missiles.

NPT and General and Complete Disarmament

As previously stated, support for the TPNW can effectively address the loophole of non-explosive testing in the CTBT, which can further the CTBT's intent to promote nuclear disarmament and strengthen the Non Proliferation Treaty (NPT). However, Article VI of the NPT also calls for general and complete disarmament (GCD), which supplements nuclear disarmament by including the diminution and regulation of conventional weapons.[74] The significance of GCD is illustrated by the advent of future weapons technologies such as hypersonic weapons, which, as previously shown, can escalate conventional conflicts into nuclear ones. Additionally, such technology should draw attention to a gap in existing arms control treaties that have not addressed such dual-capable missiles that could function as conventional weapons and delivery vehicles for weapons of mass destruction.[75] Academia can play a crucial role in progressing GCD by providing additional investigations of this nexus between nuclear disarmament and conventional arms control, given the small attention provided by the academic community to this issue and GCD.[76] Academic contributions can also be provided to the development community by investigating the socio-economic dimensions of GCD and the scale of resources diverted to military purposes and away from addressing human security and development needs.[77]

Taken together, pursuing peace and demilitarisation requires an interdisciplinary approach combining natural and social sciences. Social science and its sub-disciplinary approaches, such as peace studies, development studies, and political economy, can address international security dynamics and the political and socio-economic dimensions of the arms trade and disarmament; while natural science approaches provide technological solutions and civilian alternatives, as discussed in the next section.

Economic Conversion

The strong concentration of the military and arms industry's maritime presence in Scotland necessitates a conversion of military-focused shipbuilding to civilian and commercial shipbuilding. The decay of commercial shipbuilding in states such as the U.S. and UK has historically made the shipbuilding sector a prime focus for broader economic conversion efforts.[78] However, if researchers in science, technology, engineering, and mathematics (STEM) disciplines are heavily dependent on contracts

74 Department for Disarmament Affairs 2005. United Nations. The Treaty on the Non-proliferation of Nuclear Weapons. 2005 Review Conference of the Parties to the Treaty on the NPT. https://tinyurl.com/yap9c9cd

75 Benedict, K. 2016. Preface. Setting the doomsday clock back from midnight with general and complete disarmament. In (Eds.) United Nations Office for Disarmament Affairs. Rethinking General and Complete Disarmament in the Twenty-First Century. United Nations. p.viii

76 Finaud, M. 2016. Reconciling national security and general and complete disarmament. In (Eds.) United Nations Office for Disarmament Affairs. Rethinking General and Complete Disarmament in the Twenty-First Century. United Nations. p.42

77 Ibid 2016, p.43-44

78 Peattie, L. 1988. Economic Conversion as a Set of Organizing Ideas. In Thee, M. Dumas, J. (Eds.) Making Peace Possible. (Pergamon Press, Great Britain)

for shipbuilding, and commercial shipbuilding is largely stagnant, then the capacity of academics to promote civilian research alternatives can also be strengthened by the simultaneous economic conversion of the surrounding economy and shipbuilding sector. As noted by GMB, one of the largest unions in the UK, the long-term dependence of large commercial companies on military contracts for shipbuilding and refusal to diversity has resulted in job losses.[79] Therefore, joint initiatives can be formed between academia, local communities, and trade unions for local job creation and conversion. Furthermore, both academics and workers dependent on military funding can gain added security from developing civilian alternatives in the event of funding cutbacks from the military-industrial complex. This also illustrates how plans for economic conversion in universities must adapt to the particular local and regional context in which universities are located.

Dual Use Guidelines

Universities should investigate and implement stringent guidelines to ensure that work such as those linked to the AWE and EDTs do not contribute to nuclear weapons development or weapons systems respectively. Yet, as also shown in the case of quantum technologies, universities can consciously pursue military research into dual-use technologies. Students can collaborate with staff to campaign and lobby their student unions and/or administrations to introduce controls to prevent the weaponization of such dual-use technologies.

79 Turner, L. 2018. Turning the Tide: Rebuilding the UK's Defence Shipbuilding and the Fleet Solid Support Order. GMB Making It, Campaign for Manufacturing Jobs. p.24

Conclusions and Recommendations

UOS plays a role in the MIAC through supporting recruitment and R&D for warship technologies, which has provided economic and PR benefits to BAE Systems. Such research however has contributed to the growth and greenwash of the global arms trade. The arms trade provides economic benefits to arms companies but imposes significant opportunity costs on its employees, the wider community, and the natural environment, as well as contributing to escalating global insecurity and instability. Redirecting government spending and academic resources to the civilian and green sector would provide quantitative and qualitative improvements. More employment, ethical jobs, improved manufacturing, and environmental sustainability could be generated from such investment. Additionally, UOS has played a role in the MIAC through conducting research in facilities aimed at securing nuclear weapons knowledge, and aiding the development of future military capabilities such as unmanned systems and hypersonic weapons. Considering the threats these existing and emerging capabilities pose to global security and strategic stability, academia can instead play a crucial role in advancing global security through support for disarmament at the international level.

The following recommendations are for universities themselves, and for concerned staff, students, and civil society groups to consider in addressing the implications of UOS's involvement in the MIAC.

Recommendations for students, staff, and civil society

- Advocate for the UK government to support the Treaty on the Prohibition of Nuclear Weapons.
- Advocate for dual-use codes of conduct to prevent the weaponization of dual-use technologies.
- Encourage governments and civil society to raise discussions and participate in international forums on general and complete disarmament. This can involve organising conferences, presentations, or putting such an item on the agenda at high level meetings.
- Organise forums to gather inputs from key stakeholders in military shipbuilding, such as local communities and trade unions, to understand their perspectives and concerns.

Recommendations for Universities

- Ensure that research projects with military-industrial partners are fully transparent, including their purpose, funding, and anticipated outcomes.
- Require academics to report dual-use issues emerging from research proposals submitted to ethics committees.

Recommendations for staff

- Conduct and disseminate investigations into the nexus between nuclear disarmament and conventional arms control, and the opportunity costs of diverting resources to the military sector.
- Avoid collaboration with facilities intended to maintain nuclear weapons knowledge.
- Organise concerned faculty into alternative-use committees dedicated to designing civilian alternatives to military research, such as commercial shipbuilding.

CAMPAIGN
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education