NORTH ATLANTIC TREATY ORGANIZATION

SCIENCE AND TECHNOLOGY ORGANIZATION

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STO TECHNICAL REPORT **TR-HFM-ST-335-A**

Biotechnology, Human Enhancement and Human Augmentation: A Way Ahead for Research and Policy

(Biotechnologie, amélioration et augmentation de l'être humain : marche à suivre pour la recherche et les politiques)

The present report provides a way ahead for challenges around BHEA as seen through a security and compliance lens by proposing recommendations for creating international coherence. It is hoped that the NATO STO panels, especially the HFM panel, use the recommendations proposed herein to steer their respective programmes of work.

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The NATO Science and Technology Organization

Science & Technology (S&T) in the NATO context is defined as the selective and rigorous generation and application of state-of-the-art, validated knowledge for defence and security purposes. S&T activities embrace scientific research, technology development, transition, application and field-testing, experimentation and a range of related scientific activities that include systems engineering, operational research and analysis, synthesis, integration and validation of knowledge derived through the scientific method.

In NATO, S&T is addressed using different business models, namely a collaborative business model where NATO provides a forum where NATO Nations and partner Nations elect to use their national resources to define, conduct and promote cooperative research and information exchange, and secondly an in-house delivery business model where S&T activities are conducted in a NATO dedicated executive body, having its own personnel, capabilities and infrastructure.

The mission of the NATO Science & Technology Organization (STO) is to help position the Nations' and NATO's S&T investments as a strategic enabler of the knowledge and technology advantage for the defence and security posture of NATO Nations and partner Nations, by conducting and promoting S&T activities that augment and leverage the capabilities and programmes of the Alliance, of the NATO Nations and the partner Nations, in support of NATO's objectives, and contributing to NATO's ability to enable and influence security and defence related capability development and threat mitigation in NATO Nations and partner Nations, in accordance with NATO policies.

The total spectrum of this collaborative effort is addressed by six Technical Panels who manage a wide range of scientific research activities, a Group specialising in modelling and simulation, plus a Committee dedicated to supporting the information management needs of the organization.

- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS System Analysis and Studies Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These Panels and Group are the power-house of the collaborative model and are made up of national representatives as well as recognised world-class scientists, engineers and information specialists. In addition to providing critical technical oversight, they also provide a communication link to military users and other NATO bodies.

The scientific and technological work is carried out by Technical Teams, created under one or more of these eight bodies, for specific research activities which have a defined duration. These research activities can take a variety of forms, including Task Groups, Workshops, Symposia, Specialists' Meetings, Lecture Series and Technical Courses.

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List of Acronyms

ACT	Allied Command Transformation
BHEA	Biotechnologies and Human Enhancement/Augmentation
BTWC	Biological and Toxins Weapons Convention
COMEDS	Committee of the Chiefs of Military Medical Services
DPP	Defence Policy and Planning Committee, NATO
EDT	Emerging and Disruptive Technologies
ESC	Emerging Security Challenges Division, NATO
HFM	Human Factors and Medicine
HQ	Headquarters
IST	Information Systems Technology
JISD	Joint Intelligence and Security Division
LED	Light Emitting Diode
MilMeD COE	Centre of Excellence for Military Medicine
NATO	North Atlantic Treaty Organization
NExTRAC	Novel and Exceptional Technology Advisory Committee
PREPARE	One of the clusters considered during EDT discussions
RFID	Radio Frequency Identification
RST	Research Specialist Team
RTG	Research Task Group
SAS	Systems Analysis and Studies
SME	Subject Matter Expert
STB	Science and Technology Board
STO	Science and Technology Organization
TRL	Technology Readiness Level

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Biotechnology, Human Enhancement and Human Augmentation: A Way Ahead for Research and Policy

(STO-TR-HFM-ST-335-A)

Executive Summary

Biotechnologies and Human Enhancement/Augmentation (BHEA) are one of the eight Emerging and Disruptive Technologies (EDT) identified by the NATO Science & Technology Board. The way head for research and policy to address the security and compliance challenges surrounding the deployment of biotechnologies in pursuit of human enhancement and augmentation is explored in this paper which follows the main report by the NATO Human Factors & Medicine (HFM) Research Specialist Team (RST)-335. The ST was convened to generate a high level, comprehensive overview of biotechnologies that are relevant to operators. BHEA is not only a key EDT, it is as such, of interest to the wider international S&T, and operational communities (e.g., militaries, paramilitary forces). The objective of the present report is to provide a focused understanding of the regulatory challenges around BHEA as seen through a security and compliance lens; highlighting the opportunities to create international coherence in the development of an appropriate governing framework. The overall intent is for the NATO bodies, including but not limited to the HFM panel, to use the recommendations proposed herein to steer their respective programmes of work.

Background

Biotechnology is a broad discipline in which biological processes, cells, or cellular components are exploited to develop products and new technologies for specific purposes. One of the potential uses for biotechnology is to enhance and/or augment the human. Human enhancement, broadly defined, is the process to extend physical form or cognitive, physiological, sensory or social functions beyond baseline biological potential (STO-TR-HFM-335). By extension, human augmentation is an amplification of performance above the baseline. The increasing adoption of biotechnology into everyday life brings with it a number of ethical, legal, moral, and social challenges. Its potential use in an operational context, raises even more ethical concerns. From a security perspective, the development of new sensors and new sources of data generates new avenues for adversaries to obtain and exploit personal information or location data, potentially placing users' physical integrity under risk. The existing regulation around data protection places the onus on each state to protect the rights and safety of its citizens and serving personnel. From a compliance perspective, the implementation of novel technology may require new legal definitions that adhere to existing international humanitarian law as well new governance mechanisms. The appropriate oversight for assessing and responding to the legal and ethical challenges of human enhancement, will require cross-disciplinary expertise from across the allied nations. It falls to existing international bodies to provide an agreed legal framework for the use of biotechnologies for human enhancement. The absence of such effort will impact on interoperability between allies and maneuverability against the adversary. Recommendations were synthesized from a number of existing unclassified NATO reports including STO-TR-HFM-ST-335 and NIAG SG-253. The recommendations are aligned to the five-pillar framework outlined in the HFM-ST-335 report (Naik et al. 2021 STO-TR-HFM-ST-335), as a basis to structure future HFM activities against the NATO capabilities. The recommendations, broadly construed, are to support preparation of Allied use of biotechnologies in an operational context. More specifically, the recommendations provide a way ahead in terms of evaluating the technical maturity of developments in biotechnology, Human Enhancement/Augmentation (BHEA) research; developing a framework to assess the ethical, social, legal,

and environmental issues and; a route to establish the international governance of operational bioethics. The present report will be of interest to those setting the agenda for policy within NATO Headquarters (HQ) as well as those directing future research areas within the NATO Science and Technology Organization (STO) Panels. This includes other NATO bodies such as Allied Command Transformation (ACT), the Committee of the Chiefs of Military Medical Services (COMEDS), and the Centre of Excellence for Military Medicine (MilMeD COE).

Biotechnologie, amélioration et augmentation de l'être humain : marche à suivre pour la recherche et les politiques

(STO-TR-HFM-ST-335-A)

Synthèse

Les biotechnologies et l'amélioration/augmentation de l'être humain (BHEA) sont l'une des huit technologies émergentes et révolutionnaires (EDT) identifiées par le Comité pour la science et la technologie de l'OTAN. Le présent article explore la marche à suivre pour la recherche et les politiques face aux difficultés, en matière de sûreté et de conformité, liées au déploiement des technologies pour améliorer et augmenter l'être humain. Il suit le rapport principal de l'équipe de chercheurs spécialisés RST-335 de la Commission sur les facteurs humains et la médecine (HFM) de l'OTAN. L'équipe spécialisée a été réunie pour donner une vue d'ensemble de haut niveau des biotechnologies pertinentes pour les opérateurs. Les BHEA ne sont pas seulement une EDT essentielle, elles intéressent plus largement les communautés de S&T et des opérations (par exemple, les forces militaires et paramilitaires). L'objectif du présent rapport est de présenter de manière synthétique les défis réglementaires qui entourent les BHEA, sous l'angle de la sûreté et de la conformité, tout en mettant en évidence les opportunités pour créer une cohérence internationale de développement d'un cadre adéquat. L'intention générale est que les organes de l'OTAN, notamment la Commission HFM, utilisent les présentes recommandations pour piloter leur propre programme de travaux.

La biotechnologie préexistante est une vaste discipline dans laquelle les processus biologiques, cellules ou composants cellulaires sont exploités pour développer des produits et de nouvelles technologies à des fins spécifiques. L'un des usages potentiels de la biotechnologie est d'améliorer et/ou augmenter l'être humain. L'amélioration de l'être humain, de manière générale, est le processus qui consiste à prolonger la forme physique ou les fonctions cognitives, physiologiques, sensorielles ou sociales au-delà du potentiel biologique de base (STO-TR-HFM-335). Par extension, l'augmentation de l'être humain est une amplification des performances de base. L'adoption croissante de la biotechnologie dans la vie quotidienne entraîne un certain nombre de problèmes éthiques, juridiques, moraux et sociaux. Son usage potentiel dans un contexte opérationnel suscite encore plus d'inquiétudes éthiques. Du point de vue de la sûreté, le développement de nouveaux capteurs et de nouvelles sources de données ouvre de nouveaux boulevards aux adversaires cherchant à obtenir et exploiter des informations personnelles ou des données de localisation, ce qui met en danger l'intégrité physique des utilisateurs. La réglementation existante de protection des données attribue à chaque État la responsabilité de protéger les droits et la sécurité de ses citoyens et de son personnel en service. Du point de vue de la conformité, la mise en œuvre d'une nouvelle technologie peut nécessiter de nouvelles définitions légales respectant le droit humanitaire international, ainsi que de nouveaux mécanismes de gouvernance. La supervision adaptée pour évaluer et répondre aux défis juridiques et éthiques de l'amélioration de l'être humain nécessitera une expertise interdisciplinaire de tous les pays alliés. Il incombe aux organes internationaux existants de fournir un cadre légal convenu à l'utilisation des biotechnologies améliorant l'être humain. L'absence de ce cadre sera préjudiciable à l'interopérabilité entre les alliés et à la manœuvrabilité contre les adversaires. Les recommandations ont été synthétisées à partir d'un certain nombre de rapports non classifiés de l'OTAN, incluant STO-TR-HFM-ST-335 et NIAG SG-253. Les recommandations s'alignent sur les cinq piliers décrits dans le rapport HFM-ST-335 (Naik et al. 2021 STO-TR-HFM-ST-335), afin de structurer les futures activités HFM au regard des capacités de l'OTAN. Les recommandations, interprétées de manière large, sont censées soutenir

la préparation de l'usage des biotechnologies par l'OTAN dans un contexte opérationnel. Plus précisément, les recommandations fournissent une marche à suivre en termes de : 1) évaluation de la maturité technique des évolutions de la recherche en biotechnologie, amélioration et augmentation de l'être humain (BHEA), 2) développement d'un cadre d'évaluation des questions éthiques, sociales, juridiques et environnementales et 3) voie à suivre pour établir la gouvernance internationale d'une bioéthique opérationnelle. Le présent rapport intéressera ceux qui établissent l'ordre du jour politique au sein de l'état-major de l'OTAN (HQ), ainsi que ceux dirigeant les futurs domaines de recherche au sein des commissions de l'Organisation pour la science et la technologie de l'OTAN. Cela inclut d'autres organes de l'OTAN tels que le Commandement allié Transformation (ACT), le Comité des chefs des services de santé militaires au sein de l'OTAN (COMEDS) et le Centre d'excellence pour la médecine militaire (MilMeD COE).

BIOTECHNOLOGY, HUMAN ENHANCEMENT AND HUMAN AUGMENTATION: A WAY AHEAD FOR RESEARCH AND POLICY

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1.0 INTRODUCTION

1.1 Background

1.1.1 NATO Human Factors and Medicine (HFM) Research Specialist Team (RST) – 335 Mandate

The NATO Human Factors and Medicine (HFM) Research Specialist Team (RST) – 335 was convened to generate a high-level, comprehensive overview of biotechnologies that may be used for improving human physical, cognitive, physiological, sensory, or social functions for defence applications. Biotechnologies and Human Enhancement/Augmentation (BHEA) are one of the eight Emerging and Disruptive Technologies (EDT) approved by the NATO Science and Technology Board (STB) [1].

The work of NATO HFM-335 revolves around the following objectives/tasks:

- Identify the most promising S&T work strands in the context of warfighter performance, military medicine, force protection and biosecurity and its compliance; and their military relevance through a horizon scan.
- Produce a short, high-level overview of the key applications of Biotechnologies[1] used for Human Enhancement /Augmentation[2] with potential for causing disruption.
- Identify future research areas and activities for S&T Organization panels.

The RST used a five-pillar approach: i) Warfighter systems; ii) Warfighter performance; iii) Force protection; iv) Military medicine; and v) Security and compliance to identify areas of interest and relevance to operators.

While the first 4 pillars are capabilities, the security and compliance pillar extends across all of biotechnology and the other 4 pillars.

1.1.2 Ethical and Legal Considerations of BHEA

Recent publications (NATO NIAG-SG-253, DCDC, and EBRC, among others [2], [3], [4]) indicate nations are exploring the use of biotechnologies to enhance their militaries, medicine for their warfighters and the

[1] **Biotechnology** is a broad discipline in which biological processes, cells or cellular components are exploited to develop products and new technologies.

[2] **Human enhancement** is the process to impact physical, cognitive, physiological, sensory or social functions beyond normal performance.

personnel themselves. This raises issues that must be considered by the international community. For example, there are vast differences in the ethical and regulatory frameworks used by nations to guide the research, development and use of biotechnology for enhancing or augmenting human performance. All these elements are associated with compliance to ethical principles, domestically and internationally, and therefore should be considered through the ethical and legal lens by the international community.

1.2 Security and Compliance Pillar Approach

The Security and Compliance pillar team examined security and compliance challenges that may arise with the use of different biotechnologies intended to enhance or augment the warfighter. As well, while being cognizant of implications for impact of Biotechnological advancements on the planetary environment, the team limited its scope to only those advances as the ones that had a direct bearing on NATO and Defence end goals. By way of example, the team considered the legal, moral and ethical challenges based on the deliberations of NATO STB on EDTs, specifically the PREPARE Cluster. Further, NATO STB proposes the use of the following three assessment criteria: Operational Urgency,[3] Technology Maturity,[4] and Policy Maturity[5] to guide evaluation of each proposed activity to ensure the Panels and Groups focus available resources on the most pressing areas; AND consider the Status of Research with respect to overlaps between previous and ongoing activities and the need for further investigation.

Using the approach outlined above, the team make seven agenda-setting recommendations for a way ahead for research and policy partitioned into compliance and security, respectively (see Section 2). The report concludes with an analytical table showing the application of the recommendations across the 4 capability pillars in the main report (see Section 3).

[3] The Panels and Group in collaboration with colleagues in NATO Allied Command Transformation (ACT) and Joint Intelligence and Security Division (JISD) should consider the threats and vulnerabilities currently faced by NATO and the associated operational need for solutions. The opportunity space to gain operational advantage should also be considered.

[4] The Panels and Group should examine the technology maturity of the EDTs, not only in isolation but also to the degree that differing maturity levels may impact the implications of technology convergences. They should consider the competing priorities of moving high TRL technologies into active exploitation phases versus the importance of maturing low TRL technology into prototypes. They should also consider industry involvement in the maturation of technologies.

[5] The Panels and Group in collaboration with colleagues in Emerging Security Challenges (ESC) and Defence Policy and Planning (DPP) should determine the maturity of policies relating to the EDTs and the areas which most need and would most benefit from supporting S&T advice. For example, the production of an Ethics Strategy for conducting work on EDTs/ BHEA.

2.0 RECOMMENDATIONS FOR A WAY AHEAD

The emergence of novel enhancement technologies brings with it numerous, significant implications, which challenge the ethical, moral, and legal dimensions of modern democratic society. For Defence, the issues are both symbolic and realistic; threatening to erode the human values of character and virtue in service but also potentially risking the safety of personnel or limiting the scope of their role, given new, unique vulnerabilities to security and data integrity.

2.1 Security and Compliance Considerations

2.1.1 Societal Considerations

On a societal level, enhancement to Defence and Security personnel may be rejected by sections of society, particularly where radical augmentation is perceived. This may further exacerbate the distance of understanding from a civilian population to its serving military. Such resistance could influence the pace of technological development or national adoption. It will be the role of local government to facilitate ongoing discourse and engagement reaching across state and society.

2.1.2 Temporal and Permanence Considerations of Technology Adoption

Adoption of novel technologies will vary depending on the extent and permanence of change, and the inherent associated risks. Moderate enhancement (which are impermanent, temporary and non-invasive, for example: wearable technology or nutraceuticals) are likely to fit into existing domestic legal, ethical, and political frameworks. However, more invasive technologies, likely also permanent with potentially greater gains in efficacy but greater risks (e.g., implanted brain computer interfaces or genetic editing) will necessarily require new legal definitions for adoption or prohibition depending on the ruling of domestic and intentional bodies (see tables provided in the Military Medicine, Force Protection, and Warfighter Performance chapters in Naik et al, 2021 [5]). The implementation of new law or the amendment of existing law will require the efforts and involvement of scientists, lawyers, medics, and bioethics experts. In addition, more radical approaches to policy development may be required in order to keep pace with technology development and ahead of adversarial adoption (Triggered Recommendations 1 and 2).

2.1.3 Compliance Considerations

From a Compliance perspective, the autonomy of individual states may create an uneven landscape in terms of legal definitions. Where domestic law may vary, it will be the onus of international bodies (such as NATO and the United Nations) to provide an agreed legal framework for the use of biotechnologies for human enhancement. The absence of such effort will impact on interoperability between allies and maneuverability against the adversary (Triggered Recommendations 3 – 5).

The Security and Compliance team considered the enhancement and augmentation of human performance at the physical, sensory, and/or cognitive levels through technologies including devices or biotechnology (including at the genetic level therefore includes consideration of synthetic biology; again guided by tables from other pillars, in particular by Warfighter Performance (e.g., biosensors, implanted and wearable devices, exoskeletons, etc. see Naik et al, 2021 [5])) and promising areas for innovation in Military Medicine such as immunizations, medications for environmental threat prophylaxis, and therapeutics.

2.1.4 Security Considerations

From a Security perspective, there are security concerns arising from citizen biohacking. That is, members of the public who experiment on themselves, by implanting devices in their body (such as Radio Frequency

Identification (RFID) tags, Light Emitting Diodes (LEDs), temperature sensors, etc.) and share their experiences within relatively closed communities. This has implications to the fields of medicine, law enforcement, border control, customs, and the military, in addition to challenging the development and implementation of effective regulation. For the military, for example, bespoke implants which generate, transmit, and receive data could possibly prohibit interoperability, with allied forces, or with existing capabilities/systems. Efforts should be pursued to understand the implications of this kind of biometric data storage for the armed forces (Triggered Recommendation 6).

Defence (warfighters) and Security personnel are already using technologies that may inadvertently lead to safety/security issues (e.g., wearables/apps revealing secret military locations). A number of militaries are collating genetic information (genomic data) with medical data from their service personnel to find linkages between genes, military exposure, and health. Likewise other nations are exploring the use of such data to identify and enhance their warfighters. The predictive value of genomic data is currently limited, however as the technology advances there may be increasing threat from forging biomedical data, identifying individuals, and using biological information to infer the battlefield. It is recommended that an international effort is made to keep a watching brief on advances in this area as well as to understand the wider implications of new security vulnerabilities emerging from convergence of genomic and biometric data (Triggered Recommendation 7).

The issue is not only that technology is evolving faster than regulatory frameworks but the exacerbation with differences in ethical, moral, and legal perspectives across nations in regard to human enhancement and augmentation. In an effort to better address this, the current landscape of BHEA; and mitigate against the Security and Compliance (including legal and ethical) challenges now and into the future, the team has developed the following recommendations for consideration in terms of Compliance, followed by two within the realm of Security.

2.2 Recommendations for NATO-HFM

Compliance Related Recommendations for NATO-HFM

Listed below are compliance related recommendations for follow-on work/agenda setting options for NATO-HFM. HFM Research Specialist Team(s) should be established to:

2.2.1 Stand up an operational bioethics panel

Stand up an Operational Bioethics Panel, whose remit[6] would be to provide ongoing independent oversight and advice on research and the pursuit of implementation of biotechnologies for human enhancement by constituent nations. Such pursuit should include an NATO HFM activity to determine the scope and regularity of need of coming together of the Operational Bioethics Panel. The membership must be multidisciplinary, include at a minimum scientists, ethicists, medics, lawyers, and end-user operators.

2.2.2 Conduct trend analysis on EDT research, development and use

Conduct a trends analysis on developments that could lead to changes in behavior, strategy, or policy (i.e., ‘weak signals’), for example from BHEA developments in lower levels of technical maturity and operational application. The impact of this activity would be aid in anticipatory / a priori policy initiation associated with BHEA within the EDT’s rather than reactionary policy in response to an unforeseen incident.

[6] Refer to work of the US NIH NExTRAC (Novel and Exceptional Technology Advisory Committee; [6]) and adapt.

2.2.3 Develop an assessment framework for ethical, legal, social, and environmental issues

Develop a framework for the assessment of Ethical, Legal, Social, and Environmental Issues (ELSEI) regarding proposed BHEA research and implementation conducted by NATO and non-NATO countries especially in the case of a high probability of deployment by nations with different ethical standards; similar to U.S. Government Dual Use Research of Concern Policy [7] but with different research aims that trigger review.[7] To ensure international compliance, this activity should identify existing domestic frameworks in order to: 1) Increase data/document sharing among nations while 2) Ensuring the security of documents and data from multinational research and operations. Recommend assessment timeframe to be sensitive to Technology Readiness Level (TRL; [9]), operational urgency, permanence and invasiveness, diversity of international viewpoints with respect to BHEA. The framework should enable/facilitate decisions on whether action should be taken to prevent further use/application and/or ensure development of countermeasures against the use/application of BHEA or more widely EDTs.

2.2.4 Examine the biological toxins and weapons convention for impact on genetically modified organism applications

Examine the likes of Biological and Toxins Weapons Convention (BTWC) language and determine impact on genetically modified bacteria uses for BHEA internationally (e.g., microbiomes). Consider drafting article to clarify scope/applicability of BTWC to genetically modified organisms used for BHEA.

2.2.5 Convene a human enhancement/augmentation Convention

Convene a Human Enhancement/Augmentation Convention (much like BTWC) to develop an agreement with respect to BHEA, increase transparency and develop confidence building measures among nations and consequently the public.

Security Related Recommendations for NATO-HFM

Listed below are security related recommendations for follow-on work/agenda setting options for NATO HFM. HFM Research Specialist Team(s) should be established to:

2.2.6 Stand up HFM Exploratory Team / Research Task Group to monitor issues associated with data collection, storage, and distribution

Stand up a HFM Exploratory Team or a Research Task Group (jointly with Information Systems Technology (IST) Panel) to monitor issues surrounding collection, storage, distribution of data from biosensors used by armed forces personnel and their impact on interoperability, as well as genetic data from people and organisms.

2.2.7 Stand up complementary HFM Exploratory Team or Research Task Group to consider means to secure data and protect it from misuse

Stand up a complementary HFM Exploratory Team or a Research Task Group to consider the means to secure data from biosensors, genomes or other genetic information from people and organisms, ability of forces to reduce the potential of its misuse, intersections with privacy laws and other legal considerations. Such teams would at minimum include a review of literature.

[7] Develop Intelligence measures to detect the use of banned BHEA [8].

3.0 CONCLUSION

The security and compliance team made seven recommendations that meet the original mandate set out for the NATO HFM RST-335. In general, the RTGs or RSTs proposed within the recommendations are wide in scope. Thus, these could be taken up by various NATO bodies, in particular the STO panels, specifically the HFM to proactively design their future programmes of work in relation to research or policy. These recommendations span across the four capability pillars of: i) Warfighter systems; ii) Warfighter performance; iii) Force protection, and iv) Military medicine, as well address both security and compliance issues.

For ease of access, each recommendation is mapped to the pillars in Table 1.

Table 1: Security and Compliance Recommendations Mapped to the HFM-335 Pillars.

Name of Sub Pillar	Recommendation Number as Proposed in Section 2
Security and Compliance	All 7 recommendations.
Military Medicine	**Recommendation 2.2.2** Conduct a trends analysis on developments that could lead to changes in behavior, strategy, or policy (i.e., 'weak signals'), for example from BHEA developments in lower levels of technical maturity and operational application. The impact of this activity would be aid in anticipatory / a priori policy initiation associated with BHEA within the EDT's rather than reactionary policy in response to an unforeseen incident.
Warfighter Performance	**Recommendation 2.2.3** Develop a framework for the assessment of ethical, social, legal and environmental issues regarding proposed BHEA research and implementation conducted by NATO and non-NATO countries especially in the case of a high probability of deployment by nations with different ethical standards; similar to U.S. Government Dual Use Research of Concern Policy [7] but with different research aims that trigger review.[8] To ensure international compliance, this activity should identify existing domestic frameworks in order to: 1) Increase data/document sharing among nations; while 2) Ensuring the security of multinational research and operations documents and data. Recommend assessment timeframe to be sensitive to TRL, operational urgency, permanence and invasiveness, diversity of international viewpoints with respect to BHEA. The framework should enable/facilitate decisions on whether action should be taken to prevent further use/application and/or ensure development of countermeasures against the use/application of BHEA or more widely EDTs. Develop case studies to show the use of the framework which can be used by other NATO Panels that engage as needed. **Recommendations 2.2.4 and 2.2.5** provide the framework for the implementation of **Recommendation 2.2.3.**
Force Protection	**Recommendation 2.2.6** Stand up a HFM Exploratory Team or a Research Task Group (jointly with Information Systems Technology (IST) Panel) to monitor issues surrounding collection, storage, distribution of data from biosensors used by armed forces personnel and their impact on interoperability, as well as genetic data from people and organisms.

[8] Develop Intelligence measures to detect the use of banned BHEA.

Name of Sub-Pillar	Recommendation Number as Proposed in Section 2
Warfighter Systems	**Recommendation 2.2.6** Stand up a HFM Exploratory Team or a Research Task Group (jointly with Information Systems Technology (IST) Panel) to monitor issues surrounding collection, storage, distribution of data from biosensors used by armed forces personnel and their impact on interoperability, as well as genetic data from people and organisms. **Recommendation 2.2.7** Stand up a complementary HFM Exploratory Team or a Research Task Group to consider the means to secure data from biosensors, genomes or other genetic information from people and organisms, ability of forces to reduce the potential of its misuse, intersections with privacy laws and other legal considerations. Such teams would at minimum include a review of literature.
Security and Compliance	All 7 recommendations Note that **Recommendation 2.2.1** recommends standing up an Operational Bioethics Panel, i.e., a governance issue which applies across all use and application of Biotechnology especially BHEA end goals.

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Biotechnology, Human Enhancement and Human Augmentation: A Way Ahead for Research and Policy

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The present report provides a way ahead for challenges around BHEA as seen through a security and compliance lens by proposing recommendations for creating international coherence. It is hoped that the NATO STO panels, especially the HFM panel, use the recommendations proposed herein to steer their respective programmes of work.

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14. Abstract

The NATO Human Factors & Medicine (HFM) Research Specialist Team (RST) 335 was convened to generate a high level, comprehensive overview of biotechnologies that may be used for improving human physical, cognitive, physiological, sensory, or social functions for defence applications. Biotechnologies and Human Enhancement/Augmentation (BHEA) are one of the eight Emerging and Disruptive Technologies (EDT) approved by the NATO Science & Technology Board. The RST used a five-pillar approach: 1) Warfighter systems; 2) Warfighter performance; 3) Force protection; 4) Military medicine; and 5) Security and compliance to identify areas of relevance to operators. While the first 4 pillars are capabilities, the security and compliance pillar extends across all of biotechnology and the other 4 pillars. BHEA is not only a key EDT, it is as such, of interest to the wider international S&T, and operational communities. The present document builds on the main high-level report of the RST to provide a focused understanding of the regulatory challenges around BHEA; highlighting the opportunities to create international coherence in the development of an appropriate governing framework. Keeping the Alliance, militaries, paramilitary security forces in mind, it elaborates a way head for research and policy for addressing the security and compliance challenges surrounding the deployment of biotechnologies in pursuit of human enhancement. It is intended for use by the NATO bodies, including but not limited to the HFM Panel, to steer their respective programmes of work.

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