Information Fusion for Defence: Discussion of Ethical Concerns

Wolfgang Koch
Chief Scientist
Fraunhofer FKIE
Wachtberg, Germany
w.koch@ieee.org

INTRODUCTION

As an opinion piece, meant to be somewhat provocative, this essay wishes to shed some light on artificially intelligent data and information fusion for securing security. It is the author's hope that it stimulates a discussion within the international information fusion community.

"All kinds of instruments are turned into weapons. […] We love the world of Kant but must prepare to live in the world of Hobbes. Whether you like it or not" [1]. This statement of Josep Borrell, High Representative of the European Union for Foreign Affairs and Security Policy, made in November 2021, marks the beginning of a new epoch. The information fusion community did wake up to its realities at the latest on February 24, 2022, when Russia attacked Ukraine. Evidently, the American political scientist Franzis Fukuyama was not right with his thesis of the "end of history" [2], which heralds its own end with comprehensive world peace. The opposite is the case.

Thirty years after the end of the Cold War, Western societies are being forced to learn again what truly sustainable and precious good security is to achieve all other individual, social, economic, cultural, political, or even ecological goods, i.e., the common good. Part of this new and austere reality are armament activities that are increasing around the globe, with the focus not only on the hopefully rather symbolic pursuit of nuclear weapons but also on the use of the latest technologies in artificial intelligence (AI), in combination with uncrewed platforms in all military domains. The focus here is on AI-assisted military systems.

ARTIFICIALLY INTELLIGENT DATA FUSION IN DEFENCE

Comprehensive data and information fusion from all available sensor and nonsensor sources, both model-based and data-driven—in short, AI in a rather broad view—already plays a key role for allied defence of humanity, freedom of nations, legal order, and world peace. Without this powerful technology, there are no effective armed forces, which depend on information superiority and decision dominance on land, at sea, in the air and space, or in cyberspace.

AI-driven multiple-source information fusion already transforms massive data streams from a vast variety of sources into comprehensive situation pictures, the basis for optimised management of sensors, communication links, and other resources, as well as command and control (C2) of weapon systems, including electronic warfare, on stationary or moving platforms. The resulting situational awareness and decision-making capabilities are enablers of improved interoperable effectiveness of allies cooperating with one another in combined multi-domain operations (MDOs).

In view of these considerations, artificially intelligent information fusion for defence poses a general question:

> *How should we decide "well" in terms of military action according to what is recognized as "true" in terms of reliable situation pictures and insight into their deficiencies in the "fog of war," i.e., their "known unknowns"?*

Turned into systems engineering, this leads to three fundamental tasks:

1. Design information fusion and decision support in a way that humans are not only mentally but also psychologically able to master each situation.
2. Identify technical design principles that facilitate the responsible use of artificially intelligent C2 and manned–unmanned teaming (MuM-T).
3. Guarantee that human decision makers in such support systems still have full superiority of information, decision-making, and execution of action.

"All thinking is art," observed the Prussian general and military philosopher Carl von Clausewitz (1770–1831). "Where the logician draws the line, where the pre-fixes end, there art begins" [3]. For this reason, applied ethics and a corresponding ethos and morality are essential soft skills, not only for commanders and staff but also for information fusion engineers, to be built up systematically in a spiral approach to operational and technical excellence.

Engineers do not need to execute military operations, just as soldiers will not program systems for situational awareness and for C2. However, both engineers and soldiers should be able to assess the strengths and weaknesses, risks, and opportunities of AI-enabled operations and technologies. The associated operational and technical competence, as well as the applied morality required, is teachable. It addresses key questions of soldierly dignity and responsible systems design, which are aggravated by using AI for defence and require special considerations, but are not fundamentally new ones.

In the age of digitalised military operations, loops to observe, orient, decide, and act, according to John Boyd (1976), and then to assess, so-called OODAA loops, are dramatically accelerating and thus to be executed "at machine speed" in a network-centric and collaborative way (Figure 1). Moreover, the pragmatic US definition of AI as "the ability of machines to perform tasks" that "normally require human intelligence" [4] also includes physical assistance systems such as AI-controlled exoskeletons or robots. For this reason, the immediate physical presence of humans in a potentially lethal environment is becoming increasingly dispensable.

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Quite in line with the US use of it, the term AI comprises not only, e.g., machine or deep learning but a whole "world" of data-driven and model-based algorithms, including approaches to Bayesian learning, game theory, and adaptive resources management, as shown by Koch [5], amongst many others. This "world of algorithms," realised by the art and craft of programming, enabled by qualitatively and quantitatively appropriate testing and training data, and running on distributed devices, drives a data processing cycle that starts from elementary signals, measurements, and observer reports collected from multiple and heterogeneous sources.

NEW ENGINES FOR ACCELERATING OODAA LOOPS

Interoperability in all military domains does not mean that it must be possible to directly access any means of a certain domain, such as air, sea, land, space, or cyber, from any domain. On the contrary, each domain must maintain its own competences and specific capabilities by developing them further in the sense of a common understanding of strategic, operational, and tactical planning. The German Army's concept of an AI-enabled MDO is an example of a domain-specific suboperation under the leadership of a domain leader. Sensors, effectors, and support services of different domains can achieve spatial and temporal superiority under a unified command focused on operational objectives. The essential prerequisite of the MDO is the end-to-end digitalisation of all levels and forces, which creates the preconditions for effect-oriented information superiority and decision dominance, the necessary basis for dominance in battle.

In future defence scenarios, crewed and uncrewed systems (UxSs) form a comprehensively networked system of systems. Cooperating multiple-sensor, multiple-effector UxSs protect soldiers or assets and execute reconnaissance or combat missions with electronic or kinetic impact, whereas satellites, early warning, refuelling, or transporting are integrated. The core infrastructure needed consists of so-called combat clouds, symbolically visualised for multiple domains in Figure 2, which fuse all required data, make mission-relevant information available in real time, and provide a means for adaptive resources management.

The US definition of AI explicitly includes "even decades-old AI," such as aircraft autopilot, missile guidance, and signal processing systems. Though many AI technologies are in a sense "old," there have been technological breakthroughs that have greatly increased the diversity of applications in defence where AI is practical, powerful, and useful.

Many recent achievements have been focused on machine learning, for example, a subfield of AI, and data-driven algorithms more generally. Such algorithms are closely related to mathematical statistics and encode knowledge that is automatically "learnt" from data in AI models. Due to the extremely large number of numerical values that characterises them, AI models are not accessible to direct human understanding; i.e., they are in a sense black boxes that may sometimes be turned into grey boxes using methods from explainable AI, perhaps exaggeratedly called so.

Figure 1
OODAA loops to be executed at ever-increasing speed by using a cloud of algorithms that perform tasks that normally require human intelligence. © Fraunhofer FKIE.

Algorithms for harvesting information from data and collecting data via adaptive resources management belong to the methodological core of cognitive and volitive engines for intelligence, surveillance, and reconnaissance; C2; and MuM-T that assist the intelligent minds and autonomous wills of commanders and staff. The concepts of mind and will to be assisted, and therefore of consciousness and autonomy, bring into view humans as people that are somebody and not something. Most interesting reflections on intentionality and its fundamental causal role in human behaviour have been presented by Kathryn Laskey [6].

Within this framework, new types of engines enhance and even augment the perceptive mind and the deliberate will of people, who alone are able to perceive intelligently and to act autonomously, in my view:

- *Cognitive engines,* in part already existing, fuse massive streams of sensor, observer, context, and mission data to produce comprehensive situation pictures, the basis for conscious human cognition to plan, perceive, act, and assess effects appropriately.
- *Volitive engines,* in part already existing, transform overall decisions of deliberate and responsible human volition into chains of automatically executed commands for data acquisition, subsystem control, and achieving effects on objects of interest.

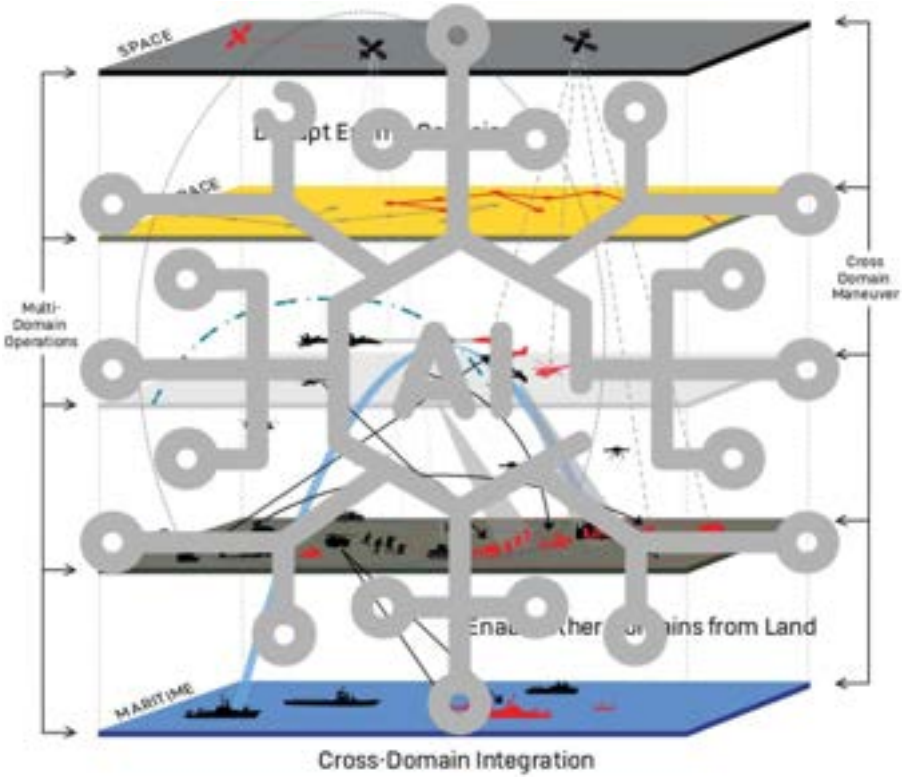

Figure 2
A multidomain combat cloud enables artificially intelligent automation in combat and reconnaissance missions. © Fraunhofer FKIE.

The goal of cognitive and volitive assistance provided by such machines is to enable decision makers to remain capable of acting in complex situations with spatially distributed, moving assets and on short timescales. In a sense, certain processes that underlie conscious perception and causal action and that were previously reserved for humans are, so to speak, "excarnated," i.e., in contrast to "incarnation," no longer bound to a human body but transferred to machines on which they may be executed at enormously reduced processing time, scaled to enable massive processing at highly increased data rates. By this, they enable human performance enhancement far beyond the natural human levels.

Nevertheless, processes triggered by such engines are to be distinguished from natural intelligence and autonomy in the sense that they enhance the perceptive mind and the active will of people, who alone perceive intelligently and act autonomously and which is understood as a moral right, and the capability of a person to think for oneself and decide in a way that achieves a freely set effect, i.e., freely set by the chain of command. For this reason, and in accordance with the North Atlantic Treaty Organization's (NATO's) strategy on the use of military AI, to name an example, the responsibility of human decision makers is pivotal. It is always a human decision and within his or her responsibility to delegate subordinate decisions to a machine.

SOLDIERLY DIGNITY: A STARTING POINT FOR ETHICS

Perhaps surprisingly and rarely discussed so far, I base my considerations on a view of soldierly dignity. However, soldierly dignity cannot only include the dignity of the individual soldier and that of his or her comrades. The dignity of the opponent always plays a role. According to the first article of Germany's post-WWII constitution, for example, which drew lessons from the Nazi dictatorship, human dignity is the basic principle: "Human dignity shall be inviolable. To respect and protect it shall be the duty of all state authority" [7]. Its "inviolable" character is not limited to German citizens. It also includes hostile soldiers. Even during the Cold War and the confrontation with East German and Warsaw Pact soldiers standing on the inner-German border, the military documents spoke of "opponents" to be fought, not "enemies" to be destroyed. The ethical attitudes that are evident in current wars worry the observer.

Dwelling on this example, which is familiar to me, the founders of the post-WWII German Armed Forces, the Bundeswehr, that were shaped by their Christian faith and horrible experiences, saw it as their responsibility to start anew and anchor

themselves in an ethical framework, which is characterised by human dignity and their Christian view of humanity. A prominent figure is General Wolf von Baudissin (1907–1993) [8]. In other countries, other religions may have led to similar conclusions. As a parliamentary army, exclusively acting on behalf of a mandate, the Bundeswehr is thus a deliberate antithesis of the German Wehrmacht, the regular armed forces of Nazi Germany. However, almost 80 years after the end of World War II (WWII), questions have arisen that need to be answered again today:

- What concrete values apply in today's societies and should therefore apply fundamentally to the armed forces as well?
- What exactly do our societies mean by "ethics" when we call for an ethical framework of values for soldiers and their use of military AI?
- What are concrete and societally acceptable criteria for "measuring" ethical and unethical actions, a major issue critical to any automation?
- Are legal standards to be equated with ethical standards? In addition, are they merely the "least common denominator"?
- How do modern societies define the relationship of ethics, virtues, values, norms, and the morality of armed forces?
- What is and must be unchangeably constant, and what is subject to a generally accepted "change in values"?
- How do AI-enabled situational awareness, options for intervention, and communication change the notion of ethically acceptable action in war?
- How can the Christian image of humanity, which the founders of the German Bundeswehr breathed, be assumed in the face of a force that is more than 50 percent nondenominational and hardly has any religious education or training?
- Are soldiers, despite all their training, sufficiently prepared for situations that demand ethical action in spatially boundless and accelerated battles?

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Answers to these questions presuppose what societies also postulate as "ethical behaviour" in war. Is it defined by compliance with legal frameworks, such as international humanitarian law and the Geneva Additional Protocols, or the Christian principle of transforming the enemy into an opponent, which is based on the fundamental principle of love of neighbour? Opinions on this differ widely.

The relationship between soldier and society is of general interest. Some societies seem to consider their soldiers a "warrior class" apart from them. The concept of seeing soldiers as "citizens in uniform," which is realised in Germany, to mention an example, binds them to society, just as society is bound to its soldiers. Soldiers are therefore neither special in the sense of their citizenship nor standing outside of it or capable of being viewed negatively due to their profession. It is therefore just as unnecessary to pay special honour to soldiers as it was unacceptable to call them murderers in the NATO rearmament debate of the early 1980s. The profession of soldier is special because it requires the use of one's own life in an emergency. But this also applies to the police, bodyguards, and aid organisations in crisis areas. To German ears, it is impressive to hear uniform wearers in the United States being greeted on the street by schoolchildren with a "Thank you for your service." This would be inappropriate, as it seems, for a "citizen in uniform," as all citizens should be thanked more or less in this way.

Ethical action guarantees the dignity of the other person and one's own, the friendly fellow human and the military opponent. There are two options for discussing ethical issues in military AI that I do not follow here. The first sees only the military necessity and considers ethics in analogy to ergonomics: It is not really needed for the functionality of a weapon system, but if it does not imply any limitations, why not, if one feels better? The other option lists the dangers and risks of new technologies and, in view of these risks, proposes banning the use of AI in military systems regardless of what is happening in reality. I instead focus on humancentric design.

HUMANCENTRIC DESIGN OF INFORMATION FUSION

The importance of automation for the German Armed Forces, to take an example, was recognised as early as in 1957, one year after the term AI was coined, when their conceptual architect wrote that because of automation, "human intelligence and manpower will once again be able to be deployed in the area that is appropriate for human beings" [8].

According to high-level documents of the German Ministry of Defence, to name an example, the importance of AI does not lie "in the choice between human or artificial intelligence, but in an effective and scalable combination of human and artificial intelligence to ensure the best possible performance" [9]. This statement comprises the ergonomic dimension, as well as the ethical and legal dimensions, of AI-based systems for defence; forms the basis for research questions concerning ethically aligned AI-based systems engineering; and aims at fulfilling a more fundamental military requirement.

Ethical criteria can only become "practicable" if it is possible to "translate" them into technical design principles to be considered in technology development from the outset, addressing three areas, as illustrated in Figure 3. First, care must be taken regarding what needs to be adhered to at any rate in a Kantian sense, i.e., international law or the rules of engagement. Second, we need to consider what is to be achieved, as mission success is also a moral good in a consequentialist sense. Finally, the soldierly virtues in an Aristotelian sense constitute

the concept of the "citizen in uniform" and may comprehensively guarantee soldierly, and therefore human, dignity.

As the war in Eastern Europe or the attacks in the Gulf of Aden, with severe impact on the global economy, show, artificially intelligent drone technology may serve as an example of great significance for future conflicts.

Within this context, it must first be clarified whether the technical prerequisites for the responsible use of partially or fully automated reconnaissance and combat drones are feasible, i.e., compatibility with soldierly dignity. The spectrum ranges from remotely piloted air systems, in which the entire targeting cycle is completely under human control via partially automated individual drones and fully automated swarms of drones, to loitering ammunition, which can wait for hours for a target to be detected and then can be engaged.

So-called fire-and-forget weapons with sensory seeker heads have been around for a long time and are in use. It would therefore be perfectly legitimate to ask whether these weapons should or should not be replaced by artificially intelligent and ethically aligned weapon systems that can be used responsibly until the final weapon effect is released, thereby minimising collateral damage.

Figure 3
Intrapersonal tension of ethically acceptable action that typically leads to dilemmas. © Fraunhofer FKIE.

ON THE FUTURE COMBAT AIR SYSTEM ETHICAL AI DEMONSTRATOR PROJECT

In this spirit, and for the first time in Germany, an intellectual struggle over the technical implementation of ethical and legal principles accompanies a major air defence project from the outset. In the European Future Combat Air System (FCAS), manned jets of the latest generation are elements of a complex and comprehensively networked system of systems. Unmanned remote carriers protect the pilots as loyal wingmen and accompany them on reconnaissance and combat missions.

Based on exemplary scenarios discussed with the German Luftwaffe (German air force) and given rules of engagement, the FCAS ethical AI demonstrator identifies ethically relevant requirements for FCAS systems engineering. The focus is on the individual functions to be executed in the OODAA loop. So far, the observe and orient steps have been examined with regard to critically reflected situational awareness. The decide and act steps relate more directly to military action. The scenarios are intended to provoke ethical dilemma situations that are to be examined from a consequentialist and virtue ethics perspective. International humanitarian law, which can be astonishingly "cruel" for a naïve mind, is to be kept at any rate.

The central question is how ethically acceptable action under extreme time pressure and masses of data can be technically supported. I highlight several observations from ongoing discussions:

1. Ethically aligned system design must determine the situation picture, with its limitations, as reliably as possible. The use of artificially intelligent information fusion, which may be turned into a grey box, is indispensable. The request for full explainability seems to be an unfulfillable promise.
2. Which of the conceivable options for action are legally compliant must be checked automatically, i.e., instantaneously. If, for whatever reason, soldiers decide in a way that does not comply with the law or the rules of engagement, they must be informed of this in an appropriate manner.
3. Automated functions are to be provided that quickly calculate the probable consequences, along with uncertainties, of the respective decision alternatives, in the sense of a consequentialist evaluation of the act step, and present them in an ergonomically comprehensible manner. This aspect is related to the assess step.
4. Soldierly virtues are acquired as a trained habit, for example, in dealing with various forms of bias or grey boxes, and by confronting military personnel with ethical dilemma situations in a digital twin in the run-up to a mission.
5. The interplay between the consequentialist assess step and the exercise of soldierly virtue influences mission planning and personnel selection. The problem of self-protection would be at least partly eliminated by unmanned platforms. Dilemma situations between mission fulfilment and protection of noncombatants remain.

6. Under certain circumstances, combat decisions must be made automatically. The step to decide on the use of such a system in operations and on its technical design in advance must be consciously made by humans—beyond the operator in the cockpit—and they must take responsibility for them. The operator then represents the "human in the loop" by making a situation-dependent overruling decision.
7. Dilemmas remain even then. Consequentialist and virtue ethical considerations are made not during the operation but by parameterising the system in preparation for the operation. A situation-dependent "nevertheless" of an operator must remain possible.

My considerations lead to the thesis that the technical prerequisites for the responsible use of partially and fully automated drones within the framework on FCAS can be created. Moreover, this can be done in such a way that the risk to noncombatants and to soldiers deployed is minimised in accordance with the rules of engagement, or at least is considerably lower than, when using alternative weapon systems.

However, this does not mean that technological development will naturally lead to responsibly usable, artificially intelligent standoff weapon systems or that the quality of the decision-making basis for their use cannot be further improved. Even the development of ethically irresponsible AI-based drone technology is entirely possible and may be pursued.

This includes the conception of well-thought-out rules of engagement that address the risks of these AI-based technologies, which permeate all technical system components from their very design principles and comply with international humanitarian law, ethical values, and soldierly dignity. In accordance with the inherent nature of defence technology developments, the potential threat to own forces from hostile drone use needs to be countered. It is one of the tasks of the information fusion community to design solutions to counter this threat.

ETHICALLY ALIGNED INFORMATION FUSION IS ACHIEVABLE

Technically assisted information harvesting from uncertain observations and background knowledge in the "fog of war" always was, even more increasingly is, and will be key for military decision making and achieving intended effects. In the age of AI, military information fusion affects more than just the aspect of technical innovation, e.g., by "clever" fusion algorithms. It influences the entire way armed forces think and act. This leads to the following conclusions:

1. Appropriate applied ethics and corresponding morals are part of the human competencies that need to be developed and expanded to develop and deploy military information fusion systems responsibly.
2. In addition to the operational added value of artificially intelligent information fusion, ethical skills in dealing with information fusion technologies and ethical acceptance in the eyes of the conscience of individual soldiers, but also in the eyes of the research community, are essential characteristics of successful innovation.
3. In analogy to the oath of Hippocrates for physicians, the ceremonial oath of new recruits was considered indispensable when the German Bundeswehr was founded. It should be viewed with a fresh eye in the context of digitalisation in defence.

In the age of artificially intelligent uncrewed systems based on information fusion, direct contact between a system's own soldiers and their opponents is becoming rare. It seems almost impossible that troops will morph into an uncontrollable "mob of war." If soldierly dignity relies on remaining dignified themselves, then responsibly designed and professionally deployed drones will be helpful.

According to von Baudissin, the conceptual founder of the Adenauerian post-WWII armed forces in West Germany, a soldier is a soldier as a human. This means both that the dignity of soldiers, their own and of those to be fought, must be respected and that there is an obligation to develop their soldierly personality. The fact that soldiers are prepared for war, and thus for killing, does not contradict this. Rather, according to von Baudissin, "moral maturity can be achieved in the ethically challenging handling of lethal violence." He continues: "As human beings, soldiers are also required to respect the dignity of others" [8].

To let a modern soldier speak, General (ret.) Ansgar Rieks, Ph.D., Vice Chief of the German Air Force until 2023, soldierly dignity is generally preserved under seven conditions to which the information fusion community can contribute [10]:

1. Soldiers must be well equipped with technologies that provide situational awareness, trained in them, and prepared for their missions. In addition, they must derive pride from their military craft.
2. This includes the integration of information fusion technologies with well-adapted man–machine interfaces and an ethically aligned design from the outset.
3. The right of defence against a military aggressor remains a fundamental principle and is enabled by fusion-based decision support systems and automation.
4. Good leadership and mission tactics adapted to these technologies determine how the armed forces are treated.
5. The society as a whole supports its soldiers as citizens in uniform.
6. Soldiers are provided with operationalised ethical criteria that are oriented towards the new world of operations and technology.

7. Warfare observes fundamental ethical principles for action even "in war," without giving up the ability "to win" through technological superiority.

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Wolfgang Koch studied Physics and Mathematics at the RWTH Aachen, where he earned a Ph.D. degree in Theoretical Physics. At Bonn University, he holds a habilitation degree and teaches as a Professor for Computer Science. For many years, he has been head of "Sensor Data and Information Fusion" at Fraunhofer FKIE. His research comprises many aspects of defence digitalization. Within the areas of his scientific interests, he has published a monograph as well as numerous handbook chapters, journal articles, and conference papers.

Wolfgang Koch is a Member of the Board of Directors of the International Society of Information Fusion (ISIF). Being a Fellow, Distinguished Lecturer, Member of the Board of Governors, and head of the Germany Chapter of the IEEE Aerospace and Electronics Systems Society (AESS), he is active within the IEEE. Moreover, he is a member of the Sensors and Electronics Technology (SET) panel of the NATO Science and Technology Organization (STO) and contributes to many STO activities.