# Use of Artificial Intelligence (AI) in Air Defence Systems and Unmanned Aerial Vehicle Drone Platforms: Identifying Areas of Improvement

**Usama Nizamani**

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POLICY BRIEF

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# Use of Artificial Intelligence (AI) in Air Defence Systems and Unmanned Aerial Vehicle Drone Platforms: Identifying Areas of Improvement

By: *Usama Nizamani*[*]

**Executive Summary**

Warfare, due to disruptive technologies, demands efficiency in decision making loop. Similarly, among array of other military platforms, Air Defence (AD) systems and Unmanned Aerial Vehicles (UAV) also offer opportunities for incorporation of Artificial Intelligence (AI) to reduce time in overall kill-chain. The entire system of Air Defence and UAVs can benefit from incorporation of AI, coupled with technologies available under Fourth Industrial Revolution. Multiple factors are associated with accomplishing this goal: selection of AD or UAV platforms; sensor and data-fusion across the theatre; sanitization of data; development and training of algorithms and AI-based models; development and reinforcement of secure networks; data processing capabilities; AI enabled decision-making models and intelligent- platforms with independent data library. In UAV systems a special focus is required on auto-pilot code to achieve autonomy in flight-operations; use of maintenance data for predictive maintenance in UAV platforms; separate payload computer; internal communication system; communication network and telemetry for communication upon certain range. At the strategic level, government agencies need to promote six fold measures over the short and long-term to develop capability for incorporation of AI:-

- Familiarization of political and military leadership to trust unmanned systems and reliable AI assisted decision making loops. A basic orientation for leadership on 'AI' will serve the utility to understand strength and limitations of AI related applications.
- Capacity building of military personnel through constitution of Center for Army Artificial Intelligence and Computing. This center to be responsible for human-machine training to enable seamless integration between AI-enabled platforms and operators. Each combat or support arm trainees to include light-aid detachments from corps of Electrical and Mechanical Engineering (EME) for imparting training on maintenance. The initiative to be funded by Ministry of Defence, General Headquarters – Pakistan Army and Ministry of Finance. Ultimately Army and PAF's centers can be merged to create a tri-services center in the long-run.
- In UAV systems, contextualizing R&D approach to 'integration' and 'development' of solutions in Pakistan. In the short-term, instead of reinventing the wheel, buying-off-the shelf solutions from international supply-chain and customizing them. This can bolster demand driven research and contribute to development of customized solutions.[1]
- Additionally, to promote design and development of UAV systems in Pakistan: allocation of flight testing zone for private research and commercial organizations in Karachi, Lahore, Multan, and Islamabad; one-window operation for securing clearances or No-Objection Certificates of imported parts; and exemption in duties on import of critical components – including strong discouragement of corrupt practices by officials, while clearing components on ports.

[*] Usama Nizamani is an Assistant Research Associate at Islamabad Policy Research Institute. The author holds an M.Phil. in Strategic Studies from National Defence University, Islamabad.

[1] Raja Sabri Khan/Integrated Dynamics, Phone Interview, Islamabad June 23, 2021.

- Ratification of policy and operationalization of Civil Drone Authority 2021. In addition revision of Civil Drone Authority policy, prior to ratification, to cater areas of research and development from private sector in drone manufacturing.
- Enhancement of public-private sector collaboration as a lynchpin for strengthening defence manufacturing capability and to tap broader economic dividends.

**Issues to be analyzed**

This study attempts to investigate what are some of the critical elements that need focus on integration of Artificial Intelligence (AI) in Air Defence and UAV platforms. Some of the notable questions, to ensure integration of AI situational awareness or kill-chain, are discussed as follows.

1. What elements are needed to incorporate AI, across the situational awareness domain, in the aforementioned platforms?
2. How to have capable human-resource for operating (semi and fully) autonomous platforms in AD and UAV systems.
3. What are some of the broader structural and strategic initiatives that need to be promoted to develop an ecosystem that promotes innovation, research and development in commercial and defence industry?

**Limitations of the Study**

Application of AI in platforms can be undertaken to meet various purposes. However, on the whole, this paper identifies areas across the situation awareness loop which can be augmented with application of AI. For UAV platforms these include: improvement in areas of auto-pilot code for autonomous flight operations; navigation; tracking; identification; engagement of target and type of platforms (rotary and fixed wing) that can be prioritized for autonomous operations. Potential role of AI, in brief manner, is also explored to contribute towards maintenance of UAV platforms. Similarly, in Air Defence systems, this brief focuses on the aspects of monitoring and tracking; identification and engagement of targets, which can be integrated with application of AI. In extension to this, the prospect of projecting airborne flight path remains an area of opportunity and possible augmentation. To this end, the critical elements are also identified and discussed that may need to be factored in for integration of AI in both: the UAV and AD platforms.

**Analysis**

During the Gulf war, network centricity, was one of the hallmarks of the war, which not only changed the manner of warfare; it also demonstrated US armed forces' effective linkage of sensors, command posts and shooters under communication network to effectively take on the adversary.[2] Augmentation of AI in warfare is likely to achieve another goal: information-dominance; which requires sensor-fusion in the kill-chain and ability to make sense of overall adversary's data.[3]

AI and its integration in Air Defence platforms and UAV systems require a different approach: both, at the technical and operations level. This study attempts to understand, whether, integration of AI is feasible in Air Defence (AD) platforms and UAV platforms. To this end, it was studied, that AI's integration, despite challenges, is feasible in AD and UAV platforms.

[2] "Air Power in the Gulf War," RAND Corporation Provides Objective Research Services and Public Policy Analysis | RAND, accessed March 4, 2021, https://www.rand.org/pubs/research_briefs/RB19.html.
[3] Pravin Sawhney/FORCE, Zoom Interview, November 29, 2020.

***From Drawing Board to Real-time Application***

This would essentially require improving the existing ability to store, filter and organize data of AD platforms (in short range missile systems) and UAV platforms for research and development related purposes. AI's use in AD and UAV platforms is conditioned to sanitized use of data for designing and execution of algorithms in machine learning and ANI related requirements.[4] The second most critical aspect is development of intelligent networks hardened for cyber and electronic warfare attacks. Broadly, information dominance and AI require prioritization of four virtuous elements: sensor and data-fusion; data processing capabilities; AI enabled decision-making models and an intelligent-system or platform with independent data library – so that it least relies on data-link or human in the loop arrangements.[5] Another important infrastructure capability is cloud-computing facilities: for data mining and data processing.

**Air Defence Systems and AI**

Traditionally, for detection, and identification of threats to its airspace, Pakistan relies on ground based radars and sensors, airborne early warning platforms, and human sensors. In the past, the Air Defence Committee was with the Pakistan Air Force's Air Headquarters.[6] [7] A technical obstacle that requires overcoming in realization of an integrated air defence is to have inter-operable software codes and interfaces. Hardware manufacturers, due to intellectual property concerns, are usually protective of sharing software codes of their platforms with end users.[8] This eventually is likely to impede integration of platforms under a uniform operating system; a major challenge that may need surmounting by end-users and developers.

Integration of AI in air defence platforms, however, is conditioned to data mining and sensor fusion. Pakistan Air Force is reported to archive troves of data, of legacy platforms, from Air Defence radars on magnetic tapes. Former officials believe that PAF is likely availing use of cloud-computing facilities to store, archive and use such data for training related purposes. Such data, although may not be entirely useful for detection of modern platforms; however, treated data, both, latest and legacy, remains useful in training the algorithms through reiteration of simulations for detection and identification of existing airborne threats by AI enabled Air Defence platforms.[9] Particularly, it can enable development of predictive modeling features in AI enabled air defence platforms: to project flight path, altitude, and possible maneuvers of enemy platforms in real time situations.

Again, it will require intensive training of algorithms, through deep learning applications, to develop models that then can be refined for physical trials to improve reliability. Another key factor, of utmost attention, is that the development of (software) programmes for short and medium range AD platforms will be different, due to concerns discussed earlier. Furthermore, sensor fusion through secure communication remains critical for AD systems to detect, identify and engage threats. Sensor fusion is critical also, for an AI-based platform, for

[4] Kaleem Saadat/CASS, Zoom Interview, Islamabad, December 11, 2020.
[5] Sawhney.
[6] Saadat.
[7] It was then placed under the Joint Staff Headquarters. However, the progress on scale of integration remains classified and is likely to be a work-in-the-progress.
[8] Ibid.
[9] Ibid.

linkage and integration with data processing components, and AI enabled decision-making models in the AD platform to effectively function as a composite AI based platform.

On the ethical-end, experts still appear concerned at assigning complete autonomy to air-defence platforms to engage an enemy platform; presence of a human-in-the-loop or human-over-the-loop arrangements remains a priority – due to accidental use and fratricide.

**UAV Systems**

Pakistan has short endurance drone platforms, nevertheless; it is in the process of acquiring medium altitude long endurance (MALE) and high altitude long endurance (HALE) drone platforms.

The war on terror demonstrated efficacy of UAV platforms in engaging individual targets: especially, when terrorists were positioned atop mountains and it was difficult to neutralize them with accuracy.[10] [11] Traditional drone platforms are operated manually through operators on the ground. The operations under this include: payload discharge; flying, take-off and landing tasks. Some operations, even in traditional drone platforms are designed to be carried out in an automatic manner: such as, the prefab path.[12] This capability allows drones to fly towards a designated path at the determined coordinates and altitude, after achieving a certain altitude.[13]

Pakistan deploys UAVs, of both, rotary wing and fixed wing types, for conducting various natures of operations: intelligence, surveillance and reconnaissance, training and targeting missions, and kinetic operations. These drones vary in their configuration and features. On the other hand augmenting role of semi and fully autonomous drones can help reduce operational, manpower costs, threat to personnel's security and offer round the clock surveillance capability. Such platforms can be deployed to array of situations, such as tracking militant hideouts, and logistical routes; identifying and tracking smuggling routes and monitoring of natural disasters such as jungle fire, or floods.

***Autonomous (Fully and Semi) UAV Systems***

A team of drone operators consist of three members: (a) pilot on ground; (b) system operator, that is, operator of camera which acquires information; and (c) information analyst. ANI enabled tasks may need to master these three areas to enable integration of artificial intelligence. A drone team or the pilot is able to operate the platform in a month's time. This will consist of 10-15 hours of actual drone flying, under supervision.[14]

For achieving (semi and fully) autonomous capabilities in drone platforms, neural network and machine learning algorithms appear as effective routes for incorporating AI based operations: especially, image detection capabilities[15] in autonomous UAV deployed for ISR

[10] Javier Jordan, "The Effectiveness of the Drone Campaign against Al Qaeda Central: A Case Study," Journal of Strategic Studies 37, no. 1 (2014): 24-26, doi:10.1080/01402390.2013.850422.
[11] Saadat.
[12] Kimberely Mok, "Drones that Fly and Drive using Path Planning Algorithms," *Newstack*, July 16, 2017, https://thenewstack.io/drones-fly-drive-using-path-planning-algorithms/.
[13] Norine MacDonald and George Howell, "Killing Me Softly Competition in Artificial Intelligence and Umanned Aerial Vehicles," *PRISM* 8, no. 3 (January 2020): 103-126, https://ndupress.ndu.edu/Portals/68/Documents/prism/prism_8-3/prism_8-3_MacDonald-Howell_102-126.pdf.
[14] Ibid.
[15] Lidia M. Belmonte, Rafael Morales, and Antonio Fernández-Caballero, "Computer Vision in Autonomous Unmanned Aerial Vehicles—A Systematic Mapping Study," Applied Sciences 9, no. 15 (2019): 9-10, doi:10.3390/app9153196.

operations; navigation capability; flight operations, including take-off and landing capabilities.[16] [17] AI can also be embedded, for ground crew, to improve predictive maintenance of drone platforms: to prolong its operational life.[18] Among autonomous drones for military applications, it is preferred that, line-of-sight drones are not deployed: although, it is observed that both Pakistan and India deploy line-of-sight rotary wing (quad-copter) drones for tactical ISR operations, especially along the Line of Control.[19] [20]

For developing autonomous UAV systems: technological development and mastery of auto-pilot systems is one of the most critical elements in drone platforms; especially the autopilot code. In addition to achieving autonomous operations in a drone, especially take-off and landing capability essential drone components need installation in a UAV platform: including; barometer, for precision landing, Ground Positioning System (GPS) kit for navigation; and communication mechanism[21], if operators intend to communicate to the platform, in a ground controlled mission.[22] To summarize, some elements are critical for a drone: such as, autopilot computer; communication network; separate payload computer or manager; basic internal communication mechanism; telemetry that requires communication upon a certain range. Secondary elements such as doctrinal considerations determine the aerodynamic model, and calibration of the auto-pilot system.

For autonomous mission capability, mission control software can be trained in lab-setting and installed on the platform. However, to adapt around possible eventualities, UAV can be programmed under a semi-autonomous mode.[23] Furthermore, operating a UAV in peripheral areas of Pakistan may require a robust communication network to communicate with the platform. Such system, as iterated earlier, can also enable commanders to delegate command of the UAV to local commanders for remaining execution of the operation.[24] The use of a robust navigation and location system is critically important: both for the platform and the payload. Similarly, sensor fusion is critical to reduce the accuracy around the target-location. For navigation, Pakistan has access to China's Baidu satellites for communication, which may enable improved operational reach. Satellite based communication, overcome restrictions imposed by earth curvature and geographical constraints: providing greater range to UAV platforms.[25] For training UAV platforms, with AI, a small scale local data center, in form of a cloud, may need to be developed; ideally, a small size local data facility may be needed. For independent navigation in UAV platforms uploading or installing computer with pre-designated navigation paths can also achieve this purpose.[26]

[16] Ibid.
[17] Uzair Khan/QuestLab, Zoom Interview, Islamabad, December 16, 2020.
[18] Ibid.
[19] Manjeet Negi, "Indian Army shoots down Pakistan Army quadcopter along LoC in J&K's Keran sector," India Today, October 24, 2020.
[20] Dawn, "Indian quadcopter shot down in AJK," Dawn, January 3, 2021, https://www.dawn.com/news/1599334.
[21] Khan.
[22] In other cases, operators can assign UAV drone a pre-planned mission.
[23] Khan.
[24] Ibid.
[25] Ibid.
[26] Ibid.

**Long Term Intervention**

***Capacity Building***

To have work force familiarized and able to operate on AI enabled platforms and systems, dedicated institutes need to be developed to train work force, in future, to train them with necessary skills and knowledge.

***Technical Independence and Public-Private Collaboration***

A major problem, as per experts, for Pakistan's defence industry is that it largely relies on global supply chain for components in domestically assembled and manufactured platforms. Complex components such as radar systems; communication systems and the telemetries are usually obtained from China. Similarly, engines are also imported due to absence of industrial base in Pakistan. The major constant which may determine technological-independence for Pakistan is motivation of public stakeholders, availability and allocation of resources: especially by Pakistan's armed forces. There are two kinds of industries to meet the demand of armed forces: first; market players that procure and sell those systems to end-users, whereas other companies build or assemble platforms domestically. If a policy, which encourages locally manufactured commercial and military UAV systems, then the civilian market can contribute to their development. For private industry, at present, dearth of funding provisions is one of the major concerns; usually funds and efforts are not dedicated to convert this towards applied research and development (R&D) or towards broader innovation.

**Policy Recommendations**

- For technology-transfer it is critical to enable technology-absorption; especially, availability of human resource and the industrial base. Therefore, development of industrial-base is critical for indigenous development of platforms, in future.
- Software engineering as a discipline should be recognized, as a discipline, by the Pakistan Engineering Council (PEC), since; software is an indispensable component of any hardware or machinery in contemporary technological products.
- Revision of Civil Drone Authority Policy 2021, prior to ratification, to cater areas of research and development from private sector in drone manufacturing and incorporation of AI.
- Capacity building of military personnel through constitution of Center for Army Artificial Intelligence and Computing. This center to be responsible for human-machine training to enable seamless integration between AI-enabled platforms and operators. Each combat or support arm trainees to include light-aid detachments from corps of Electrical and Mechanical Engineering for imparting training on maintenance of AI enabled platforms. The initiative to be funded by Ministry of Defence, General Headquarters – Pakistan Army and Ministry of Finance. Ultimately Army and PAF's centers can be merged to create a tri-services center in the long-run.
- Tax incentives need to be offered to local UAV developers in Pakistan. Import of certain components can be allowed for a certain time period, through sunset provisions, after which their production be undertaken locally. For achieving this, private sector needs to be encouraged, incentivized and funded by military, Ministry of Science and Technology and other multiple stakeholders: both public and private entities.
- Additionally, to promote design and development of UAV systems in Pakistan: allocation of flight testing zone for private research organizations in Karachi, Lahore, Multan, Islamabad; one-window operation for securing clearances or No-Objection

Certificates of imported parts be ensured– including strong discouragement of corrupt practices by officials, while clearing components.

- To target low-hanging fruits in design and development, of UAV systems, two pronged approach can be availed. In the short-term contextualizing R&D approach to 'integration' and 'development' of UAV solutions in Pakistan. Instead of reinventing the wheel, buying-off-the shelf solutions from international supply-chain and customizing them is a preferable approach. This can bolster demand driven research and contribute to development of customized solutions.[27] In the long run to build complex components prioritizing consortium with international companies for component production in Pakistan can enable technology and know-how transfer.[28]
- Building up an innovation ecosystem of different actors with cross-sectorial approach: industry; armed forces; ministries and government agencies; academia and universities.[29] To this end, development of National Centers (NCs) connected with private corporations, multiple universities and multiple disciplines (both tech and humanities) in the broader innovation ecosystem. These NCs to consist of computational biology; physics; software engineering; humanities, etc.[30]

[27] Sabri.
[28] CENTAIC.
[29] CENTAIC, Personal Interview, Rawalpindi, December 12, 2020.
[30] Ibid.

## ABOUT THE AUTHOR

Mr. Usama Nizamani joined IPRI as an Assistant Research Associate in 2017, bringing along his professional experience of behavior sciences, after having conducted national and international training sessions as a Psycho-Social Trainer (2015-2017) with IREX and Bytes for All, Pakistan. At IPRI, he has developed extensive experience on emerging technologies, application of Artificial Intelligence and cyberspace and maps their impact on future strategic landscape. He also augments his academic and professional experience of behavioral sciences in studying strategic decision making. On strategic affairs, he focuses on Pakistan-India, India-China, US-China engagement in South Asia and Asia Pacific. Mr. Nizamani has published rigorous research-based policy papers on technology and policy related issues. He has featured as a speaker, discussant and panelist in various national and international conferences/webinars. He regularly contributes in national and international dailies. Mr. Nizamani has also participated as a delegate of Track-II dialogues. Mr. Nizamani is a graduate of National Defence University (NDU), Islamabad where his post-graduate research specialized on “Emerging Shifts in India’s Nuclear Strategy: From No First Use to First Use?” He also holds a BS in Psychology from Virtual University of Pakistan, Lahore.

**Usama Nizamani**
Email: usama.research@gmail.com,
usama.nizamani@ipripak.org