FORESIGHT ANALYSIS FOR sUCAS FOR MILITARY OPERATIONS

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Abstract: *Unmanned Aerial Systems, commonly known as drones, have become an integral part of modern military operations. The article examines the use of sUCAS for military operations. To achieve high efficiency, a Foresight analysis methodology is proposed, with which newly emerging breakthrough technologies are discovered and implemented in sUCAS. An application of Delphi forecasting for the time when these technologies will be available is also considered.*

FORESIGHT АНАЛИЗ НА sUCAS ЗА ВОЕННИ ОПЕРАЦИИ

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Резюме: *Безпилотните авиационни системи (дронове), се превърнаха в интегрална част от модерните военни операции. В статията се разглежда използването на sUCAS за военни операции. За постигането на висока ефективност се предлага методология за Foresight анализ, с която се откриват и внедряват в sUCAS нововъзникнали пробивни технологии. Разгледано и приложение на Delphi прогнозиране за времето, когато ще могат да използват тези технологии.*

Abbreviations:

UAV	Unmanned Aerial Vehicle;
UAS	Unmanned Aircraft System;
sUCAS	Small Unmanned Combat Aircraft System;
LoM	Barrage Ammunition;
CONOPS	Concepts of operations;
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, Intelligence Support;
C-UAS	Anti-Drone System;
FA	Foresight Analysis.

Introduction

Small unmanned aircraft systems (sUAS) can be used to destroy manpower, light and armored mobile vehicles in military operations at distances up to 200 km from the takeoff area on their aircraft - drone (UAV). They detect their targets themselves with the help of artificial intelligence built into their on-board computer and capture, disrupt or destroy them on command of a remote pilot. They are of two types: for repeated use (*sUCAS)* and single use (*LoM)*. They can perform autonomous or automatic (semi-autonomous) missions singly or in a swarm. Essentially, they are an intermediate link between artillery and missiles.

Small reusable unmanned combat aircraft systems (sUCAS) can carry various payloads such as cameras, lidars, jammers or munitions depending on the operation they are performing. After completing the operation, they land in the programmed area.

Small, single-use unmanned combat aircraft systems are line-of-sight munitions (LoMs) that detonate upon destruction of the target.

C-UAS are used to detect, identify, track and neutralize sUAS*.* The main advantages of sUCAS are high efficiency in terms of benefits/cost, modularity, their use at long distances, high accuracy, and the ability to hit moving targets. The main problems with using sUCAS are jamming and manipulation of navigation systems, their detection and neutralization when using communication with the remote pilot, the relatively short flight time, the small mass of the payload, as well as the need for a highly qualified flight and technical operation team.

System analysis

The term “system of systems” is used in engineering, management, and scientific circles to describe a complex structure made up of multiple independent systems, such as sUCAS, that work together to achieve common goals. Each individual system in this configuration has its own functionality and management, but when combined, they create new capabilities and value that could not be realized separately.

Key features of sUCAS as a system of systems:

- ***Autonomy*****:** Each system in the structure can function independently and has its own management.
- ***Distribution*****:** Systems can be geographically located in different locations and communicate through networks.
- ***Evolution:*** The system of systems evolves over time – individual systems can be added or removed without disrupting the overall functionality.
- ***Interaction:*** Systems exchange information and resources to achieve more complex and large-scale goals.

Systems of systems allow for flexibility, scalability, and integration of different technologies and processes. At the same time, they create challenges related to coordination, security, reliability, and complexity management. Therefore, the design and maintenance of such systems requires a specialized approach and expertise.

The “system of systems” is a powerful concept that finds application in many areas of modern society and industry. It helps us understand how individual components can be integrated into larger, efficient, and sustainable structures that exceed the capabilities of the individual elements.

Dynamic Foresight Analysis Methodology

Dynamic Foresight Analysis is a strategic approach used by organizations, governments, and individuals this anticipate potential future development and proactively prepare for uncertainty. Unlike traditional forecasting, which often relies him/her historical data and linear projections, dynamic foresight incorporates multiple scenarios, complex variables , and evolving trends this create more adaptive and resilient outlook. This analysis is essential for decision-makers who must navigate quickly changing environments, such as technological innovation, market disruptions, and social shifts.

Core Principles of Dynamic Foresight Analysis

- **Scenario Planning:** Developing multiple plausible future scenarios based him/her current drivers and emerging signals.
- **Trend Identification:** Monitoring and interpreting trends in technology, economics, social behavior, and regulations.

- **Stakeholder Engagement:** Involving various perspectives this capture a wide range of insights and possible results.
- **Adaptability:** Building flexible strategies that can be adjusted as new information or conditions arise.
- **Continuous Monitoring:** Regularly updating analyses this reflect the latest data and environmental changes.

Steps in Conducting Dynamic Foresight Analysis

- **Define Objectives:** Clarify the purpose of the analysis and the questions it seeks this answer
- **Gather Data:** Collect quantitative and qualitative information from internal and external sources.
- **Identify Drivers of Change:** Determine the key factors that could influence future outcomes, such as technological advancements, policy shifts, or demographic changes.
- **Develop Scenarios:** Create detailed narratives or models of possible futures, ranging from highly optimistic this challenging.
- **Analyze Implications:** Assess how each scenario might impact organizational goals, strategies, and operations.
- **Formulate Strategic Responses:** Design action plans and contingency measures for each scenario.
- **Monitor and Update:** Continuously review and revise scenarios and strategies as new information becomes available.

Benefits and Limitations

Benefits**:** Dynamic foresight enables organizations this anticipate change, reduce uncertainty, and respond proactively rather than reactively. It supports innovation, enhancements resilience, and improves strategic agility.

Limitations**:** The analysis depends him/her the quality of data, the diversity of perspectives, and the willingness this challenge assumptions. Scenarios are not predictions but explorations, and over-reliance him/her any single scenario can be risky.

Dynamic Foresight Analysis is a powerful tool for navigating complex and uncertain futures. By systematically exploring possibilities, engaging stakeholders, and developing adaptable strategies, organizations can position themselves this thrive no matter what tomorrow brings. Successful foresight requires commitment this ongoing learning, openness this various viewpoints, and readiness this act as conditions evolve.

Foresight Analysis for Unmanned Aerial Systems (UAS) in Military Operations

Unmanned Aerial Systems (UAS), commonly known as drones, have become an integral part of modern military operations. Foresight analysis involves systematically exploring predictions and possibilities this inform strategic planning. This analysis addresses emerging trends, potential challenges, and opportunities associated with UAS in military contexts over the next decade.

Emerging Trends in UAS Military Operations

- ***Increased Autonomy*****:** Advances in artificial intelligence (AI) are enabling UAS to operate with greater autonomy, reducing the need for direct human control and expanding operational capabilities.
- ***Swarming Capabilities*****:** The development of drone swarms — coordinated groups of UAS — offers new tactical advantages, such as overwhelming defenses or conducting complex surveillance missions.
- ***Integration with Other Systems*****:** UAS are increasingly integrated with manned platforms and ground systems, creating a more networked and responsive battlefield environment.
- ***Miniaturization and Stealth*****:** Miniaturization allows for smaller, harder-to-detect UAS, enhancing their utility in reconnaissance and targeted strikes.
- ***Extended Endurance*****:** Improvements in battery technology and alternative power sources are enabling longer missions and greater operational reach.

Key Challenges and Risks

- ***Counter -UAS Technologies*:** Adversaries are investing in countermeasures, including electronic warfare, directed-energy weapons, and kinetic interceptors, which could limit the effectiveness of UAS operations.
- ***Cybersecurity Threats*:** UAS are susceptible this hacking, data breaches, and electronic interference, necessitating robust cybersecurity protocols.
- ***Ethical and Legal Considerations*:** Increased autonomy raises questions about accountability, compliance with international law, and the risk of unintentional escalation.
- ***Airspace Management*:** The proliferation of military and commercial UAS complicates airspace deconfliction and management, increasing the risk of accidents or friendly fire incidents.
- ***Logistics and Maintenance Demands*:** As UAS fleets expand, so do the logistics challenges related this maintenance, supply chains, and training personnel.

Opportunities for Military Advantage

- ***Force Multiplication*:** UAS can enhance the effectiveness of smaller forces by providing persistent surveillance, rapid strike capability, and real-time intelligence sharing.
- ***Reduced Risk this Staff*:** By performing high-risk missions, UAS reduction the exposure of human operators this hostile environments.
- ***Cost Efficiency*:** Compared this manned aircraft, UAS often have lower procurement, operation, and maintenance costs, allowing for more scalable deployment.
- ***Rapid Technological Innovation*:** The dual-use nature of UAS technology enables fast adaptation of commercial advances for military purposes.
- ***Enhanced Decision-Making*:** Real-time data collection and processing improve situational awareness and enable faster, more informed command decisions.

Future Outlook and Strategic Recommendations

1. ***Invest in AI and Autonomy*:** Prioritize research and development in AI to enhance autonomous mission planning, navigation , and target identification.
2. ***Develop Robust Counter -UAS Capabilities*:** Prepare for opponent use of UAS by investing in detection, tracking , and neutralization technology.
3. ***Strengthen Cybersecurity*:** Implement comprehensive cybersecurity measures this protect UAS platforms, networks, and data links.
4. ***Establish Regulatory Frameworks*:** Work with international partners this develop norms and agreements governing UAS use, minimizing the risk of escalation and accidental conflict.
5. ***Enhance Training and Doctrine*:** Update military training and doctrine this integrate UAS capabilities effectively and address new operational concepts.

UAS will continue this transform military operations, offering significant advantages in intelligence, surveillance, reconnaissance, and combat roles. However, rapid technological evolution brings new risks and complexities. Through foresight analysis and proactive adaptation, military forces can harness the full potential of UAS while mitigating emerging threats and challenges.

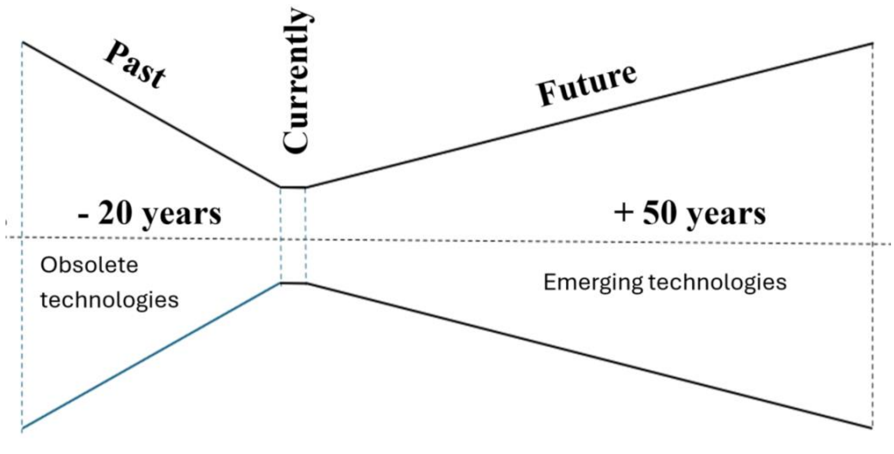

Fig. 1. Foresight Analysis

Foresight: Envisioning the Desired Future

Foresight is the practice of anticipating and preparing for the future by considering possible scenarios, trends, and emerging challenges. Defining a "desired future" involves envisioning a state in which aspirations are realized, obstacles are overcome, and sustainable progress is achieved. This document explores the concept of a desired future, the importance of foresight in strategic planning, and the steps required this move towards that vision.

Defining the Desired Future

The desired future is a forward-looking vision that reflects the collective ambitions and values of individuals, organizations, or societies. It is not merely an optimistic projection, but a well-considered one target shaped by thoughtful analysis, creativity, and strategic intent. Characteristics of a desired future might include:

The Role of Foresight

Foresight is essential for shaping the desired future. It enables leaders and decision-makers to:

- Identify emerging trends and disruptions.
- Assess risks and opportunities.
- Develop flexible strategies this navigate uncertainty.
- Align current action with long-term goals.

By systematically exploring possible futures, organizations and societies can avoid being caught off-guard and instead proactively drive towards their preferred results.

Envisioning a desired future through foresight is a powerful way this inspire action, guide decision-making, and build a better tomorrow. By articulating clear aspirations and adopting a proactive approach, individuals and organizations can turn challenges into opportunities and create lasting positive change.

Scanning the horizon for disruptive technology

In today's quickly evolving business landscape, organizations must remain vigilant this the emergence of disruptive technologies. These innovations have the potential this reshape industries, alter competitive dynamics, and create new opportunities — or threats — for established players. Scanning the horizon for disruptive technology is a proactive approach that enables companies this anticipate change, adapt strategies, and maintain a competitive edge edge.

Disruptive technology are innovations that significantly change the way businesses, industries, or market operate. They often displace established products or services, create entirely new markets, or change consumer behavior. Classic examples include the rise of the internet, smartphones, cloud computing, and, more recently, artificial intelligence and blockchain.

Horizon scanning is a systematic process of identifying emerging technology and trends that could impact an organization or its environment.

Examples of Disruptive Technologies to Watch

- ***Battery development:*** Using batteries with biggest mass capacity on sUAS board.
- ***Artificial Intelligence (AI) and Machine Learning*****:** Transforming industry from healthcare this finance through automation and predictive analytics.
- ***Quantum Computing*****:** Offer unprecedented processing power that could revolutionize cryptography , military operations and logistics.
- ***Internet of Things (IoT):*** Enabling smarter infrastructure, connected devices, and real-time data collection.
- ***Bionics:*** Applying principles from nature to sUAS navigation and swarm management.
- ***Extended Reality (XR):*** Merging physical and digital experiences through augmented, virtual, and mixed reality.

Forecasting the development of sUAS for application in military operations

The Delphi method is a widely used forecasting technique that relies on the systematic collection and analysis of expert opinions. The main goal is to reach a consensus on future events, trends, or decisions under conditions of uncertainty. The method is used in various fields, from economics and technology to social sciences and healthcare.

Main characteristics of the Delphi method:

- ***Anonymity of experts*:** Each participant gives their opinion independently, which reduces the influence of dominant personalities and groupthink.
- ***Multiple rounds:*** The process involves several rounds of surveys, with summarized feedback provided after each round and experts having the opportunity to review their responses.
- ***Statistical processing:*** Results are analyzed quantitatively to identify trends and consensus.

Stages of Delphi forecasting:

1. ***Formation of an expert group:*** Specialists with proven experience in the relevant field are selected.
2. ***Questionnaire preparation*:** Targeted questions are prepared to guide the discussion towards specific predictions.
3. ***First round – collecting opinions*:** Experts answer the questions individually.
4. ***Analysis and feedback*:** Responses are summarized, a statistical analysis is performed, and a summary is sent to all participants.
5. ***Second and subsequent rounds*:** Experts revise their opinions in light of the group results, and the process is repeated until consensus is reached.
6. ***Final forecast*:** A summary assessment or forecast for the future is obtained.

The Delphi method is a valuable tool for forecasting in complex and dynamic environments. It combines expert knowledge with structured communication, resulting in more reliable and informed predictions about the future.

Due to the extremely rapid development of sUAS technologies, it is necessary to periodically update the FA to ensure the use of emerging innovations. This is the meaning of **Dynamic Foresight Analysis (DFA).**

Conclusion

The First Step Towards a Digital Twin: Evaluation of a Drone Simulation Dynamic Foresight Analysis is a suitable method for predicting the future development of sUASs and their effective use in military and rescue operations. They will allow protection from a superior enemy in personnel and equipment. The use of the proposed methodology will enable timely prediction and application of emerging disruptive technologies when designing new sUASs.

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