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Analysis of Selected Unmanned Aerial Systems Applications for International Safeguards

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ABSTRACT

- Unmanned Aerial Systems (UASs) could be used as a platform for IAEA safeguards inspection and verification activities
- SNL conducted a detailed analysis focusing on technology readiness of UASs to support selected safeguards applications, the effects on safeguards effectiveness and efficiency, and potential impact on normal facility operations
- Out of four applications selected for in-depth analysis, survey of mining and concentration activities is the most feasible for near-term deployment for IAEA use with UASs

BACKGROUND

- Advancements in UAS & sensor technology are being leveraged by various industries to enhance the effectiveness, efficiency, and safety of operations
- UASs could assist IAEA inspectors in the field by automating tasks currently performed manually, providing novel types of data, or providing information with higher veracity/accuracy
- Potential applications were prioritized based on a 2017 expert elicitation survey
- Final selection for in-depth analysis from this prioritization list was made with the goal of optimizing technical and safeguards application variety

CHALLENGES / METHODS / IMPLEMENTATION

SELECTED APPLICATIONS

- Site Evaluation – Collection of detailed site information
- Survey of Mining and Concentration Activities – Collection of detailed site imagery-based information
- Nuclear Material Accountancy – Verification of container inventory
- Containment and Surveillance – Tag/Seal verification

METHODS OF ANALYSIS

- Survey of the Current State of UAS and Sensor Technology
- Assessment of the Impact on Safeguards Effectiveness & Efficiency
- Assessment of the Impact to Nuclear Facility Operations
- Definitions for the purposes of this study:
  - **Effectiveness:** *the ability of an inspector (or the UAS technology) to attain quality data in order to draw a safeguards-relevant conclusion*
  - **Efficiency:** *the ratio between the quantity of data (used to draw said conclusion) and the time and costs in which it takes to acquire*

CHALLENGES

- Potentially exaggerated capabilities from vendors
- Rapid pace of technological change
- UAS sensor integration
- Insufficient analysis and legislation regarding safety, security, & operation

State of UAS Technology

Capability	Typical Range
Imaging Cameras-Visual range (MP)	(12-20) [1],[2]
Payload (kg)	(1-9) [3],[4]
Cost (USD)	(1.5k-25k) [5],[6]
Flight Range (km)	(2-480) [7],[8]
Flight Time/Battery Life (mins)	(10-900) [9],[10]

Additional features may include: Obstacle avoidance, return-to-home, autonomous flight path, autonomous landing, first-person view (FPV)

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OUTCOMES

SAFEGUARDS EFFECTIVENESS & EFFICIENCY

- **Site Evaluation**: Digital map creation with high resolution imagery and automated change detection would enhance effectiveness. Decreased inspection time through pre-programmed flight paths may be offset through increased setup and flight preparation time to secure the facility, making efficiency the same overall
- **Survey of Mining and Concentration Activities**: Light detection and ranging (LiDAR) for 3-D imaging, volume assessment, and change detection would enhance effectiveness. This increased data quality is expected to more than offset the slight increase in setup time due to the low security requirements for mines, increasing efficiency overall
- **Verification of Container Inventory**: Gains in effectiveness are plausible. However, significant barriers to UAS implementation, including inconsistent radiofrequency identification (RFID)/barcode placement, or payload restrictions for radiation detectors make gains in efficiency unlikely
- **Tag/Seal Verification**: Limited gains in effectiveness are possible for verification of active seals. However, gains in efficiency are diminished by regulatory and implementation challenges
- **Overall note on costs**: Low for initial equipment; most costs are equipment maintenance and sustainability, transportation, and training

EFFECTS ON FACILITY OPERATIONS

- **Safety**: UASs are a potential safety hazard at nuclear facilities; While most UASs are small and lightweight, care must be taken to prevent damage to sensitive material or equipment, as well as workers
- **Security**: UASs are considered to be a security risk to nuclear facilities; More work should be done to assess the impact of UASs on nuclear facility security, but implementation will be site-specific
- **Regulatory Concerns**: There is no comprehensive international framework for UAS regulations; Rules and regulations of different states must be consolidated if IAEA, State, facility, or other third-party personnel are to operate under a consistent framework during inspections, and to mitigate the possibility of disagreements

CONCLUSIONS

- Technological advancements in UASs should be leveraged for safeguards applications
- Analysis focused on a survey of the current state of UAS technology, the potential implications of the introduction of UAS technology on safeguards effectiveness and efficiency, and the impact to nuclear facility operations.
- Mining and concentration activities may be the best opportunity for immediate or near-term safeguards application
  - This activity can be implemented using currently-available commercial off-the-shelf (COTS) UAS and associated sensor technology. Safety and security concerns are the lowest for this application
- Other safeguards applications may become plausible as technology improves

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