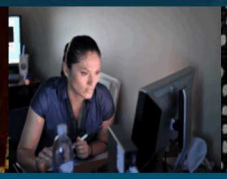
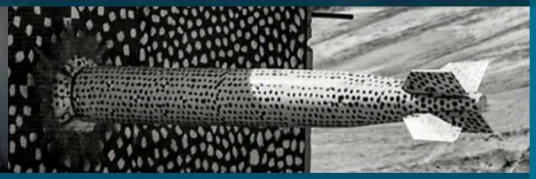
SAND2019-7927C

Unmanned Aerial Systems for Safeguards Inspections of Uranium Mines





PRESENTED BY

Daniel Small, Steven Horowitz, Alexander Solodov, David Novick

UNCLASSIFIED UNLIMITED RELEASE

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Emerging UAS

- Legal Framework for Safeguarding Uranium Mining
- Current UAS systems and their capabilities – Feasibility
- Sensor Payloads
- Concerns
- Conclusions

Legal Framework for Safeguarding Uranium Mining and Uranium/Thorium Concentration Activities

Under INFCIRC/153 Uranium mining and concentration do not need to be reported

State must declare the quantity, composition, and destination of the uranium or thorium if it is exported for nuclear purposes to a non-nuclear weapons state

Additional Protocol (AP) warrants greatercooperation between the state and IAEA (INFCIRC/540 or the AP, Article 2.a.(v)

Legal Framework for Safeguarding Uranium Mining and Uranium/Thorium Concentration Activities

Requirements under AP

- Imports as well as composition, origin, destination, date of shipment, and receipt
- Imports of Uranium > 10 tons
- Imports of Thorium >20 tons
- Inspector access, location, status, and annual production capacity of its uranium mines and concentration plants

Not required under AP

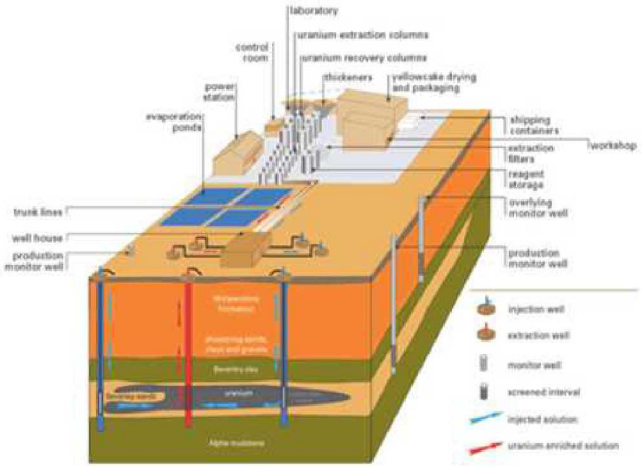
- Detailed nuclear material accountancy
- Mechanistical or Systematical verification the activities and material at mining and milling facilities

Safeguards reporting to the IAEA regarding a State's uranium mining and concentration activities contains limited but crucial information to enforce the nonproliferation regime

Types of Uranium Mining Activities

The Canadian McClean Lake open-pit mine

The Canadian McArthur River underground mining facility

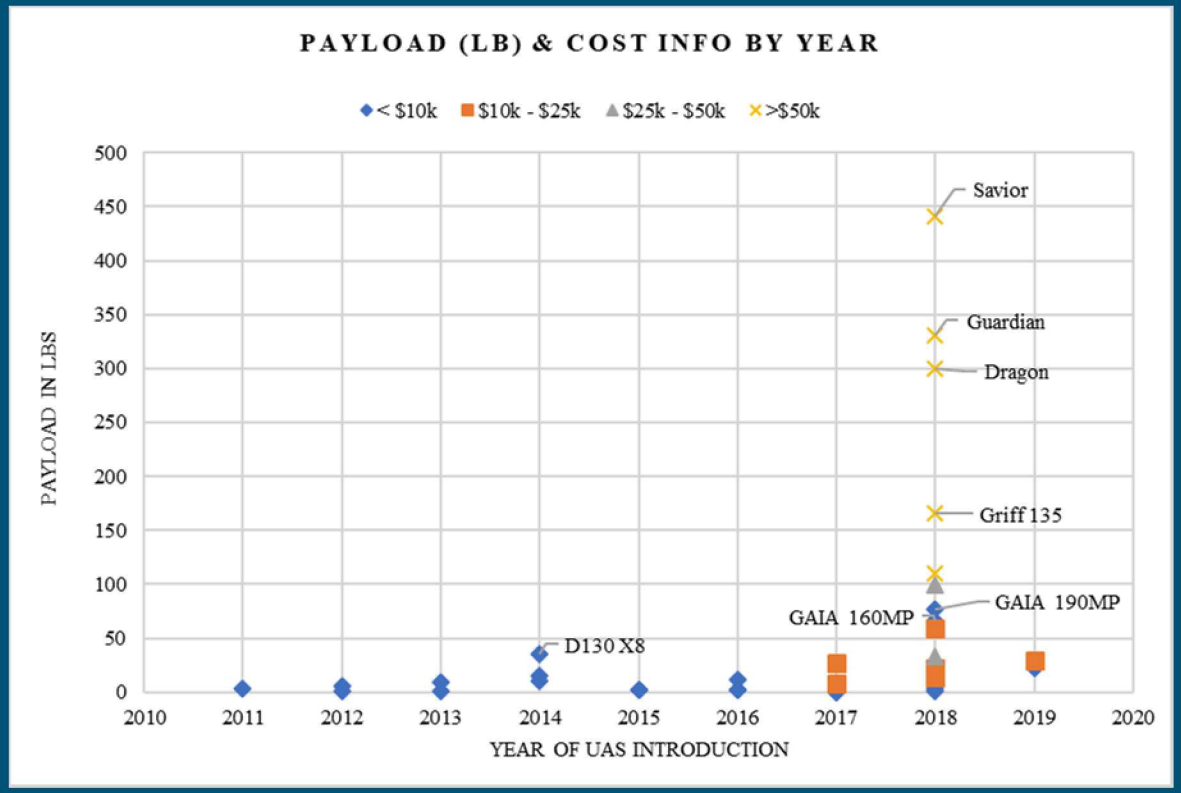


In situ leach mining process

Heap leaching of uranium ore.

FEASIBILITY ANALYSIS

Technical feasibility is an assessment of a technology's readiness to be deployed for the specific safeguards application



Evolution of UAS payload capability differentiated by the year they were introduced on the market and their cost

- The Foxtech Gaia MP line of UASs ($3,600 to $9,700) with significant payload capabilities from 35 to 60lb
- Hybrid energy gas/electric UAS are available in the $25k-$45k range with flight times in the 4 to 5-hour range with up to 30lb payloads

UAS Hybrid Power Systems Provide Extended Flight Time and Range

Gas/Electric

- Combination of an electric motor and an internal combustion engine Hybrid
- A heavy-lift payload is required, usually in the 10-15kg

Hydrogen Fuel Cells

- Hydrogen fuel cell converts chemical energy stored by hydrogen fuel into electricity
- Hydrogen fuel cells have a higher energy density over batteries, refuel quickly and function in low temperatures.
- The first hydrogen-fueled small UAS entered the market on April 2016

SENSOR PAYLOADS

Volumetric Assessments and 3-D Imaging

Light detection and ranging (LiDAR) sensors on UAS can create three-dimensional maps of mines:

3-D imaging and Unmanned ground vehicles (UGVs) can be used for determining the site layout, roads, and major equipment of the following applications

- Open-Pit Mine
- Underground Mine
- In Situ Leach (ISL) Mine
- Heap Leach Mine

Commercially-available 3-D imaging and volumetric sensing technologies exist which are capable of conducting 3-D surveys of sites with great speed and precision

Real-Time LIDAR Mapping with Riegel 3D Scanner and UAS

RiCOPTER,
fully integrated RIEGL VUX LiDAR sensor IMU/ GNSS unit with antenna
up to 4 optional cameras providing 330deg Field of View, 500,000 measurements/sec @ 10mm accuracy

Radiation Detection

Topographic Mapping of Radiation Dose On Site

- UAS with dosimetry equipment
- Dose rate
- ID marking and sampling by IAEA

Real-Time On-Board Gamma Spectroscopic Measurements

- Verify the absence of undeclared nuclear material or activities
- Verify the absence of highly-radioactive material

Kromek radiation detectors on wheeled rover & UAS

Kromek can now offer an out of the box solutions for radiation mapping and detection using unmanned ground and aerial vehicles. The solution includes the vehicles, detectors, controls and mapping software you need.

2-D Hyperspectral and Visible Imaging

UASs can be equipped with cameras for real-time transmission of photographic or video data to the IAEA for verification of new buildings or equipment

- Hyperspectral imaging can verify material composition at the site and help inspectors determine where to samples and verify exposed ore
  - ***The concentration of uranium in deposit samples at mines may not meet the minimum detectable quantity for hyperspectral imaging***

Concerns

CONCERNS

The implementation of UAS technology presents a number of significant safety, security concerns:

- Safety
  - Concern: navigation challenges when attempting to operate in an enclosed environment with radioactive dust (underground mines)
  - Mitigation: most uranium mines and concentration facilities are outdoors
- Security
  - Concern: Hacking, Data Security
  - Mitigation: Uranium mining and uranium/thorium concentration activities do not carry significant sensitive information which would be a security or proliferation concern
- Regulatory/Political
  - Concern: There exists no comprehensive international framework for UAS regulations
  - Mitigation: UAS Regulations & Policies from the Federal Aviation Administration (FAA) could provide initial framework

Conclusion

Mining and concentration activities present a unique opportunity for the integration of UASs, mainly volumetric assessments with 3-D LiDAR and 2-D imaging.

Hyperspectral imaging with UASs, while promising, faces several technical limitations.

Radiation detection with UASs does not appear to be particularly useful for mining applications due to the low radioactivity of material present at mines

UAS technology continues to proliferate and the individual systems will become more advanced

Alternative technologies, including hand-held sensors and satellite imaging, must be constantly compared with UASs to assess the benefits and risks of each.

Thank You

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