SALW Dashboard Methodology and Process

The prevalence of drug trafficking, coupled with emboldened organized crime groups and armed non-state actors with vast financial resources, has turned Latin America and the Caribbean into hotspots for internal conflict and violence in recent years. Criminal and militant entities have capitalized on the widespread availability of Small Arms and Light Weapons (SALW), a category that includes handguns and explosive ordnance as well as semi-semiautomatic and automatic rifles. This makes analysis of ongoing trends in the illegal weapons market essential to understanding the rise in violence in Latin America and the Caribbean. A tool that can help open-source researchers understand the issue is the SALW Dashboard, a geospatial database that tracks the usage, seizure, and trafficking of SALW in the region.

Developed by the Regional Coordinator for Social and Economic Research (CRIES) and the Jack D. Gordon Institute of Public Policy at Florida International University (FIU), the SALW Dashboard was launched in 2021. A second version was launched in 2024, integrating AI and machine learning. The tool applies open source research techniques to maintain a robust, up-to-date and publicly available database that tracks SALW incidents in the region within an easy-to-use dashboard.

Methodology Overview

In conjunction with FIU, the open-source intelligence (OSINT) team at CRIES crafted a custom methodology that merges conventional research methods with specialized open-source tools, optimized for unique conditions across more than 30 countries. The SALW Dashboard employs a comprehensive, multi-step approach to identify, verify, and analyze data on illegal arms trafficking utilizing machine learning and extensive web scrapes. This methodology involves several key stages:

1. Data Collection:

The primary data sources for the SALW Dashboard are open-source media reports collected from three main channels: Google Alerts; X (formerly Twitter); and YouTube. The overall set includes publicly available information from media reports, government publications, social media, and non-governmental organizations (NGOs).

We maintain a robust dataset capable of scaling and easy access to information, we have integrated a PostgreSQL database to store the raw forms of news articles and reports, ensuring posterity. Metadata is also recorded and stored, where applicable. A backlog is maintained for all processed incidents which have been nominated but not yet reviewed.

2. Automated Categorization and Structuring:

The SALW Dashboard starts by aggregating open-source information scraped from the web and applying a machine-learning model utilizing LLM's to automatically sort data into a standardized format. Once the data is prepared into an incident format, it enters a queue whereby it is then assigned to a researcher for review. Each incident is assigned a title containing the country where the incident occurred and a one-sentence description of the event; a longer summary detailing in two to five sentences what reportedly occurred; the identification of weapons involved; and links to original sources where the incident was identified. Each incident is

assigned a unique report ID number and, where available, includes supplementary info such as the type of incident, whether it involved diverted weapons, if any notable groups were involved, and if any multimedia is available. The incidents are then assigned an initial geographic location of each event, approximating to a centroid of the nearest associated neighborhood, town, or city when details are sparse.

Incidents must meet one or more of the following criteria to remain viable:

- If the incident involves the seizure of SALW, with the exception of single pistol or single shotgun seizures,
- All instances of theft, loss or destruction of SALW, and
- Incidents of illegal use or possession of SALW in which visual or audiovisual content can be time-stamped and geolocated to the exact site of the occurrence.

Incidents are run through a de-duping mechanism, but to ensure a higher level of duplicate avoidance, specific reviewers are assigned all events in a country for a given time period to ensure they would be identifying any duplicates that were not originally detected through our model. Data is cross-referenced by researchers with multiple sources to ensure accuracy as well as to avoid duplicate reporting. This process helps to confirm the authenticity of the information and mitigate the risks of misinformation. Additionally, each source is evaluated by researchers for reliability and credibility. Priority in reporting is given to reports from reputable entities with a track record of accurate reporting.

3. Incident, Weapon and Event Categories:

3.1 The format used for events includes the following:

- *Headline:* Includes location, the incident type, and weapon type where possible.
- *Summary*: For incidents, the summary should be 2-4 sentences. Provide enough details so that readers do not have to follow the link to understand the event. Full transcriptions/translations need not be provided unless subsequently requested.
    - For longer source material, such as an investigation or a comment piece, more information should be included, particularly if the source is not in English.
    - The summary should focus on:
        - Weapons type (be as specific as possible)
        - Date (Day and Month) and location (be as specific as possible).
        - Circumstances of the incident, parties involved (including military unit/location), any connection to criminal or insurgent groups.
        - Any information pertaining to the security measures in place at the time of the incident or other factors that may have contributed to the incident.
        - Any other relevant contextual information.
- *Report ID*: This should use the ISO country code, the date of the source report, and the sequence for that date, e.g. ISO-YYYY-MM-DD-###.
- *Region:* The geographical area where the incident took place, such as North America, Central America, South America, or the Caribbean.
- *Country*: The country of origin where the incident took place.
- *Incident Date*: Date of the primary incident.
- *Primary Incident Type*: Primary incident type should be the most relevant incident type contained in the report. Often, this will be the final event in a chain. For example: soldiers desert their unit, raid another unit, but are defeated by the

national army. Label that primary incident type as “counteraction,” with a secondary incident type as “desertion”.

- *Secondary Incident Type*: If none, leave blank. Secondary incident type is the next most important incident type related within the summary, generally something leading to the primary incident. For the example: a military officer is arrested on suspicion of selling weapons illegally. The primary incident type is “Law Enforcement,” and the secondary incident type is “Corrupt Sale or Rent,” because it was the incident type leading to the arrest.
- *Weapons Types:* Be as specific as possible and use “Unspecified” as a very last resource.
- *Location:* Be as precise as possible, down to the town/village and name of the facility/site/street/house number if available. If possible, include relation to other reference points if the location is obscure.
- *Related Reports:* The Report ID of previous reports relating to the same incident. For example, if weapons are recaptured by security forces, that report should refer to the previous report of the theft, loss, or other incident, if possible. Use discretion here and do not spend too much time linking tangential reports. For example, there is no need to link all incidents of a terrorist group to one another.

3.2 Incident Categories:

Incidents are categorized based on their nature, such as arms seizures, illegal sales, or cross-border trafficking. This classification is crucial for analyzing trends and patterns. The existing categories are the following:

- Law Enforcement: arrests, investigations, and trials conducted for prior events.
- Regulation or Reporting: legal measures passed, or public declarations made, that relate to SALW laws and regulations. Includes investigative reporting of SALW incidents by journalists and academics. Also includes summary reporting over previous arms control campaigns.
- Counteraction: successful prevention of theft, diversion, corruption, attack, diversion, etc. by legal, authorized state authority.
- Recapture: reclaiming of items previously known to be under the control of legal, authorized state authority.
- Seizure: a legal, authorized state authority taking items from individuals or non-security forces that are suspected of being, but are not explicitly reported/documented as being, under previous lawful, authorized state control.
- Theft: small-scale, opportunistic theft of items either by unauthorized individuals or by small groups not known to be affiliated with a combatant force or gang.
- Theft, Coordinated: planned and coordinated theft of items. Coordinated theft may be the product of:
    - an individual with evidence of detailed, advanced planning,
    - coordinated gangs or groups (but not as part of an armed engagement -- see Loss via engagement).
- Diversion: illicit transfer of items from someone within a legal, authorized state authority to an unauthorized end user. For example, if a soldier takes items from a military stock and transfers to a criminal element, this is diversion rather than theft. Also covers when a state transfers weapons to an embargoed regime against international law.
- Corrupt Sale or Rent: sale or renting of items from legal, authorized state authority to unauthorized end user. If a soldier sells items, it is corrupt sale rather than diversion.

- Desertion: recognized personnel of a legal, authorized state authority leaving service while in possession of service-issued weapons and/or ammunition.
- Use or Possession of Illicit Weapons: use, in combat or criminal act, of weapons or ammunition. Also used for an individual or group broadcasting that they are in possession of a diverted or illicit item.
- Looting: the taking of items during a riot or civil unrest.
- Loss: inability to account for weapons and ammunition previously known to be under security force control.
- Loss via Engagement: loss of weapons and ammunition by legal, authorized state authority during an attack, raid, or other engagement with a combatant force or armed group. This differs from Theft, coordinated because it requires armed engagement between combatant forces.

3.3 Weapon Categories:

Weapons are categorized into specific types (e.g., pistols, rifles, machine guns) and their potential origin which are a significant factors in the region's arms trafficking dynamics. The existing weapons categories are:

- Pistol or Revolver: hand-held firearm.
- Rifle or Carbine: long-barreled weapon requiring manual operation to reload prior to each shot.
- Sub-Machine Gun: short-barreled, automatic, magazine-fed weapon firing pistol ammunition.
- Shotgun: shoulder-fired small arm that fires shot or a projectile through a smooth barrel.
- Assault Rifle: rifle capable of single-shot, automatic, or burst fire; uses an intermediate- sized cartridge (e.g., 5.56 x 45mm or 7.62 x 39mm); and has a detachable magazine.
- Light Machine Gun: fully automatic weapon with an ammunition belt or large-capacity magazine, often with bipod support, with calibers less than 12.7mm (.50).
- Small Arms Ammunition: ammunition for pistols/revolvers, rifles/carbines, sub-machine guns, assault rifles, and light machine guns; less than 12.7mm (.50). Anything resembling a "bullet" falls into this category.
- Heavy Machine Gun: fully automatic weapon with an ammunition belt or large-capacity magazine, caliber 12.7mm (.50) or larger.
- Grenade Launcher: weapon that fires a standard grenade; hand-held, underslung, or mounted.
- Recoilless Gun/Rifle: lightweight artillery weapon that fires a heavy projectile, shoulder- fired or vehicle-mounted.
- Small Mortar Systems: device that launches mortar bombs up to and including 81mm.
- Portable Anti-Tank Guns: unguided, shoulder-launched, anti-vehicle grenade launcher; can be rocket-propelled. This includes RPG-2 and RPG-7 launchers.
- Anti-Tank Guided Missile System (ATGM): portable weapon that fires guided missiles, can range in size from shoulder-launched to vehicle-mounted.*
- Man-Portable Air-Defense System (MANPADS): fires a shoulder-launched, surface-to-air guided missile.*
- Surface-to-Air Missile System (non-MANPADS): weapon system that fires a guided missile from the ground at aircraft. Not man-portable.

- Light Weapons Ammunition: ammunition for heavy machine guns, caliber 12.7mm (.50) or larger.
- Light Weapons Ammunition, Explosive: ammunition for light weapons that have explosive content. This includes fired or projected grenades; rocket-propelled grenades; recoilless rounds up to and including 106mm; mortars up to and including 81mm. Does not include missiles.
- Artillery System: weapon system larger than small arms and light weapons.
- Explosive Ordnance: conventional munition containing explosives that are not defined as "Light Weapons Ammunition, Explosive." Does not include landmines.
- Explosive Material: explosive material not in a conventional munition. Includes loose and bulk explosives; for example, TNT blocks.
- Landmines: explosive device concealed under or on the ground and designed to destroy or disable enemy targets, ranging from combatants to vehicles and tanks, as they pass over or near it
- Military Vehicles or Tanks: vehicle with mounted weapons, tanks, or tank components.
- Military Equipment (non-vehicular): military equipment that is not a weapons system, munition, or vehicle/tank component.

Weapons identification, beyond categorization as described above, is the in-detail identification of weapons models and makers via visual analysis of available pictures and videos of the incident. This identification is conducted by trained researchers and using OSINT techniques provides as much accuracy of weapons identification in the "Summary" section and in narrative format to provide a greater degree of detail to SALW Dashboards users. For example, while in the "Weapon Type" box "Assault Rifle" might be the selected option, the summary may include further details on the weapon in the summary such as "AR15 pattern rifle utilizing an Anderson Manufacturing lower".

4. Subject Matter Expert Review

The SALW Dashboard starts by aggregating open-source information scraped from the web and applying a machine-learning model utilizing LLM's to automatically sort data into a standardized format, which is organized and displayed on the dashboard. Once the model has completed its scheduled and automated process for detection, scraping, and categorization, it enters a queue, wherein reviewers check each incident before confirmation.

This process of review is as follows:

1. Incidents are assigned by a manager to a specific reviewer, prioritizing incidents occurring in the same country over a specified period to ensure an additional level of duplicate detection.
2. Incidents are reviewed in chronological order, starting with the oldest estimated date of the incidents assigned to a researcher.
3. The original source of the incident is quickly reviewed to make sure it meets minimum criteria for inclusion. If it does not, it is excised from the queue.
    a. Sources that are not legitimate may be banned from inclusion or detection in perpetuity.
4. For legitimate incidents, reviewers then proceed to make any necessary edits and apply their expertise in correcting any miscategorization done by the model, adding in contextual information in the summary and/or assigning a more precise geolocation.
5. The corrections and rewrites then automatically inform the model's reinforcement learning.
6. Notes are left for any questions and/or concerns that need to be addressed before final confirmation, and these incidents remain in another queue to await a final approval by a supervisor before entering into the confirmed dataset.

5. Analysis and Visualization:

- Trend Analysis: The structured data is analyzed to identify trends and patterns in illegal arms trafficking. This includes geographic hotspots, frequency of incidents, and the types of weapons most commonly trafficked.

- Visual Dashboard: The results are visualized through an interactive dashboard that allows users to explore the data in detail. These visual tools provide insights into the scale and scope of illegal arms movements in Latin America and the Caribbean.

6. SALW Model Process

Below is a summarization of the model's automated processes:

I. Data Sources and Ingestion
   a. Google Alerts
      i. Keyword Configuration: Keywords are specified in a YAML configuration file, defining terms of interest for monitoring.
      ii. Scheduled Scraping: Kubernetes Cronjobs schedule scraping tasks, triggering Docker containers to parse XML feeds obtained from Google Alerts.
      iii. RSS Scraping: Extracts news links from XML feeds:
         1. Utilizes XPath or custom parsers to navigate XML structures.
         2. Retrieves article URLs, timestamps, and brief summaries.
      iv. News Content Extraction: Employs a dual approach for content extraction:
         1. Automated Extraction: Utilizes NLP pipelines for primary extraction:
            a. Tokenization and part-of-speech tagging to analyse text.
            b. Named Entity Recognition (NER) to identify entities like persons, organizations, and locations.
         2. Fallback Mechanism: Custom scrapers are employed when automated extraction fails:
            a. Removes HTML tags using regular expressions.
            b. Applies tokenization and language-specific heuristics to isolate relevant information.
   b. Twitter Deck
      i. Two steps scraping: Twitter deck's data will be scraped first and persisted, then Twitter scraper process each tweet and save the final output to database.
      ii. Scheduled Scraping: Kubernetes Cronjobs orchestrate Docker containers to fetch tweets from specified Twitter decks.
      iii. Content Retrieval: Handles tweet content and embedded media:
         1. Text Extraction: Uses Twitter API endpoints for retrieving tweet metadata and content.
         2. Link and Video Extraction: Identifies embedded links and multimedia content:

a. RSS scraping for linked articles.

b. Dedicated video scrapers for multimedia files.

c. YouTube and News Videos

i. YouTube Processing:

1. Metadata Extraction: Utilizes direct API calls to retrieve video details such as title, description, and upload date.

2. Video Download: Implements efficient streaming protocols (e.g., HLS) for video retrieval.

3. Transcription: Utilizes cloud-based services for speech-to-text transcription of video content.

ii. News Video Handling:

1. Video Conversion: Uses multimedia frameworks like FFmpeg for converting videos to audio formats.

2. Transcription: Employs speech recognition APIs for audio-to-text conversion.

II. <u>Data Persist</u>

a. *Database Integration*: We integrated our system with a robust PostgreSQL database to store raw news articles and reports. This ensures scalable and secure data management.

b. *Backlog:* All the data processed from scraper will be persisted as backlog for model pipeline to process.

c. *Content Retrieval:* Handles tweet content and embedded media:

i. Text Extraction: Uses Twitter API endpoints for retrieving tweet metadata and content.

ii. Link and Video Extraction: Identifies embedded links and multimedia content:

1. RSS scraping for linked articles.

III. <u>Model Pipeline</u>

a. Query and Preprocessing

i. Dynamic Querying:

1. Our pipeline dynamically queries the database to retrieve only the records that need processing, optimizing resource usage and performance.

ii. Advanced Data Cleaning:

1. Using pandas, our system meticulously cleans and preprocesses the data, ensuring that only high-quality, relevant text is analysed. This step involves removing null values, handling special characters, and normalizing text formats.

iii. Natural Language Processing:

1. Leveraging spaCy, one of the leading NLP libraries, we load pre-trained language models like "en_core_web_sm" to perform tasks such as tokenization, part-of-speech tagging, and named entity recognition. This

enables the system to understand and process human language with high accuracy.

IV. Translation and Summarization

a. State-of-the-Art Language Models:

i. We utilize OpenAI's GPT-3 and Facebook's BART-large-CNN for translation and summarization. GPT-3 is renowned for its human-like text generation, while BART-large-CNN excels in summarizing lengthy articles into concise, coherent summaries.

b. AI-Powered Summarization:

i. Our system generates summaries using advanced text summarization techniques. The summarization engine distils the core information from lengthy articles, ensuring that critical details are captured concisely.

c. Dual Summarization Strategy:

i. Both GPT and BART-large-CNN generate summaries of the text. GPT then acts as the judge, evaluating the outputs and selecting the best summary between the two. This ensures the highest quality and most accurate summaries.

d. Relevant Fields:

i. Headline, Summarization.

V. Duplication Checks

a. Vector Similarity Search:

i. Employing advanced vector similarity algorithms powered by Qdrant and Chroma, we compare new incidents with existing records to detect duplicates. This involves high-dimensional vector representations of text and state-of-the-art similarity measures like cosine similarity.

ii. Our system performs multi-stage duplication checks using both vector-based and rule-based methods, ensuring comprehensive and accurate duplicate detection.

VI. Information Extraction

a. Entity Recognition:

i. Using NLP techniques, we extract essential entities such as dates, locations, and weapon mentions. This involves complex pattern recognition and context analysis, leveraging models trained on vast datasets to ensure precision.

b. Date Parsing and Validation:

i. We use the date our library to accurately parse and validate dates mentioned in unstructured text. This ensures that dates are correctly identified and formatted for further processing.

c. Detailed Extraction:

i. We extract comprehensive insights from processed data.

ii. Identify entities (e.g., persons, organizations) involved in incidents.

d. Relevant Fields:

i. Location, incident date, names, etc.

VII. Classification

a. Incident Categorization:

i. We utilize a sophisticated text classification model to categorize incidents into primary and secondary types. This model is trained on extensive datasets to ensure high accuracy and relevance.

b. Group Association:

i. Our system identifies and associates relevant groups mentioned in the incidents, providing deeper insights into the involved parties.

c. Relevant Fields:

i. Primary incident type, secondary incident type, associated groups, etc.

VIII. Image OCR and Captioning

a. Optical Character Recognition (OCR):

i. Our system uses advanced OCR technology to recognize and extract text from images attached to news articles. This ensures that any text embedded in images is captured accurately.

b. Image Captioning and Summarization:

i. Utilizing sophisticated image captioning models, the system generates summaries of the descriptions of these images. This adds another layer of context and detail to the analysed incidents.

c. Relevant Fields:

i. Multimedia

IX. Geographical Data

a. Geocoding Services:

i. By integrating with high-precision geocoding APIs, such as ArcGIS, our system retrieves accurate geographical coordinates for identified locations. This enables precise mapping and analysis of incident locations.

b. ISO Code Retrieval:

i. Our application fetches ISO country codes using the GeoLocator module, standardizing location data and facilitating global analysis of incidents.

c. Relevant Fields:

i. Longitude, latitude, country, etc.

X. System Architecture

a. *Microservices Architecture*: Implements modular services:
   i. Deploys microservices using container orchestration platforms (e.g., Kubernetes).
   ii. Ensures scalability and fault tolerance for handling varying workloads.
b. *Containerization:* Utilizes Docker for application deployment:
   i. Simplifies deployment across different environments with consistent runtime environments.
c. *Data Pipelines:* Orchestrates ETL processes:
   i. Uses workflow management tools (e.g., Kubernetes scheduler) for scheduling and monitoring data pipelines.
d. *Cloud Integration:* Leverages cloud services for:

    i. Scalable infrastructure provisioning (e.g., AWS EC2, Google Cloud Compute Engine).
    ii. Managed database services (e.g., AWS RDS, Qdrant Vector DB) for data storage and retrieval.
e. *Security Measures:* Implements robust security protocols:
    i. Secures data with encryption (e.g., TLS) in transit and at rest.
    ii. Implements access control mechanisms (e.g., OAuth, IAM) to safeguard resources.
f. *Monitoring and Logging:* Utilizes centralized logging and monitoring solutions:
    i. Integrates with Grafana for real-time analytics and troubleshooting.

The SALW Dashboard represents a significant advancement in the monitoring and analysis of illegal arms trafficking in Latin America and the Caribbean. By combining meticulous data collection, rigorous verification processes, and advanced analytical tools, the dashboard provides a comprehensive view of the dynamics of small arms and light weapons trafficking in the region. This tool not only aids in understanding current trends but also supports efforts to combat illegal arms flows and enhance regional security.