Pathways to Action: Harnessing Arms Flow Data for Conflict Early Warning

Insights from expert exchanges in 2024

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1. Introduction

The number of armed conflicts is at a record high level since World War II and they have become more complex.[1] Even wars that have supposedly ended subsequently re-emerge. They have devastating humanitarian and long-term impacts.[2] Early warning of armed conflicts is thus essential, as it enables anticipatory action to prevent their outbreak, escalation and relapse, or to mitigate their consequences.

Conflict early-warning efforts need to have access to all the relevant data that can improve their performance. Data on flows of conventional arms and ammunition (henceforth: arms flow data) could be relevant for such efforts: weapons flows into unstable regions have long been considered as a possible signal of a future outbreak, escalation or relapse of armed conflict. Ultimately, it is the use of these weapons that turns tensions into armed violence.[3] However, arms flow data is only used sporadically for early warning and its potential remains underexplored. This is a missed opportunity in the light of conflict reality and the renewed appeals for stronger prevention, such as in the United Nations Secretary-General's New Agenda for Peace and the Pact for the Future.[4]

To address this gap, the United Nations Institute for Disarmament Research (UNIDIR), Conflict Armament Research (CAR), the Peace Research Institute Oslo (PRIO) and the Violence & Impacts Early-Warning System (VIEWS) launched the initiative **"Building Bridges and Incubating Ideas for Stronger Conflict Prevention: Harnessing Arms and Ammunition Flow Data for Early Warning"** to foster use of arms flow data for more effective early warning. In 2024, they brought together key experts on early warning and arms flows from the United Nations, international and regional organizations, civil society, research, and academia to engage in two activities:

▶ Virtual focus groups in June 2024 to identify gaps and challenges in harnessing arms flow data for early warning

▶ An international conference, held in Geneva in November 2024, to jointly create potential pathways and partnerships to overcome these gaps and challenges

This Insight distils the key takeaways and pathways for action that arose from these expert exchanges.

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[1] S.A. Rustad, *Conflict Trends: A Global Overview, 1946–2023* (Oslo: PRIO, 2024), **https://www.prio.org/publications/14006**; United Nations and World Bank, *Pathways for Peace: Inclusive Approaches to Preventing Violent Conflict* (Washington, DC: World Bank, 2018), **https://unsdg.un.org/sites/default/files/2021-02/Pathways-for-peace_web.pdf**.

[2] See for instance P. Vesco, et al., "The Impacts of Armed Conflict on Human Development: A Review of the Literature", *World Development*, vol. 187 (2025), **https://doi.org/10.1016/j.worlddev.2024.106806**; D. Wang et al., "Assessing the Impact of Armed Conflict on the Progress of Achieving 17 Sustainable Development Goals", *iScience*, vol. 27, no. 12 (2024), **https://doi.org/10.1016/j.isci.2024.111331**.

[3] S. Yazgi at al., *Addressing Conventional Arms Risks and Impacts to Prevent Conflict and Build Peace: What More Should the United Nations Do?* (Geneva: UNIDIR, 2020), **https://unidir.org/wp-content/uploads/2023/05/Community-of-Practitioners-Workshop-report.pdf**.

[4] United Nations, *A New Agenda for Peace*, Our Common Agenda Policy Brief no. 9 (New York: United Nations, 2023), **https://dppa.un.org/en/a-new-agenda-for-peace**; United Nations, General Assembly, Resolution 79/1, **https://docs.un.org/en/A/RES/79/1**.

BOX 1

Key Terms

Arms flow data

Arms flow data refers to information about movements of conventional arms and ammunition – whether authorized or not – that:

▸ Go from one geographical point to another (e.g., export or import)

▸ Go from one user to another (e.g., transfer, donation, sale, seizure, diversion)

▸ Go from one use to another (e.g., conversion)

or are a combination of the above.

The varied sources of such data include:

▸ Publicly available official government data (e.g., arms control instruments, national reports, border control, law enforcement)

▸ Publicly available open-source data (e.g., social media, satellite data, news reports)

▸ Field monitoring data (e.g., physical documentation, interviews with locals, eyewitness reports, photos, surveys)

Conflict early warning

Conflict early warning is a process that:

▸ Alerts decision makers and other practitioners to the potential outbreak, escalation, intensity or resurgence of violent conflict

▸ Promotes an understanding among early-warning users of the nature and impacts of violent conflict

It involves the regular collection, processing and analysis of a wide array of indicators coupled with crucial information on contexts of conflict, tension or other concern. All this information is then used to produce forward-looking risk assessments or predictions with a view to help decision makers and practitioners mitigate or even prevent future violence and its adverse impacts.

Methodological approaches to conflict early warning vary and may be used in combination. They include traditional methods (e.g., qualitative expert assessments) and computational methods (e.g., forecasting models based on machine learning that process large volumes of data). Early warning initiatives may also have different geographical coverage (e.g., covering only specific locations or seeking to produce comparable, scalable assessments with international or global coverage).

Community early warning, 2009. Credit: UNISDR / Amir Jina.

2. Key Takeaways

Building more solid evidence on the links between arms flows and conflict dynamics is a good starting point but is not a prerequisite for the use of arms flow data in early warning

The links between arms flows and conflict dynamics are complex and highly context-dependent. Research has shown that, in specific circumstances, flows of weapons have an impact on conflict dynamics – relating to onset, duration and intensity of conflict. However, the precise causal links have not yet been fully established; that is, it is not yet possible to say that more weapons necessarily equals more conflict. The availability – or lack – of weapons, the specific weapon types, the willingness and ability of armed actors to deploy them, and the wider socio-political context are all factors that influence this relationship.

Establishing direct causality between arms flows and conflict would be a good starting point to foster the use of arms flow data in early warning. However, this causal link is often not a prerequisite for early-warning efforts. For many computational methods, what is most important is the ability of arms flow data to increase predictive performance of forecasting models. Indeed, technological advances (e.g., machine learning) have increased the capabilities of such models to extract signals from complex relationships between variables (e.g., links between arms flows and conflict dynamics). Similarly, in traditional early warning, contextual knowledge on the role of weapons and the larger sociopolitical dynamics can help assess complex relationships.

Different early-warning initiatives have different requirements for arms flow data

Enhanced collection, utility and use of arms flow data could benefit many early-warning providers. There are two main common requirements across the different early-warning approaches that determine if this data might be suitable for use:

▶ The data needs to be **well-maintained**, that is, it must be regularly updated, validated for reliability, and managed to ensure long-term accessibility and usability.

▶ The data needs to be **verifiable**, that is, it must originate from publicly available sources.

Mostly for traditional early-warning providers (i.e., those using predominantly qualitative methods), there is generally an additional requirement: the data needs to be **contextual** (e.g., with actor- or weapon-specific details), whether originating from open sources, eyewitness reports or information collected on the ground.

Computational early-warning providers usually have, to varying degrees, a different additional requirement: the data needs to be **spatially and temporally granular**, that is, it must contain a large enough set of unique and sequenced time-related (e.g., year, month, day) and space-related (e.g., regional, subregional, national) data points. Thus, rather than one-off data points with detailed contextual information, these providers instead need many different data points over time, preferably with high variance, in order to detect potential patterns and conflict risks. Furthermore, certain computational models may only introduce new data if it provides additional, relevant signals that indicators already in use do not yet fully capture.

The relevance of specific arms flow data for an early-warning provider depends not only on fulfilling the above data requirements. It also results from the interplay with other input data, and from each early-warning provider's methodological approach, geographical coverage and prediction target (e.g., what conflict outcome is predicted). For this reason, a specific set of arms flow data that adds little predictive value for one early-warning provider may still be valuable for another. Overall, even imperfect data remains more valuable than no data.

Key challenges remain to be overcome for greater use of arms flow data in early warning

The use of arms flow data in early warning is currently limited. This is partly due to limitations in the nature of the existing data, such as:

▶ **Not all data is accessible for public use** but many early-warning providers require publicly available input data to ensure transparency.

▶ There is often a **time lag** between primary collection, validation and release of data, which can make the data unfit for early warning with short prediction or monitoring cycles.

▶ Data is sometimes **not released frequently** or **not maintained regularly**, while certain early-warning providers rely on the sustained and consistent provision of data to be able to observe trends.

▶ Data can have **limited (temporal and spatial) granularity** and geographical coverage, which may, in particular, affect its use in computational models.

Besides specific data limitations, **minimal dialogue and knowledge-sharing** between the early-warning and arms flows monitoring communities also poses a challenge. The former may have limited awareness of existing arms flow data sources and use cases, while the latter may not always have a full understanding of potential data users and their requirements. Fostering mutual knowledge is a key precondition for better harnessing the predictive potential of arms flow data.

Finally, arms flow data can require **technical knowledge**, and can be **sensitive and political**. Stakeholders (e.g., states) may be reluctant to release it. On the ground, it can also be difficult or risky to collect and share. Importantly, while the acquisition and holdings of arms and ammunition by non-state armed groups – the prevalent type of conflict party today – are relevant for conflict dynamics and arguably also for early warning, they and their suppliers usually have strong reasons to keep some or all of this information confidential.

These key challenges should not prevent relevant stakeholders from exploring avenues to make better use of existing data and improve its suitability for early warning. Indeed, they should incentivize it. Facing these challenges can also provide the starting point for future innovations, such as gathering new types of arms flow data or making collection approaches more useful for early warning.

Strengthened use of arms flow data is more realistic in traditional early-warning initiatives, while use in computational systems requires further data improvement and testing

To date, the use of arms flow data in operational early warning has been limited to early-warning providers that use traditional methods. The Economic Community of West African States (ECOWAS) Warning and Response Network (ECOWARN) and the Conflict Early Warning and Response Mechanism (CEWARN) of the Intergovernmental Authority on Development (IGAD) are two good examples in this regard.[5] Both collect arms flow data through an extensive network of field monitors and regular open-source monitoring. These systems have arms-related indicators (e.g., number of arms seized, increases in armed violence between farmers and herders, and use of weapons in urban crimes) that are analyzed in the light of local dynamics and integrated in qualitative assessments. While challenges remain (e.g., data complexity and sensitivity, limited access to certain regions), these good practices have the potential to be used in similar initiatives in other parts of the world.

Effective use of arms flow data in computational early-warning models may require a longer-term perspective. First, the collection of data needs to be strengthened in terms of its quantity, consistency and reliability, as well as, where possible, the spatial and temporal variation requirement for computational model training. Second, the predictive performance of available weapon-related indicators should be tested to demonstrate that they actually improve forecasts. New indicators must capture signals that would otherwise be missed by

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[5] On ECOWARN, see, for instance, A. Ndinga-Muvumba and A. Lamin, *West Africa's Evolving Architecture: Looking Back to the Future* (Cape Town: Centre for Conflict Resolution, 2006), **http://www.jstor.com/stable/resrep05185.9**. On CEWARN, see **https://cewarn.org**.

the data that models already use. As testing may require time and capacity – notably in models with global coverage – a model with a local or national scope would be a good starting point to explore the use of arms flow data in forecasting. This could also be tested on a limited, historical time period for which adequate arms flow data is available. Results from such testing could, in turn, also help refine causal models and encourage collection of future data that may be of utility to other models.

Different arms flow data-collection methods and technologies can help increase data availability and utility for early warning

Despite challenges such as declining reporting by states on their arms trade activities, arms flow data is more available and reliable today than two decades ago. A few developments illustrate this:

▶ Field research has fostered the **use of different methodologies**, such as investigating illicit supply sources and variations in black market prices, or analysing photographic and documentary evidence.

▶ **Engagement and empowerment of communities** in arms flow data collection has expanded (e.g., youth, community leaders and women as typically first witnesses of weapons influx within communities). This has helped traditional early-warning providers obtain regular, contextualized and disaggregated data. Regional initiatives, such as the West African Network for Peacebuilding (WANEP), have taken the lead on the inclusivity of data collection.

▶ **New technologies** such as web scanning, data mining of "live" data, automated or semi-automated event coding, as well as open-source intelligence (OSINT) methodologies have all improved the breadth, depth and timeliness of arms flow data. The increasing application of machine learning has also advanced automation of data collection and analysis.

Such methodologies and advancements can improve the availability and quality of arms flow data for early warning. Some of these innovations remain underutilized.

Members of the CNDD-FDD rebel forces surrender their weapons in Mbanda, Burundi, 2005. Credit: UN Photo / Martine Perret.

3. Pathways for Action

Expert exchanges to date under this joint initiative have identified potential pathways for the arms control and conflict early warning communities. These focus on harnessing existing data more effectively and prioritizing practical, impact-driven ideas and partnerships in order to strengthen the utility and use of arms flow data for early warning.

Pathways for action to strengthen collection, analysis and use of data

While traditional and computational early-warning initiatives have different data requirements, there are various practical pathways to strengthen the availability, suitability and use of arms flow data in early warning. Key actions, notably for arms flow data collectors in partnership with early-warning providers, could include:

▶ **Investing in standardization, long-term maintenance, geographic expansion and more frequent updates** of existing publicly available arms flow data. This could also include fostering data-sharing between data collectors and early-warning providers.

▶ **Fostering and expanding existing innovative research approaches** in arms flow data collection for use by early-warning providers (e.g., on military arsenals of non-state armed groups).[6]

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6   See, for instance, O. Pamp et al., "Introducing the Rebels' Armament Dataset (RAD): Empirical Evidence on Rebel Military Capability", *Journal of Conflict Resolution*, Published online 6 November 2024, **https://doi. org/10.1177/00220027241297692**.

- **Exploring the resumption of previously maintained – or the creation of new – databases** on specific types of item, in particular:
  - Transfers of small arms and light weapons (SALW):[7] SALW remain the main instrument of violence in many contexts.
  - Transfers and stocks of ammunition: Ammunition being expendable, ammunition stockpiles or flows are sensitive to conflict realities and could serve as excellent input data for early warning.[8]
- **Taking advantage of, or developing, new methods and technologies** for arms flow data collection (e.g., the potential of artificial intelligence-enabled applications for automation of data collection), in partnership with data scientists and the private sector.
- For traditional early-warning providers in particular: **considering and testing – including through in-country case studies – existing arms-related indicators** that may be suitable to specific early-warning initiatives. Resources such as UNIDIR's Arms-Related Risk Analysis Toolkit, which has over 300 arms-related indicators, could be used to this end.[9]
- **Collecting data on proxy measurements** (e.g., market prices for weapons in the case of traditional early-warning initiatives in specific contexts), where existing sources of arms flow data may not be suitable or cannot be scaled for sufficient geographic coverage.
- **Systematically including women** in arms flow data collection, in particular at community level, and in early-warning modelling to address gender blind spots in both data gathering and early-warning efforts.

Specific pathways for data collection for use in computational early-warning initiatives

- For conflict data collectors, such as the Armed Conflict Location and Event Data (ACLED) project and the Uppsala Conflict Data Program (UCDP): **systematizing extraction of weapon-related data from existing conflict data collection efforts.** This is a low-cost solution to build up arms flow data at scale with frequent updates. The predictive added value of such extracted data for specific forecasting models could subsequently be tested in empirical pilot studies.
- **Increasing the use of data mining** (i.e., collecting unstructured data such as text, images, audio or video and putting it into a structured data set) by arms flow data collectors, in particular those with a global focus, to collect "live" arms-related data. This could help generate large amounts of timely data to better predict, for instance, rapid conflict escalations.

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[7] PRIO's Norwegian Initiative on Small Arms Transfers (NISAT) included ammunition data. It was discontinued in 2017 due to lack of funding, but the database remains accessible at **https://nisat.prio.org**.

[8] See, for instance, Conflict Armament Research (CAR), *Conventional Ammunition Diversion. A Supply Chain Security Approach to International Control Measures* (London: CAR, 2018), **https://www.conflictarm.com/technical/conventional-ammunition-diversion**.

[9] S. Yazgi and E. Mumford, *The Arms-Related Risk Analysis Toolkit: Practical Guidance for Integrating Conventional Arms-Related Risks into Conflict Analysis and Prevention* (Geneva: UNIDIR, 2021), **https://doi.org/10.37559/CAAP/21/PACAV/04**.

Specific pathways for data collection for use in traditional early-warning initiatives

▶ **Developing user-friendly arms flow data collection tools** and guidance by research organizations for use by early-warning field staff who are not arms experts. This can enhance data quality, quantity and standardization of early-warning initiatives that collect data via field monitors.

▶ **Enhancing guidance by United Nations agencies for local communities and staff** of United Nations missions on the most relevant arms-related data for early-warning efforts by United Nations peacekeeping and special political missions.

▶ For arms flow data collectors with a localized or regional focus: **undertaking case studies with layered data analysis** (e.g., arms flows, trade, violence) to better contextualize arms flow data. This will enhance its relevance for traditional early-warning efforts at local or regional levels.

Pathways for action to increase capacity and knowledge

Fostering the use of arms flow data in early warning requires capacity-building, broadened knowledge and information-sharing across expert communities, including as a means to strengthen national ownership. Key actions, notably for research organizations in partnership with arms flow and early-warning practitioners, could include:

▶ **Developing and sustaining a resource hub** to foster cross-thematic knowledge exchange. To meet this need, UNIDIR, CAR, PRIO and VIEWS have mapped existing arms flow data sets and early-warning initiatives as a living working tool for use by experts: **The Arms Flows and Early Warning Dashboard**.

▶ **Convening regular meetings that gather the early-warning and arms flows communities** for an exchange on their respective current initiatives and avenues for future research and collaboration.

▶ **Documenting good practices and lessons learned** of current uses of arms flow data in early warning and exploration of new uses. This could feature in a state-of-the-art report on the topic, serving as a resource for arms flow and early-warning experts.

▶ **Advancing empirical research** by academia and research organizations to strengthen understanding of the causal links between arms flows and conflict dynamics. Strengthened collection of arms flow data (see above) could boost such research.

▶ **Convening workshops and training** to raise further awareness and increase capacity on the links between arms flows and early warning. For community-focused early-warning providers, peer-to-peer exchanges can improve knowledge on collection and use of data on local arms flows

▶ **Setting up an informal advisory network** of arms flow experts for ad hoc support to early-warning providers with limited or no in-house arms expertise. This would allow these providers to access and interpret arms flow data or to help identify relevant arms-related indicators.

▶ For United Nations agencies: **considering strengthening arms-related expertise** within existing structures of United Nations peacekeeping and special political missions to better support missions' broader early-warning and protection mandates.

Pathways for action at the policy level

Engagement with leadership on arms flow data and early warning can be instrumental in advancing the topic at policy level and fostering effective action. Key actions could include:

▶ For arms flow and early-warning experts, and United Nations, international and regional partners: **increasing awareness of policymakers** on the relevance and potential of arms flow data for early warning. In a United Nations context, the Peace and Development Advisor and Resident Coordinator networks could be promising avenues.

▶ For early-warning providers: **creating spaces for exchanges** between the end user of alerts (i.e., decision makers and humanitarian practitioners) and the providers of data or prediction in order to nurture trust in data and early-warning alerts. This is one prerequisite for early action, cognizant that action ultimately depends on political will and capacities. These exchanges could help reduce the gap between early warning and action.

▶ For States and relevant policy partners: **instilling the potential of arms flow data for early warning** in relevant policy forums and processes at United Nations, regional and national level. This could be, for example, in the annual Conferences of States Parties to the Arms Trade Treaty, the 2025 Review of the United Nations Peacebuilding Architecture or the implementation of the Pact for the Future.

▶ For organizations whose use and sharing of data are constrained by their mandate: **exploring policy avenues for sharing arms flow data** for the purposes of early warning. Not all data can – or should – be made available to everyone. Some information could, however, be made available through well-established processes that prevent the release of sensitive data, such as anonymization and the screening out of certain data points.

Pathways for action for enhanced partnerships and cooperation

Arms flow monitoring and early warning are established communities with their own expertise, methodologies and systems. Collaboration is key in order to pool resources and knowledge, spark innovation, break silos and prevent re-inventing the wheel. Key actions could include:

▶ **Fostering a multidisciplinary community of practice** among early-warning and arms flow experts, across science, policymaking and implementation, to share lessons learned, connect data needs with data provision and foster partnerships.

▶ **Strengthening cross-thematic cooperation within organizations** that work on both arms control and early warning. This would strengthen institutional coherence and make full use of – sometimes isolated – in-house expertise.

▶ **Promoting cross-regional dialogue** between regional organizations with early-warning and arms control programmes. For example, this could bring together ECOWAS, IGAD, the Organization for Security and Co-operation in Europe (OSCE) or the Caribbean Community (CARICOM).

▶ For arms flow experts specifically: **exploring dialogue and sharing of lessons learned** with practitioners collecting other types of "lagged" and difficult-to-access data (e.g., displacement data) or sensitive data (e.g., medical information).

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Cover Image: Peacekeepers serving MINUSMA establish positions to prevent shelling from above and to monitor movements of self-defense groups, Mali, 2016. Credit: UN Photo/ Harandane Dicko.

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