TRACKING MUNITION STOCKPILES AND TRADES: INCREASING TRANSPARENCY FOR GLOBAL DISARMAMENT

An Interactive Qualifying Project
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Abstract

Despite increasing calls for arms transparency, many countries are reluctant to report weapons trades and stockpiles. This project transformed the *Global Weapons Tracking* website into a platform to hold nations accountable, cohere the arms control community, and inform the public on large arms control. We developed maps displaying stockpiles, trades, and transparency indicators while soliciting website design feedback from arms control organizations. Our findings suggest that a nation's journalistic freedom and local conflicts contribute towards their participation in voluntary munitions reporting.

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1. Introduction

In 2018, the top one hundred international arms-producing companies generated arms sales revenues totaling $420 billion, a 4.6% increase from 2017 and a 47% increase from 2002 (Fleurant et al., 2019). Meanwhile, in the following year, the United Nations Register of Conventional Arms (UNROCA) received arms trade reports from only a quarter of the United Nations' member states, the lowest in thirty-seven years (Wezeman, 2019). The ever-increasing flow and possession of conventional arms demonstrates the need for transparency; however, reality indicates a decrease in countries voluntarily disclosing weapons stockpiles and trades.

Despite the virtues for general and complete disarmament (GCD), the lack of transparency regarding weapons stockpiles hinders countries from trusting one another and taking disarmament initiatives. National governments are reluctant to disclose sensitive information on weapon trades and stockpiles, and most of the available data is proprietary, residing behind paywalls. For countries that do report, there are often incompatible reporting methods and weapon categorizations between parties which leave discrepancies in weapon transfers and holdings. There also is no system in place to effectively hold countries accountable for reporting inaccuracies. While a handful of national governments have made progress by adopting regulation and transparency treaties, international policy enforces no punitive measures; this results in low reporting rates limiting treaties' effectiveness. With the help of non-governmental organizations (NGOs), promoting global transparency through public awareness would encourage more states to participate in and contribute to existing munition reporting programs created through UN treaties.

Arms control, nonproliferation, disarmament agreements and related commitments continue to be important tools that protect and advance international interest. The UN has endeavored to track and regulate the global arms trade, most notably, through UNROCA and the Arms Trade Treaty that provide methods and publish data for tracking weapons. Furthermore, NGOs such as the Stockholm International Peace Research Institute (SIPRI) work to collect data presented by the various reporting tools and consolidate it into one database. There are several civil society and multilateral agencies working independently on weapons transparency issues without a clearinghouse to unite their collective efforts (Wezeman, 2019).

This project transformed the *Global Weapons Tracking* website from a portal of organizations into an advocacy tool promoting transparency and accountability of global weapons trades using data visualization tools. We surveyed and interviewed members of the arms control community to discover

the website's purpose and expand upon its contents. Following their solicited feedback, we also improved the site's responsive design to make it mobile friendly. Additionally, our team developed four interactive maps which present transparency indicators and data showcasing large conventional weapon imports, exports, and stockpiles. This central hub will serve as an advocacy tool for GCD, bringing transparency concerns into the public's view.

In what follows, we review the relevant literature on the rationales for disarmament, challenges standing in the way, progress that has been made, and the work that lies ahead. This will contextualize the current state of disarmament and underscore why the need for transparency and accountability fueled our contributions to the *Global Weapons Tracking* website.

2. The State of Global Disarmament

The social, political, and environmental harm caused by the trade and possession of conventional and non-conventional weapons hold dire ramifications. Although the virtue of general and complete disarmament is widely recognized, efforts are impeded by the associated drawbacks and risks for individual nations. Some policies and regulations have attempted to mitigate the threats posed by countries' munitions; however, transparency has been a stumbling block for disarmament. Self-reported data on weapons transfers and stockpiles are rarely voluntarily disclosed, and when they are, there are often discrepancies between country reports. In this chapter, we unpack disarmament and weapons transparency — the rationales, challenges, progress made, and work that lies ahead to achieve weapons transparency.

2.1. Rationales for Disarmament

Major conventional weapons were first popularized in World War II (WWII) with the strategy of Blitzkrieg, which translates to "lightning war". This rapid offensive strategy used large weapons like tanks, artillery, and planes to swarm the enemy with a concentrated, overwhelming force (Foley, 2011). Although war tactics have since evolved, this ploy marked a watershed moment that catalyzed the proliferation of large weapons stockpiles. These weapons provide a foundation of defense for future armed conflicts. However, the concealment of one country's stockpiles can lead to uncertainty and mistrust within the international community – these concerns have been addressed through multi-lateral agreements to varying degrees of success.

The Cold War between the United States and the Soviet Union (1945-1991) demonstrates how weapons stockpile proliferation raises tensions and security concerns. Following the end of WWII, the development of the first nuclear bombs sparked a positive feedback loop: the stockpile increase on one side would make the other feel threatened, prompting a response to produce even more weapons. During the climactic Cuban Missile Crisis in October 1962, one wrong move could have led to mutual assured destruction (MAD) with the obliteration of both sides (Countryman, 2018). Since the Cold War arms race, the number of nuclear weapons owned in the world has significantly decreased from approximately 70,300 warheads in 1986 to 13,100 warheads in early 2021 (Kristensen, 2021). One of the factors ending this prolonged conflict was the Intermediate-Range Nuclear Forces (INF) treaty signed by US President Ronald Reagan and USSR President Mikhail Gorbachev in 1987. This agreement banned land-based ballistic missiles, cruise missiles, and missile launchers with ranges up to 5,500 km. By May

1991, 2,692 missiles were destroyed, followed by a ten-year verification period of their deconstruction. As of 2019, the United States has formally withdrawn from the treaty amidst growing concerns of China's missile forces and supposed Russian non-compliance. With the removal of vital arms nonproliferation agreements such as the INF treaty, history seems to be repeating itself with tensions between the United States and Russia rising once again amidst the possibility of another arms race (SIPRI, 2007).

A major concern of stockpile accumulation is the potential for weapons to fall into the wrong hands (violent extremist organizations and terrorist groups) and inflicting harm on civilians. One notable example was the twenty thousand unsecured missiles and unguarded explosive remnants of war (ERW) left behind after the Gadhafi regime fell in Libya. The probability of ERW detonations is highly unpredictable, depending on whether the ERWs have been fired, how much corrosion or detonation the ordnance has, and the endurance of the arming and fusing mechanisms (Martin et al., 2019). Alternatively, the long-term danger posed by ERWs can be accelerated if these remnants are converted into IEDs (Stevens, 2013). These enhanced yet unconventionally fabricated "homemade" bombs used by criminals, terrorists, and insurgents incorporate destructive and lethal chemicals and can be deployed at targets with the capability to incapacitate and kill (Office of the Chairman of the Joint Chiefs of Staff, 2021). Campaigns combatting IEDs in Iraq and Afghanistan have taken a large toll on the United States. By February 2012, the US had invested $58 billion towards countering IEDs with military casualties exceeding 3,000 deaths and 30,000 wounded (Stevens, 2013).

Apart from diffusing conflicts, arms races, and unauthorized procurement, environmental concerns are a less considered rationale for disarmament. Military affairs and munition production often expel vast amounts of pollution, litter ammunition, and exploit natural resources. These activities release harmful toxins into the environment, disrupt ecosystems and biodiversity, and aggravate landscapes. Agricultural degradation can be catastrophic for communities reliant on ecosystem services such as livestock, forestry, and fishery markets. Heavy metals such as lead, antimony, and zinc that are found in small arms bullets are toxic and can leak into groundwater aquifers, contaminating drinking water supply (Rectanus et al., 2015). Furthermore, abandoned remnants of war have long lasting effects on the environment well after active conflicts subside. Munition constituents (MC), defined as materials from unexploded ordnance (UXO), discarded military munitions, or other military weapons, that have been buried in soil or dumped in the ocean can have devastating effects on surrounding biological systems (Denix, n.d.). Harmful toxins contained within MCs are only released into the environment when breached by corrosion or breakage. However, this is a function of time and munitions will decay

until all contaminants are exhausted (Lotufo et al., 2017). France, Belgium, and Germany still suffer contaminated soils from World Wars I & II, deeming certain areas in these countries 'red zones' (Dathan, 2020); two areas in France specifically, Ypres and Woëvre, show that 99% of all plants still die and arsenic accounts for up to 17% in soil samples (Russell, 2016). The toxicity and environmental damage in these red zones prevents agricultural activity and are often inhabitable.

While GCD is unrealistic and undesirable for many countries, the resulting casualties from armed conflicts and the escalation of arms races justify disarmament endeavors. Furthermore, large weapons stockpiles produced for these conflicts degrade the environment and are prone to illicit acquisition. Despite these rationales, the lack of global transparency and accountability regarding weapon holdings impedes progress towards achieving this goal.

2.2. Challenges of Disarmament

Despite the convincing rationales, there are real challenges to advocate the international community towards disarmament goals due to the lack of trust, political incentives, and security exposure. Without trust regarding the extent of munition trades and holdings, countries may be reluctant to destroy their own weapons supply for fear of becoming vulnerable or losing influence; this lack of trust may prompt countries to produce even more weapons as a precaution. Additionally, while there are regulations that require UN member states to report weapons trades (discussed in section 2.3), there are no legal repercussions for failing to report or misleading reports. For example, from 1992 to 2004, the United States reported 1,413 exported munitions to Turkey, while Turkey reported a mere 260 imports from the US (United Nations Register of Conventional Arms, n.d.). While these conflicting reports may be caused by inconsistent reporting methods, other discrepancies could be intentional. Countries weigh the risks when choosing to be transparent with their weapon trades and stockpiles; a weak arsenal could expose their vulnerability to rivals, while an intimidating one could raise tensions with neighbors.

There are also economic and political incentives for governments to continue producing and exporting weapons. Not only is arms trading profitable, but it also allows suppliers to build leverage over recipient nations. For example, many countries rely heavily on the U.S. for their military equipment, allowing the U.S. to access overseas military bases, influence voting at the United Nations, deter conflicts, and urge political reform domestically (Thrall, 2020). Between 2002 and 2018, the US led the global market at 36% for supplying major conventional weapons to 169 countries, selling over $200

billion (Thrall, 2020).[1] The high demand and profitability for these large weapons dissuades suppliers from scaling back production, hindering efforts towards stockpile destruction and disarmament.

The monetary value and security pertaining to weapon stockpiles could become obsolete if disarmament were adopted globally; investing heavily into military defense would be unnecessary without a substantial threat. However, from a single nation's perspective, game theory offers an explanation to why global disarmament is far from reality: in the self-interest of each individual country, the risk of destroying one's own stockpiles is far greater than holding onto them. One deceptive superpower is enough to cause a major power imbalance and a global security threat (Plous, 1993). Because the stakes of national security are so high, countries are apprehensive to trust one another.

2.3. Previous Disarmament Efforts and Future Tactics

Considering the aforementioned challenges, governments and NGOs have progressed towards disarmament and confidence building by setting policy to regulate munitions and encourage transparency. Although these initiatives help mitigate some risk, there remains a need for an accessible presentation of data on weapon stockpiles to advocate for global transparency. With the challenges of disarmament in mind, this section discusses relevant organizations and their efforts to overcome these challenges. Noteworthy progress includes the ratifications of the Ottawa Treaty, the Arms Trade Treaty, and the Treaty on Open Skies, as well as the introduction of the UN Register of Conventional Arms. Afterwards, we describe the coming strategies of advocating global transparency for this complex matter to help conceptualize our research goal.

2.3.1. Key Players and Progress Made

Numerous disarmament organizations have attempted to track and verify munition trade with the aim to publicize the state of global armament affairs and hold governments accountable. Additionally, the ever-increasing threat to global security has not been ignored by the world governments. A few dozen treaties have been implemented by the United Nations to address the issue;

[1] This figure does not include small arms and light weapons not requiring government approval for sale, contrary to the statistic from Fleurant's 2019 paper in the introduction, where 'arms sales' referred to the top 100 worldwide companies' sales of military equipment, services to armed forces, and ministries of defense.

these policies vary from regulating and banning classes of munitions to mandatory and voluntary reporting of weapons trade and stockpiles.[2]

The Convention on Certain Conventional Weapons (CCW) is one of the most important arms control treaties, providing regulations for and banning specific classes of conventional weapons. The CCW is structured with one main convention document and five additional "protocols" that detail the regulations themselves. The main document outlines provisions on appending new protocols, as well as general operation and administration of the treaty. For example, one such protocol restricts the use of "mines, booby-traps, and other devices" (Convention on Prohibitions … of Certain Conventional Weapons …, 1981). However, enacting a total ban on landmines was outside the protocol's scope; this shortcoming eventually led NGOs to take action, catalyzing the Ottawa Treaty of 1997. This treaty also marks the first multilateral regulation of conventional weapons since the 1920's. While its effectiveness has been inadequate since its implementation, the CCW serves as a skeleton for future policy to be appended (Matthews, 2001).

Introduced to the United Nations General Assembly in 1997, the Ottawa Treaty attempted to reduce the global impact of landmines by requiring all signatory states to report and destroy their stockpiles, among other responsibilities (Convention on the Prohibition … of Anti-Personnel Mines …, 1999). The International Committee of the Red Cross (ICRC) was the primary NGO that focused on bringing the Ottawa Treaty into reality (Rutherford, 2000). The ICRC believed a comprehensive ban was required and were unsatisfied with the regulations outlined in Protocol II of the CCW (Report of the ICRC for the review conference, 1994). The Ottawa Treaty requires all member states to submit a yearly report to the secretary general of all their stockpiles and must remove all stockpiles not necessary for military training after four years of signing (Convention on the Prohibition … of Anti-Personnel Mines …, 1999). The Ottawa Treaty was unique in its time — previously, most UN policy had been almost completely dictated by governments — this marked the first time that NGOs were able to set UN policy agenda. Bringing these concerns into the public eye raises expectations for adopting new policies, pressuring governments to take action (Rutherford, 2000). The Ottawa Treaty not only serves as a weapon regulation system, but it also models transparency regulations for countries' stockpile reports.

[2] For a selective list of the twelve most relevant general and complete disarmament treaties, see Appendix A: List of Conventional Disarmament Treaties.

Most transparency regulations focus on recording the movement of arms between nations, rather than individual stockpiles. The UNODA's reporting mechanism, the United Nations Register of Conventional Arms (UNROCA), tracks the movement of large conventional weapons.[3] The program receives reports from over 170 different nation-states and documents over 90% of the world's arms trade; however, only about 25% of member states still submit reports yearly (Wezeman, 2019). UNROCA requests data from nations to detail their large arms imports and exports and will verify the provided numbers using the reported data from both parties. The focus of verifying munitions is to hold countries accountable for an accurate arms trade report.

The Arms Trade Treaty (ATT) is another example of UN doctrine covering wider groups of armaments, signed by 130 UN member states (ATT Status of Ratifications and Accessions, 2019). The ATT provides a pathway for signatory states to submit annual reports on imports and exports of conventional arms. Within the bounds of the treaty, signatories are permitted to exclude any trades that are deemed by governments to be "commercially sensitive or national security information". Additionally, the treaty is legally binding, though there are no codified consequences for failure to uphold the outlined responsibilities (Arms Trade Treaty, 2013). Thus, the "legally binding" part of the treaty has had partial success — although many states fail to submit the required annual reports, more countries submit to the ATT than voluntary programs such as UNROCA (Wezeman, 2019).

The Stockholm International Peace Research Institute (SIPRI) is an NGO that collects reports provided by UNROCA, ATT, and various other sources, consolidating the details into their Arms Transfer Database. This database provides an open-source record of imports and exports of major conventional weapons (Sources and methods, n.d.). To assist the arms control community in disarmament efforts and to avoid duplicated work, SIPRI also created the Mapping ATT-Relevant Cooperation and Assistance Activities Database, a website made to track and relay any activity related to the ATT. This website is vital for assessing the effectiveness of international weapons transparency policies (SIPRI, 2016). While SIPRI continues to provide open-source data on arms trade and provides analyses of disarmament efforts, it falls short of supplying information on global weapons stockpiles.

[3]Large arms categories I to VII as defined by UNROCA are battle tanks, armored combat vehicles, large-caliber artillery systems, manned and unmanned aircraft, attack helicopters, warships, and missiles/missile launchers, respectively. Additionally, UNROCA implicitly defines an eighth minor category for small arms and light weapons (SALW) (United Nations Office for Disarmament Affairs, 2017).

The Treaty on Open Skies is another pivotal international agreement that builds confidence between nation-states. This agreement's central focus is the free flight of surveillance aircraft over signatory states' territory. It was initially conceived in 1955 by President Eisenhower but was rejected by the Soviet Union; it was later restored in 1989 by President George H. W. Bush and ratified by 35 countries. States with access to military information and movements of all other participants gives confidence for countries and can ease tensions. This international surveillance requires direct cooperation between states, building trust through mutual reassurance where any state can observe others' military activities themselves without causing alarm (Jones, 2014). Unfortunately, the United States and Russian Federation both withdrew from the treaty in recent years, setting back the transparency effort (Woolf, 2021). In addition to building trust, the Treaty on Open Skies promotes bilateral reconnaissance, serving as a framework for the accountability of future agreements reducing conventional and nuclear weapons.

2.3.2. Work that Lies Ahead

While the treaties and regulations initiated by leading organizations have compelled some openness in arms trade, these measures have not fully addressed the underlying disarmament roadblocks. A lack of transparency regarding stockpile holdings has persisted without any serious consequences to hold countries accountable for withholding or falsifying information. The aforementioned withdrawals from the Treaty on Open Skies have raised political tensions. Tracking weapon stockpiles and displaying it in an open-source, central fashion would boost transparency by bringing it to the public's attention. Although this may not bring immediate change, the realization of GCD must be preceded by a gradual political shift towards trust and cooperation internationally.

The world's history of armed conflicts, environmental issues, and unauthorized use of munitions form the grounds for seeking GCD. While the UN has introduced various multilateral treaties and policies to alleviate risks associated with proprietary weapons trades, the transparency gap between nation-states and the public is an integral component to facilitate GCD. The UN Register of Conventional Arms solicits reports from member states to gather their arms trade data; unfortunately, the number of states reporting this data decreases each year (Wezeman, 2019). Additionally, there is no defined verification process for reported arms trades, as it relies on the honesty of individual nations — there exists no diplomatic process to hold countries accountable for their reports (Holtom, 2010). Global stockpile information is inaccessible due to paywalls and data scarcity; governments and organizations withholding this information complicates disarmament efforts. To advocate for global weapons

transparency, our research aims to establish a coordinated, centralized hub for the arms control community; this will help promote nation-state large arms transparency and aid various NGOs working towards global disarmament.

3. Methods

Our project goal was to transform the *Global Weapons Tracking* website into an advocacy tool that promotes transparency and accountability of global weapons stockpiles and trades. We developed three objectives to achieve this goal:

1. Solicit feedback from featured disarmament organizations to improve the website design and determine the value it brings to the arms control community.
2. Develop an interactive map to display the global stockpiles and trades of 'large' weapons.
3. Showcase objective indicators representing the weapons transparency of countries.

This section details how we surveyed disarmament organizations and our process for compiling a database of weapons stockpiles, trades, and transparency indicators using open-source intelligence (OSINT). We then describe the database operations performed to create and embed interactive maps onto the website homepage.

3.1. Surveying Disarmament Organizations

Our team contacted each of the organizations listed on the *Global Weapons Tracking* website (see Appendix B for a full list) to receive feedback on navigability, design, and content. We also requested permission from each organization to publicize their profiles on the website. Representatives from SCRAP sent introductory emails on behalf of our team to organizations they had prior connections with, which produced a total 57% response rate over surveys, interviews and emails (sample size of 17 with population size 30). Organizations without a personal connection to SCRAP were contacted via their general email address listed on their organizational websites. This email requested participation in our study regarding the *Global Weapons Tracking Website* with two options: completing an online Qualtrics survey provided (see Appendix C) or scheduling an interview facilitated using video conferencing (Zoom and Microsoft Teams) (see Appendix D).

We received fourteen completed Qualtrics surveys in which we requested permission to feature each organization on the website and collected feedback for its design and content. Three interviews were conducted in a semi-structured format, in which questions were open-ended, encouraging a conversation with the interviewee. We asked participants to review their respective profiles and provide contacts for other relevant NGOs to expand our portal. The survey and interview protocol were essentially identical, except the interviews sought impressions on the proposed visualization tools. This

area was omitted from the surveys to simplify them and maintain a ten-minute completion time. Baseline questions were sent to our interviewees in advance to allow time for them to familiarize themselves with the website and collect their thoughts. We encouraged this interview option as it allowed us to ask follow-up questions and receive more detailed responses. However, offering the survey alternative provided flexibility for participants and allowed us to collect a larger pool of responses. We sent follow-up emails to organizations who did not reply within a week to increase our response rate.

We aggregated the survey responses and interview notes together in a single Word document and implemented attainable website suggestions accordingly. More significant website revisions outside our project scope were recommended for future teams to consider.

3.2 Developing the Interactive Maps

Our team developed four interactive maps presenting data from open-source intelligence databases, which were added to our website to promote awareness of global disarmament efforts and demonstrate countries' participation in transparency efforts. We first consolidated SIPRI's currently available data on large arms imports and exports into a timelapse map showing the total number of weapons by category each country had imported and exported over time. We then extracted data from UNROCA to create a map detailing the number of stockpiles each country possessed and another based on each country's total number of submitted UNROCA reports based on four types (imports/exports, military holdings, national production, and small arms/light weapons).

Our team used SIPRI's Arms Transfer Database and UNROCA because they were both publicly available and comprehensive databases on arms transfers and transparency. Retrieving data from the International Institute of Strategic Studies (IISS) Military Balance, a proprietary journal on international stockpiles, proved to be both too difficult and redundant, since the Military Balance's issues were not formatted as databases. The IISS also already provides a proprietary tool for visualizing their stockpile data (International Institute of Strategic Studies, 2021). An alternate method of independently determining stockpiles by performing large-scale approximations from SIPRI's import and export tables would have led to major inaccuracies in stockpile reporting.

Our team wrote the code for this project in Python, a popular programming language. The main Python libraries (i.e., collections of pre-compiled functions and objects) used for creating the database and map from SIPRI's Arms Transfer Database were *pandas*, *plotly*, and *sipri*.

Our program was partitioned into five stages: (1) download data from SIPRI's database, (2) perform database operations on SIPRI's database, (3) draw the interactive import and export timelapse maps, (4) draw the transparency indicator map, and (5) draw the stockpiles map. The code prompts whether to perform each stage to allow for a quicker debugging process. The processes inside the first three stages can be shown in Figure 1.

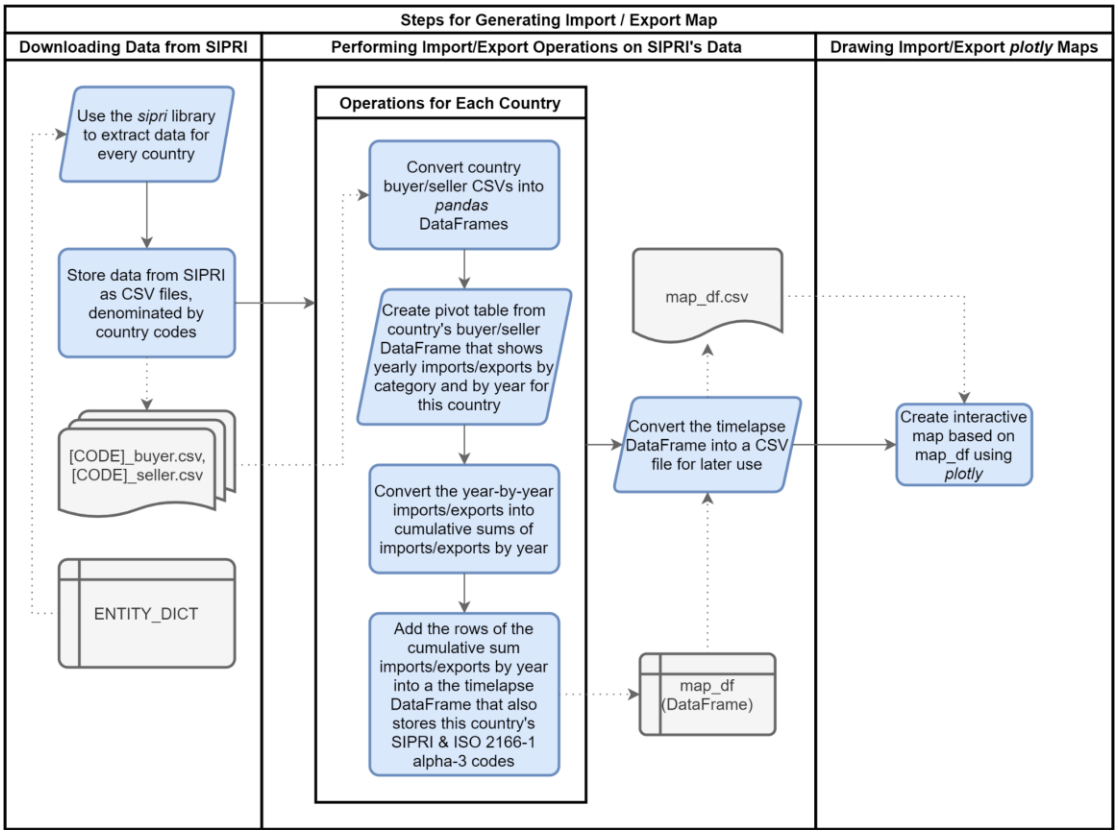


Figure 1. Flowchart describing the steps to generate the import and export maps from SIPRI. Solid arrows represent transitions between steps in the code, colored in blue. Dashed arrows represent data structures or files, colored in white, used as input or created as output from code steps.

The first stage of the program downloads each country's list of imports and exports from SIPRI's Arms Transfer Database using the *sipri* library. This library is an unofficial, third-party tool that accesses the SIPRI API to return data query results as a string of characters represented by a CSV file (comma-

separated values) (smitty10010, 2021).[4] The list of countries was constructed as a Python dictionary data structure that contains key-value pairs: the keys in this dictionary are entity names according to SIPRI, and the values contain the corresponding entity's SIPRI code and ISO 3166-1 alpha-3 country code, as shown in Figure 2.

```
13  ENTITY_DICT: Dict[str, Tuple[str, str]] = {
14      "Afghanistan": ("AFG", "AFG"),
15      # "African Union": ("AU", ""),
16      "Albania": ("ALB", "ALB"),
17      "Algeria": ("ALG", "DZA"),
18      "Angola": ("ANG", "AGO"),
19      "Argentina": ("ARG", "ARG"),
20      "Armenia": ("ARM", "ARM"),
21      "Aruba": ("ARU", "ABW"),  # Part of the Netherlands
22      "Australia": ("AUS", "AUS"),
23      "Austria": ("AST", "AUT"),
24      "Azerbaijan": ("AZB", "AZE"),
25      "Bahamas": ("BAS", "BHS"),
26      "Bahrain": ("BAH", "BHR"),
27      "Bangladesh": ("BAN", "BGD"),
```

Figure 2. Excerpt of the entity dictionary. The keys are country names, represented as string; the values are tuples containing SIPRI three-letter codes and ISO 3166-1 alpha-3 country codes. The African Union is commented out because it does not have an ISO code.

The second stage of the program used *pandas*, a Python data science library, to process and organize the downloaded SIPRI data. For each entity in the dictionary, its corresponding buyer and seller CSV files are read and converted into *pandas* DataFrames, like the SIPRI import table for the Bahamas in Figure 3. Each row of this table corresponds to a trade that the specified country has made with another entity in SIPRI's database.

[4] An API (Application Programming Interface) acts as a communication system that retrieves information from a database and sends a response to the webpage with this data.

tidn	buyercod	sellercod	odat	odai	onum	onai	ldat	term	desiq2	wcat	desc	coprod	nrdel	nrdelai	delyears
59628	BAS	CHI	2016	X	2	nan	2017	AID	Tiger	AV	APV	nan	2	nan	2017
51141	BAS	ITA	2008	X	1	nan	2009	nan	P-68	AC	Light transport ac	L	1	nan	2009
57462	BAS	NET	2014	nan	1	nan	2016	nan	Stan Lander-5612	SH	Landing craft	L	1	nan	2016
57463	BAS	NET	2014	nan	4	nan	2017	nan	Stan Patrol-3007	SH	Patrol craft	nan	4	nan	2015-2017
57461	BAS	NET	2014	nan	4	nan	2015	nan	Stan Patrol-4207	SH	Patrol craft	L	4	nan	2014-2015
40098	BAS	USA	2007	nan	1	nan	2009	nan	Cessna-208 Caravan	AC	Light transport ac	L	1	nan	2009
24893	BAS	USA	1997	nan	2	nan	2000	nan	Europatrol-250	SH	Patrol craft	L	2	nan	2000
59374	BAS	USA	2005	X	1	nan	2005	nan	King Air	AC	Light transport ac	L	1	nan	2005

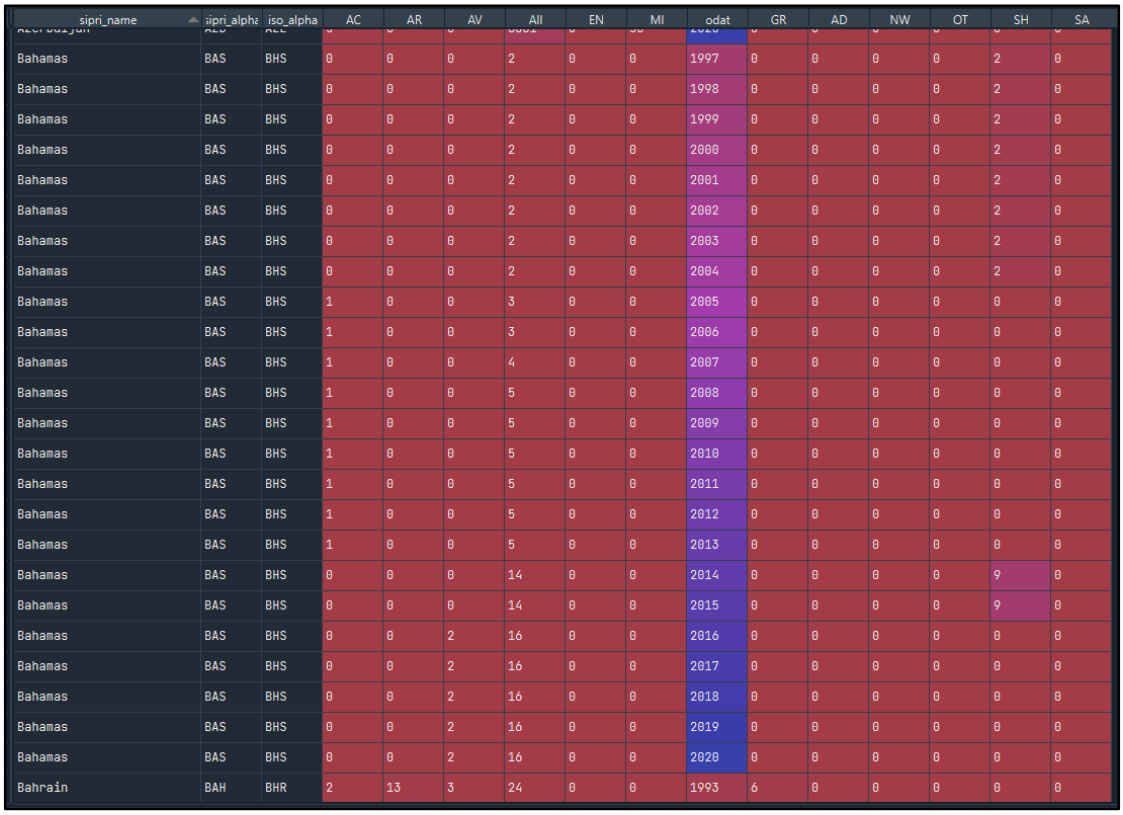
Figure 3. Bahamas SIPRI import table (since 1992)

The program creates a pivot table from each country's SIPRI DataFrame to consolidate the data; continuing the example, Figure 4 shows the corresponding pivot table of Bahama's imports from Figure 3. For example, Trade ID number 59374 in Figure 3 states that the Bahamas bought 1 aircraft (category AC) in 2005; in the pivot table in Figure 4, a '1' is placed in the row '2005' and the column 'AC'. The 'All' column evidently stores the total munitions the Bahamas bought in each row's corresponding year.

odat	AC	AV	SH	All
1997	0	0	2	2
2005	1	0	0	1
2007	1	0	0	1
2008	1	0	0	1
2014	0	0	9	9
2016	0	2	0	2
All	3	2	11	16

Figure 4. Bahamas SIPRI import year-by-year pivot table since 1992

The program then takes the pivot table of yearly imports/exports to create yearly cumulative sums for each weapon category to convert it into timelapse data, as shown in Figure 5. For example, for the year 2007, the Bahamas imported a total of two aircraft (category AC) and two ships (category SH) since 1992. This cumulative sum method does not include years before the country's earliest data, like 1996.



sipri_name	sipri_alpha	iso_alpha	AC	AR	AV	All	EN	MI	odat	GR	AD	NW	OT	SH	SA
Bahamas	BAS	BHS	0	0	0	2	0	0	1997	0	0	0	0	2	0
Bahamas	BAS	BHS	0	0	0	2	0	0	1998	0	0	0	0	2	0
Bahamas	BAS	BHS	0	0	0	2	0	0	1999	0	0	0	0	2	0
Bahamas	BAS	BHS	0	0	0	2	0	0	2000	0	0	0	0	2	0
Bahamas	BAS	BHS	0	0	0	2	0	0	2001	0	0	0	0	2	0
Bahamas	BAS	BHS	0	0	0	2	0	0	2002	0	0	0	0	2	0
Bahamas	BAS	BHS	0	0	0	2	0	0	2003	0	0	0	0	2	0
Bahamas	BAS	BHS	0	0	0	2	0	0	2004	0	0	0	0	2	0
Bahamas	BAS	BHS	1	0	0	3	0	0	2005	0	0	0	0	0	0
Bahamas	BAS	BHS	1	0	0	3	0	0	2006	0	0	0	0	0	0
Bahamas	BAS	BHS	1	0	0	4	0	0	2007	0	0	0	0	0	0
Bahamas	BAS	BHS	1	0	0	5	0	0	2008	0	0	0	0	0	0
Bahamas	BAS	BHS	1	0	0	5	0	0	2009	0	0	0	0	0	0
Bahamas	BAS	BHS	1	0	0	5	0	0	2010	0	0	0	0	0	0
Bahamas	BAS	BHS	1	0	0	5	0	0	2011	0	0	0	0	0	0
Bahamas	BAS	BHS	1	0	0	5	0	0	2012	0	0	0	0	0	0
Bahamas	BAS	BHS	1	0	0	5	0	0	2013	0	0	0	0	0	0
Bahamas	BAS	BHS	0	0	0	14	0	0	2014	0	0	0	0	9	0
Bahamas	BAS	BHS	0	0	0	14	0	0	2015	0	0	0	0	9	0
Bahamas	BAS	BHS	0	0	2	16	0	0	2016	0	0	0	0	0	0
Bahamas	BAS	BHS	0	0	2	16	0	0	2017	0	0	0	0	0	0
Bahamas	BAS	BHS	0	0	2	16	0	0	2018	0	0	0	0	0	0
Bahamas	BAS	BHS	0	0	2	16	0	0	2019	0	0	0	0	0	0
Bahamas	BAS	BHS	0	0	2	16	0	0	2020	0	0	0	0	0	0
Bahrain	BAH	BHR	2	13	3	24	0	0	1993	6	0	0	0	0	0

Figure 5. Excerpt of imports timelapse map DataFrame, focusing on the Bahamas' cumulative sum since 1992

The third stage of the program uses the *plotly* Python library to craft the interactive maps from the import and export DataFrames. *Plotly* is a graphing library compatible with *pandas* that can create choropleth maps, a type of map which has predefined geographical regions colored based on a numerical dataset. The *plotly* library uses the ISO alpha-3 codes to fill in colors for the corresponding countries based on values in a data structure like a DataFrame. When hovering over a country in the map, one can see the import or export breakdown by categories, as shown in Figure 6. We chose *plotly* over similar libraries because of its ease-of-use and supported WordPress integration (Plotly, n.d.). *Plotly*'s offline functionality generated HTML objects for both the imports map and the export map that were placed onto our website.

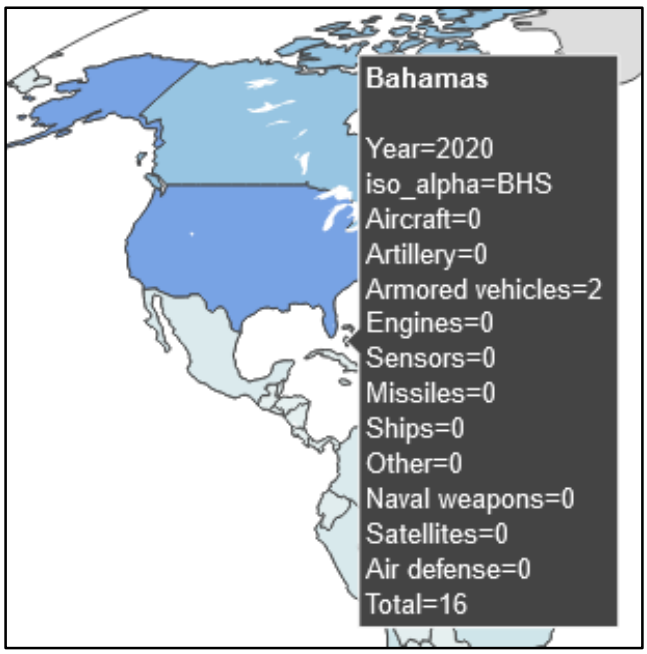


Figure 6. Hover function of the SIPRI imports timelapse map of the Bahamas. The data in this screenshot shows the total number of large conventional weapons by category that the Bahamas has imported since 1992.

The fourth and fifth stages of the program draw UNROCA transparency indicator and stockpile maps, respectively; the flowcharts for these operations are shown in Figure 7. UNROCA lists seven categories of major conventional weapons for countries to report stockpile holdings. Only 59 countries reported military holdings at least once between 1992 and 2020, and since these reports came in different years, we used each country's most recent data. We tabulated this data into a spreadsheet and summed the seven categories to represent total stockpiles. This spreadsheet was exported as a CSV file, converted into a *pandas* DataFrame in Python, and finally mapped using *plotly.* The total figure was shaded according to the color scale, with details of the seven subcategories appearing upon hovering over a country.

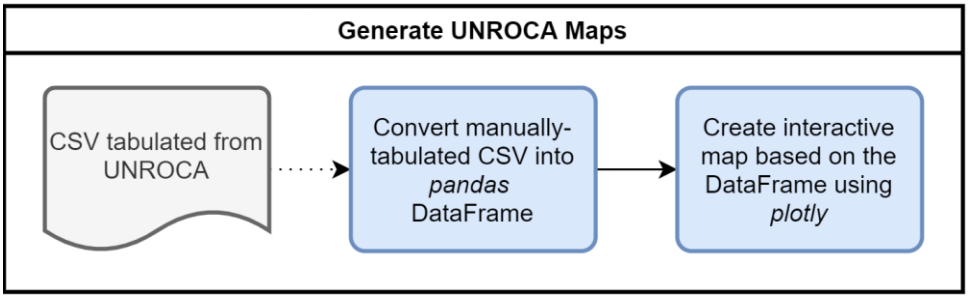


Figure 7. Flowchart describing the steps to generate UNROCA stockpiles map and UNROCA transparency indicator map. See the caption of Figure 1 for an explanation of the symbols.

For gathering transparency data, our team tabulated each country's annual UNROCA report since 1992 based on their four categories.[5] Voluntary reports from each category and year were credited one point towards a total transparency indicator; instances of "no data" or reverse-engineered reports from trade members were not counted. We plotted this data analogous to our stockpiles map procedure — the product can be seen in Figure 8.

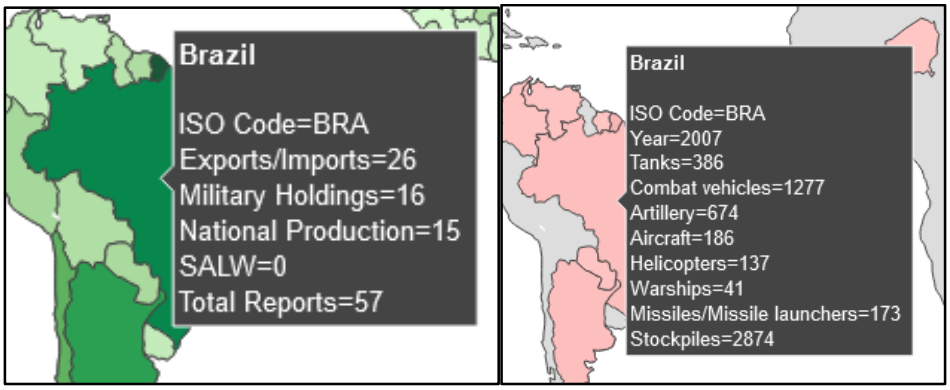


Figure 8. Hover function of UNROCA transparency indicator (left) and stockpiles (right) of Brazil.

One limitation in the import and export database created using SIPRI is the collection of trade data from countries which no longer exist and rebel groups and political factions which do not have designated borders. This raises the question of how to account for these weapons: for instance, we do

[5] The four categories of UNROCA reports are imports/exports, military holdings, national production, and SALW (small arms and light weapons) (United Nations Register of Conventional Arms, n.d.).

not know the location of Yugoslavia's imported arms after its dissolution in the early 1990s (Trade registers, n.d.). Visualizing these weapons on the map would require some method of tracking which country each weapon went to. Additionally, while SIPRI is considered a reputable organization, their arms transfer database sources are ambiguous, making it impossible to judge the validity of sources (Holtom, 2010).[6]

While the *pandas* and *plotly* Python libraries are continuously worked on and improved, the *sipri* Python library has only one maintainer. This means that there is an increased risk that this library will become unmaintained in future Python releases. Successor teams who want to run our code may run into problems if this library is not updated for future Python releases. However, the code behind this library could be reintegrated into our program to future-proof it if necessary.

[6] SIPRI's "Sources and Methods" page provides a list of the data sources used in their Arms Transfer Database. Only a few sources are specific; most of them state generic descriptions for where to find information on arms control (e.g., "Newspapers and other periodicals" or "Press releases, annual reports and other information published by arms producing companies") (Sources and methods, n.d.).

4. Results and Discussion

Our research project was branched into three main pillars -- improving the website design, displaying large weapon stockpiles and trades data, and developing transparency indicators. Our interviews and surveys identified shortcomings of the website, namely its unclear purpose and poor mobile-friendly design. We addressed these concerns through website revisions, however we have recommendations to better align the website's content with the intended audience. While there are some apparent trends from the interactive maps we developed, they were limited by data discrepancies and inaccessibility; standardizing reporting methods, weapon categories, and file formats would aid data analysts to give a better portrayal of global weapons. Based on the transparency indicator map created, there is a limited number of countries who faithfully report to UNROCA. We investigated causes for why the number of countries reporting to UNROCA has continued to fall, and our findings suggest four sources for this conduct: Countries may abruptly stop reporting from feeling threatened by hostile powers, being criticized for inaccurate reports, being ignored when suggesting improvements to the Register, or if they are undergoing a shift in political schemes. This section will sequentially unpack and discuss the results of our research objectives and make recommendations for redesigning the website and improving data accessibility of munitions.

4.1. Website Feedback and Revisions

From our 17 total responses from featured disarmament organizations, 16 reviewed their profile and granted permission to stay on the website. While the site provided incentives for added exposure, one organization asked to be removed due to their sensitive nuclear work. Out of the 16 that accepted, only four offered genuine suggestions to improve aspects of the website. The commonality of these responses pertained to the website's intended purpose and mobile-friendly design.

A recurring theme in our surveys and interviews was how the *Global Weapons Tracking* website provided little context of its intentions or added value to the arms control community. In our interview with the Assessment Capacities Project (ACAPS), a nongovernmental project following global humanitarian crises, the interviewee suggested clarifying the website's purpose on the homepage. We conversed with our sponsors about the website intentions and integrated their objectives accordingly: the new homepage of the website reads "Global Weapons Tracking is a portal of organizations which monitor weapons and weapons uses worldwide. Its purpose is to promote transparency and accountability of global weapons trades and stockpiles while uniting the arms control community."

Aside from clarifying the website's purpose, our sponsors conveyed problems with the site's mobile version, a concern that took precedence because of widespread mobile use today. The website development was driven by sequentially identifying and tackling shortcomings like the inaccessible hover descriptions and navigation wheel, missing and incorrect organization information, and minor stylistic flaws. Many of these mobile refinements were resolved within a visual editor plugin called Elementor, which enabled separate customization options for mobile, tablet, and desktop devices. These settings apply breakpoints for different screen widths to determine the device being used. This editor not only enabled us to produce a mobile-friendly website, but it helped create a fully responsive one. The key distinction between these designs is how the former is a compatible, scaled down version of the desktop site, whereas the latter dynamically adapts the content for all screen size variations (Labus, 2018). For example, content such as the category icons translate from a horizontal layout to a vertical layout when on a narrower device.

We created hover descriptions for the four main category icons ("Tracking Weapons", "Weapons and Human Rights Violations", "Think Tanks, Training, and Services", and "Tracking Tools") to help clarify each page's contents. This feature expedited navigation; initially, users had to redirect to separate links before realizing each page's intent. While adding this functionality was attainable within the visual editor, it was not ideal since mobile users do not have a distinct hovering capability. Preferably, the descriptions would show as static text on a mobile device to provide the same information in an accessible manner. To accomplish this, we implemented two sets of icons: one with the hover capability and one with static text. We applied settings to display only the desired set for each device type.

Another facet of the website's mobile version that needed refinement was the navigation wheel, which directs users between the category pages. Previously, the contents of the wheel spread too far; some of them stretched entirely off-screen on mobile devices. The navigation wheel plugin employed had no simple way to customize the icon translation distance. While one option was to find a different plugin with this customization capability, we wanted to retain the current style of the website and look for alternative ways of adjusting this element. An "Additional CSS" section within WordPress allowed us to manually add CSS code. After finding the specific HTML element responsible for the

navigation wheel, we applied new spacing values to override the default positions.[7] This was an effective approach because modifying the underlying code allowed for the most control over the website and removed the precision limitations of WordPress editors. Figure 9 shows before and after screenshots of the website on mobile: noticeable improvements include the navigation wheel icon positioning, removal of overlapping titles, and more spacing between the organization buttons to refine the overall appearance.

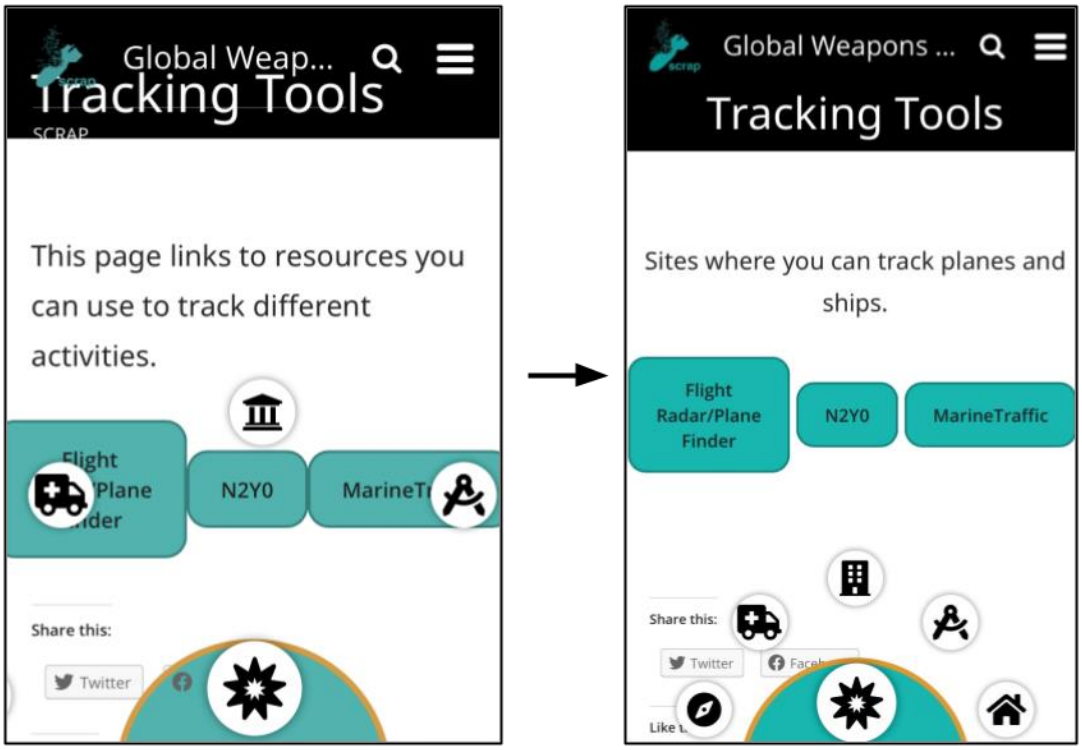


Figure 9. Before (left) and after (right) of the "Tracking Tools" page on the *Global Weapons Tracking* website, redesigned for mobile

Although addressing the website's design issues was straightforward, the target audience remains somewhat undefined. From our team's perspective, the portal of organizations in combination with the new interactive maps would be directed towards a wide audience; as a central hub for weapons tracking, the site would help encourage collaboration between organizations working in the

[7] HTML is the standard markup language which provides the backbone structure for websites while CSS is a complementary language which controls the styling aspects.

field in addition to advocating weapons transparency to the public. However, the organizations surveyed had different interpretations of the website's intentions. One insightful survey response from Syrian Archive pointed out that many of the organizations listed already work together, leading them to believe that "the intended audience is not organisations who are listed, but rather those who might be external or unfamiliar with the work being done." While the interactive maps may assist organizations, this respondent brings up a valid point that the website is geared more towards individuals outside the weapons tracking realm. However, the website's current state is mutable; Syrian Archive gave further remarks on working in a "news section [to show] what different organizations [...] are working on." Displaying the latest work of NGOs would tailor the website more towards those already familiar with the organizations themselves; the website could become a medium for relevant updates in weapons tracking and transparency efforts, thereby boosting its advocacy effectiveness. Although SCRAP's initial vision for the website's audience may not have encompassed both experts and non-experts, there is potential to surpass these expectations by expanding the proposed features.

As a future extension, the website could benefit in the long-term by revamping its overall structure. These substantial changes were beyond our project scope as we focused exclusively on the pressing short-term fixes. Currently, the website has individual links for each organization, where the four category pages display buttons with their name and a broad description. As the website's aim was to provide an accessible hub of information, this arrangement is suboptimal since the user must backtrack and view each page separately. We proposed a mock-up for a new design shown in Figure 10, where each profile would be merged to the same page for easy accessibility. The organization's logo could act as a dropdown element where their description and website link would appear. This collapsible setup would be mobile-friendly and improve navigability, enabling users to freely explore each organization.

The four website categories could also be eliminated as many surveyed organizations found them restricting. For example, the interviewee from Bellingcat felt they fit under multiple categories of "Tracking Weapons" and "Think Tanks, Training, and Services". Rather than trying to classify each organization, the portal could be all-inclusive and multiple descriptor tags could be applied to organizations. Additionally, future teams could increase the value of each organization page by adding links to their respective social media and/or to their relevant databases. This would allow for website users to get a better picture of the resources each organization offers.

Alternatively, the website's design could shift focus away from bringing together disarmament organizations to its newfound purpose of advocating transparency and accountability. This would involve highlighting data visualization tools as the website's focal point rather than the organizations' profiles. For instance, annually updating the transparency indicator we developed would signal any year-to-year progress or decline. Since this indicator was developed via tabulating data from UNROCA, it would require manual maintenance. By displaying the transparency trends, attention can be directed swiftly towards countries' who reported in the previous year but failed to submit in the current year.

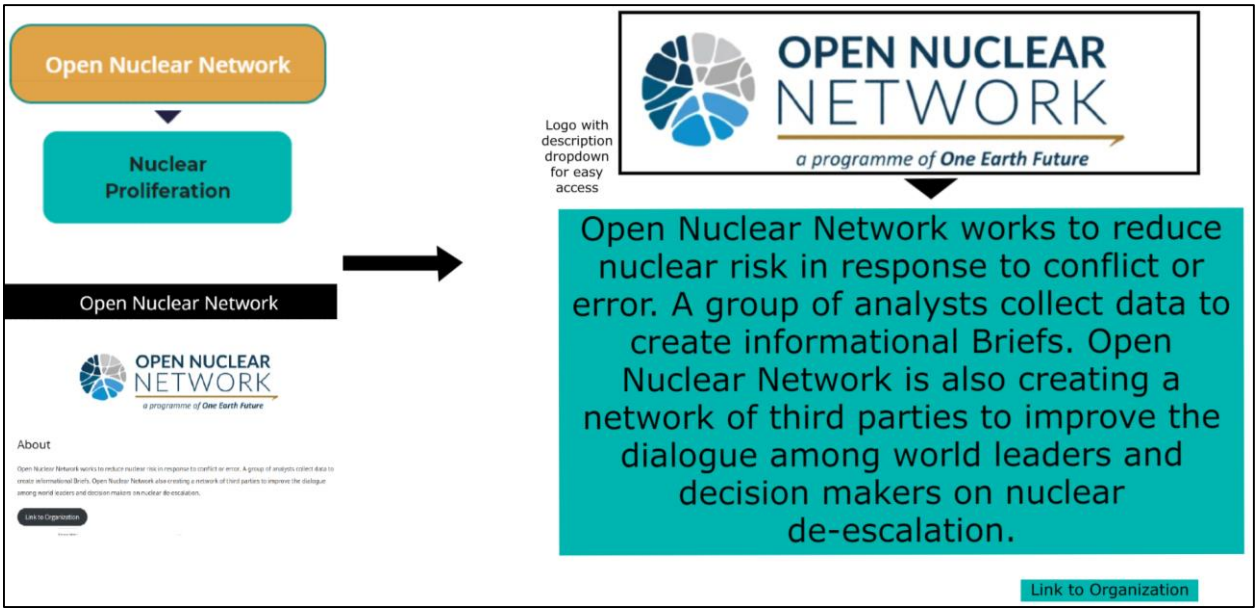


Figure 10. Website mockup to integrate each organization profile within the main category pages. The left side shows the current website design, and the right side shows the new proposed design

4.2. Weapons Trade and Stockpile Data

The map of weapons stockpiles generated from UNROCA's data is shown in Figure 11. One can clearly notice that the United States is a large outlier in this map: its most recent UNROCA report in 2019 stated that it had a total of 84,559 weapons stockpiles. The lack of available data from UNROCA for each country is this map's most glaring limitation. The map currently displays stockpile data from only 59 of 193 countries listed on UNROCA's website; if only data from 2020 was counted, only 15 countries would be represented. This map combines data from each country's most recent report to mitigate this issue; the drawback with this method is that the map does not accurately depict a point in time. For example, data from the United States in 2019 is compared to data from Mexico in 1996.

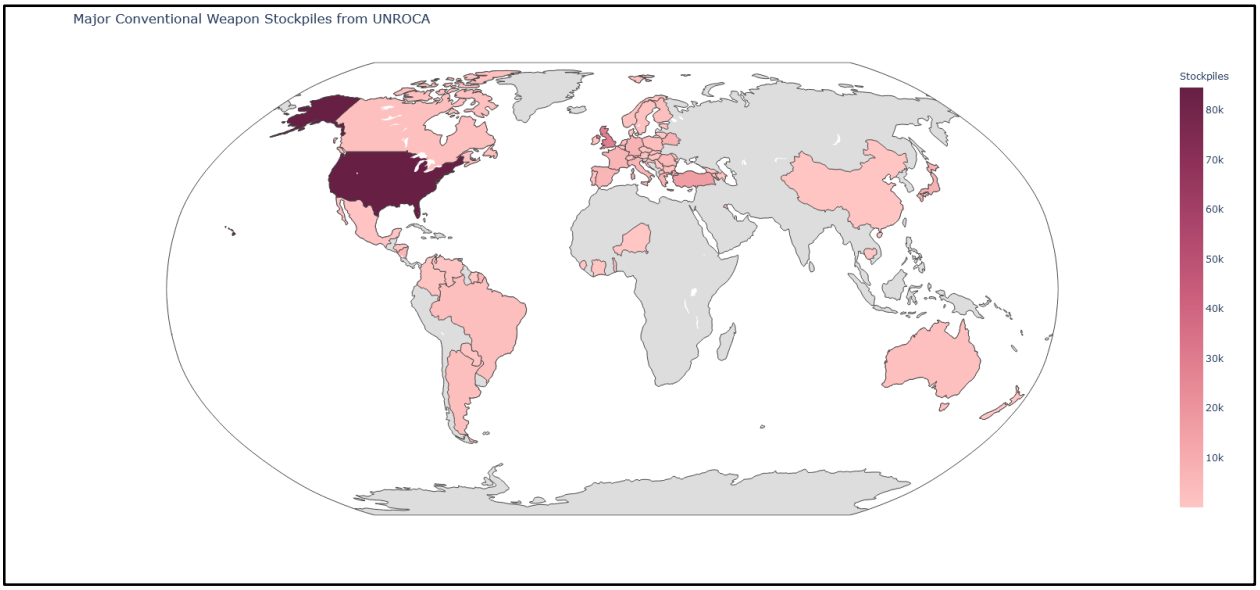


Figure 11. UNROCA Stockpiles Map. This map displays major conventional weapon stockpile data from the 7 UNROCA categories (battle tanks, armored combat vehicles, large-caliber artillery systems, manned and unmanned aircraft, attack helicopters, warships, and missiles/missile launchers) according to each country's most recent report.

The cumulative import and export maps derived with data from SIPRI's database, shown in Figure 12, tell another story. One can clearly see that the United States heavily skews the export map data. Since 1940, the US has exported a total of 1.16 million weapons; the next highest exporter, France, has exported 395 thousand weapons in the same time frame. This is because most of the munitions that the United States produces are missiles: each missile is counted as one munition — equal to one warship, for instance — and missiles are sold in bulk by the United States to other countries. The import map, however, is more evenly distributed. While Saudi Arabia does skew the data to a degree, coloration is still seen across North America, Europe, the Middle East, and East Asia. To complicate records, each member state has different methods of munition reporting: for example, the United Kingdom counts munition transfers based on licenses granted instead of actual transfers. Additionally, countries report weapon transfers at different points in time — some states report the actual transfer date, while others report contract signing date (United Nations Register of Conventional Arms, n.d.).

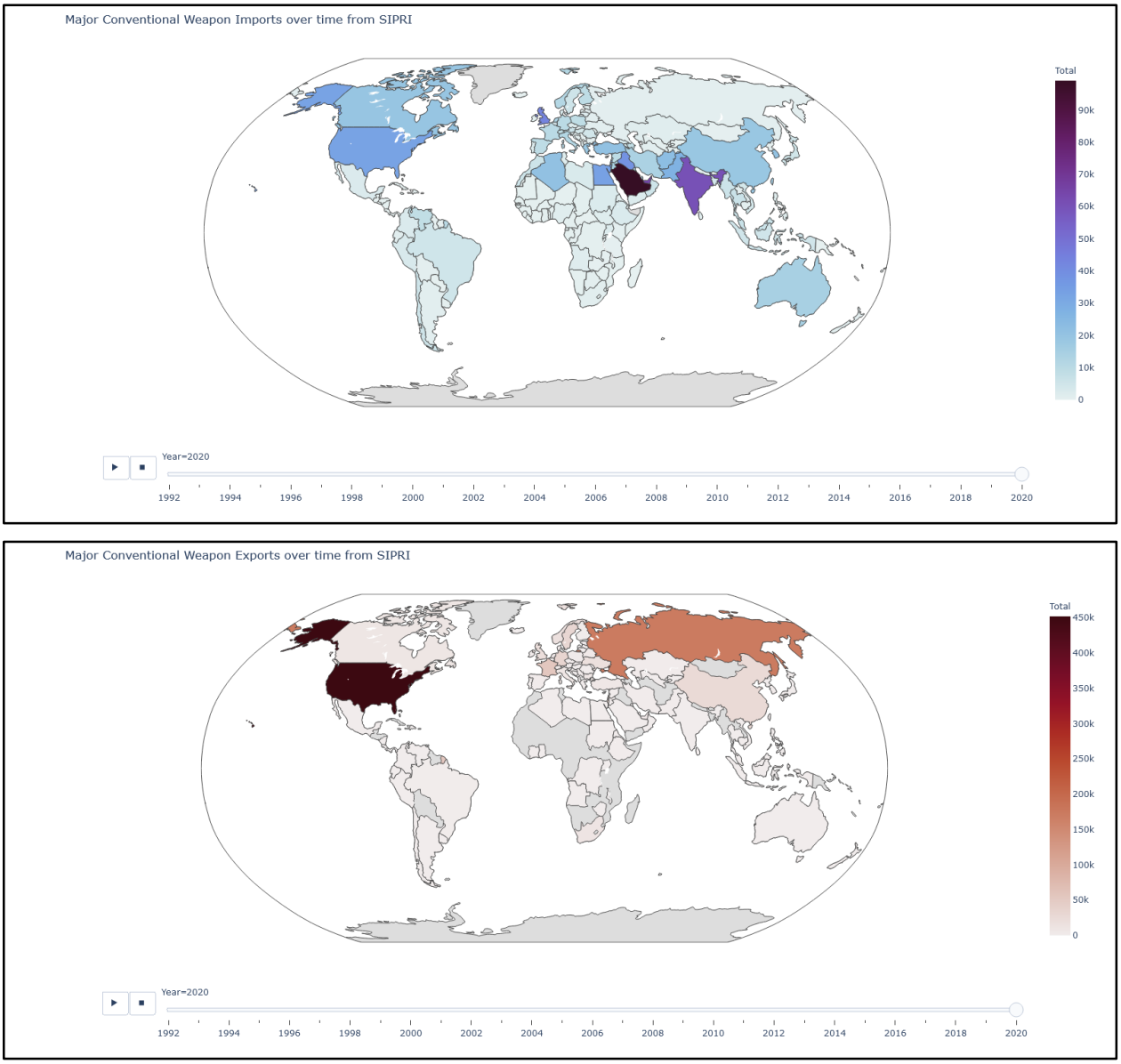


Figure 12. SIPRI Major Conventional Weapon imports (top) and exports (bottom) timelapse map screenshots for the year 2020. These maps show each country's cumulative sum of imports and exports for each year since 1992 (by SIPRI category).

The interactive maps created for imports, exports, and stockpiles have laid the groundwork for future data visualizations. Our interviewees and sponsors suggested more map variations such as tracking the correlation between weapon trades and casualties from armed conflicts. This visualization would emphasize the public harm associated with the high volume of global weapons and add tools to

support advocacy for new political measures. Additionally, a filtering feature between weapon categories could improve the representation of data, as each weapon type is currently summed together with equal one-to-one weights.

4.3. Transparency Indicator Data

The number of weapons reports that each country has submitted to UNROCA is visualized with the map in Figure 13, and there are several observable patterns. Countries with a higher GDP generally report more than those with a lower GDP — many African nations barely report, South American nations occasionally report, and European nations frequently report (GDP by Country, 2017). Countries that participated in the G7 Summit (US, UK, Canada, France, Germany, Italy, Japan, and the remaining EU countries) are amongst the most transparent. Russia previously participated in these summits, but recently left; coincidentally, they would have been the least transparent member with only 27 total reports (United Nations Register of Conventional Arms, n.d.).[8] Germany is the only country that has submitted all possible 102 self-reports to UNROCA; the United Kingdom and Japan place second and third, respectively. Conversely, there is a 25-way tie between the least number of reports, at zero.[9] One could infer that more developed regions with less international or domestic conflict tend to report the most. It may be that stable countries have more resources for complying to UN doctrine than states dealing with unrest or conflict.

[8] On average, members of the EU have submitted more UNROCA reports per country than Russia.

[9] These countries include: Algeria, Angola, Bahrain, Cabo Verde, Congo, Equatorial Guinea, Eritrea, Guinea, Guinea-Bissau, Iraq, Liberia, Morocco, Myanmar, Nigeria, North Korea, Oman, Saudi Arabia, Somalia, South Sudan, Sudan, Syrian Arab Republic, Uganda, UAE, Yemen, and Zimbabwe

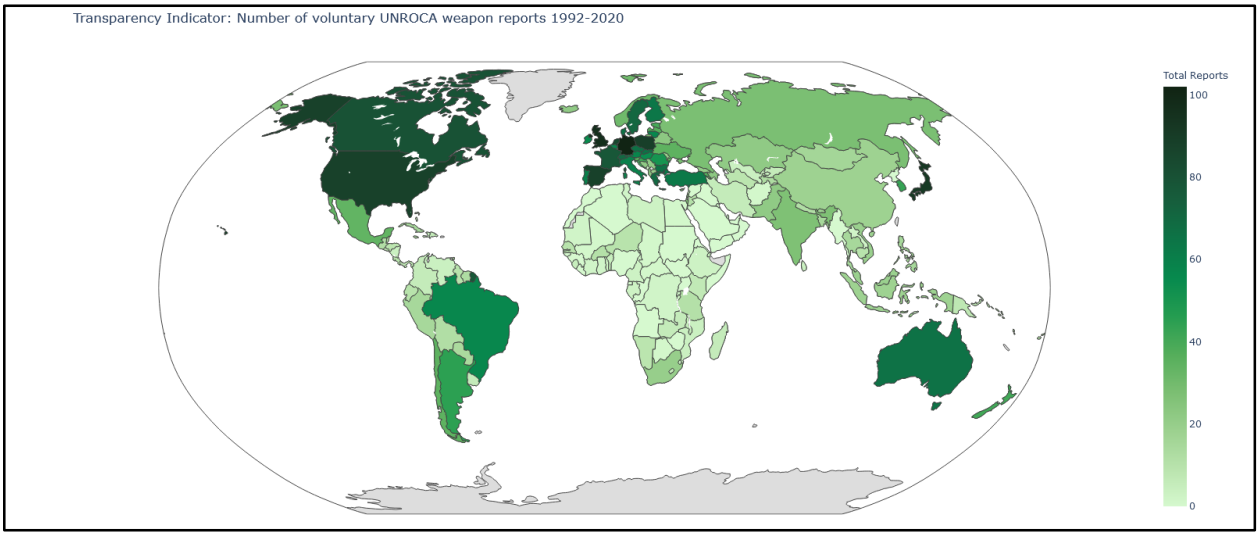


Figure 13. Transparency indicator map depicting the total UNROCA reports between 1992-2020 for the four categories: imports/exports, military holdings, national production, and SALW. Darker colors correlate to higher transparency, and lighter colors to less transparency.

Our transparency map had similar limitations to the stockpiles map: there is no way to display the authenticity of individual reports akin to how UNROCA cross-references trades on their website. For example, in 2014, Chile reported the export of 10 unmanned combat aircraft to El Salvador; while El Salvador also submitted a report that year, there was no mention of unmanned combat aircraft from Chile (United Nations Register of Conventional Arms, n.d.). Similarly, Papua New Guinea's self-report to UNROCA in 1994 showed that their current inventory contained zero large weapons for each munition category despite SIPRI's arms transfer data including multiple aircraft and patrol vessel imports in the 1980s and 1990s (Arms Transfer Database, n.d.). These inconsistent accounts raise questions regarding the validity of UNROCA reports.

So why do some countries report to mechanisms such as the UN Register while others do not? Lemke (2007) hypothesizes one reason for this could be that countries with more political freedoms are more transparent internationally. We discovered a spatial association between the transparency indicator map and the Global Freedom Status map from the *Freedom in the World* report on political rights and civil liberties. Shown in Figure 14, this status map depicts a score for each country based on 25 questions, given a score of 0-4 on each. The green (free) areas of the freedom map closely align with the regions reporting most to the Register, and purple (not free) areas where countries report the least. This correspondence can be explained from the link between political freedom and internal (public)

transparency. Governments in which citizens have more say in the activity and election of officials rely on public opinion (Holtom, 2010). Conversely, governments that do not depend on elections to stay in power may not be concerned with the public's approval. Countries with underlying human rights and freedom issues may be unwilling to adopt intergovernmental transparency as they would not be held accountable by their populace. As transparency and government forms are closely intertwined, advocating solely for transparency may not be effective as it does not address the root causes of countries' unwillingness to report.

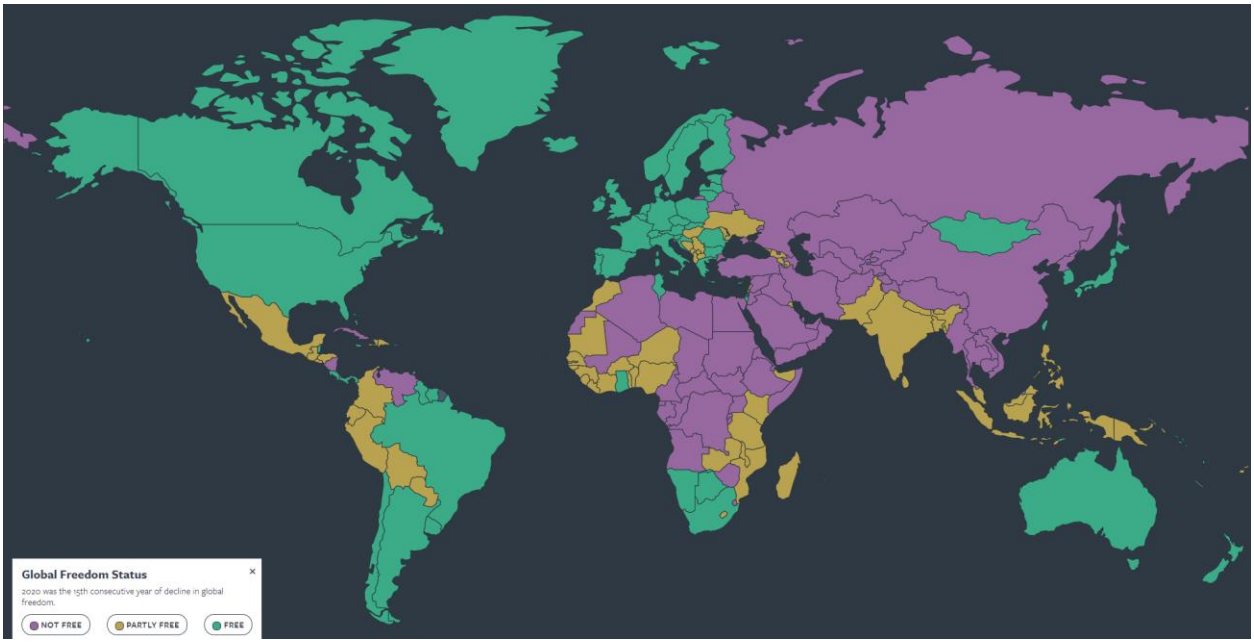


Figure 14. 2020 Global Freedom Status map displaying each country's freedom on a 100-point scale based on 25 question criteria of political rights and civil liberties. The scale contains three colors of green (free), yellow (partly free), and purple (not free) (Freedom House, 2020).

While some countries have avoided reporting weapons trades entirely, others have reported in the past and quit abruptly. In his 2010 paper, Holtom provides two examples of countries once faithful to the Register who suddenly stop reporting -- Georgia and Kenya. Inspired by these examples, we hypothesized four reasons why countries stop submitting: 1) feeling threatened by some hostile power; 2) being called out for inaccurate reporting; 3) feeling ignored when suggesting improvements to the Register; 4) undergoing a shift in political agenda. In the following discussion, we contextualize and expand upon Holtom's article to provide additional examples for these categories.

Our first hypothesis is that countries feeling threatened by neighbors or other major powers could stop submissions for the sake of their own security. Following Russian hostilities in the South Ossetia region, after over a decade of continuous reporting, Georgia ceased all submissions to the Register. Leading up to the 2008 conflicts, for years the Russian Federation had been calling for reductions in weapons exports to Georgia. Holtom inferred the halting of Georgian Register reports traced back to these reasons; given the threat Russia posed to its neighbors, countries like Georgia would want to be less transparent in their military activities (Holtom, 2010). Since then, over a decade later, Georgia's transparency indicator has not increased a single point — in other words, Georgia has not submitted a single report since 2007 (United Nations Register of Conventional Arms, n.d.). Similarly, in 2015, Estonia submitted their last report to the Register (United Nations Register of Conventional Arms, n.d.). A year prior, Russian agents kidnapped an Estonian Internal Security Service officer near the border (Schmidt-Felzmann, 2015). Building on Holtom's theories, we can infer that the sudden dip in transparency by Estonia (like Georgia) is associated with Russian hostilities.

These incidents along the Russian border are not aberrations on the global scale either. In the mid-2000s, several left-leaning countries in Latin America halted report submissions to the Register. The Pink Tide in the early 21st century saw the emergence of new leftist regimes in the area (Funk, 2017), and with that came new hostilities from the United States. During the Bush administration, US ambassadors throughout Latin America spoke out against left-leaning candidates to reflect the president's platform (Wolff, 2011). Given the United States' history of subverting leftist governments in the region, new threats from the US government could be seen as enough of a threat to revoke updating access to information on military affairs (McSherry, 2012). Bolivia submitted their last report to the Register in 2009 and Ecuador submitted their last report in 2011 (United Nations Register of Conventional Arms, n.d.).[10] Therefore, Holtom's hypothesis includes more than just the neighborhood of Russia — other powerful countries, including the United States, can inadvertently dissuade countries from reporting even outside of their immediate vicinity.

Another claim we make as to why countries may abruptly cease reporting is if they are criticized for inaccurate reports. Holtom provides the example of Kenya, and how in 2007 they submitted nil reports while the export reports of multiple other countries showed arms transfers to Kenya. Upon being called out for the discrepancy, the government stated that it does not owe explanations as to

[10] The 2011 report from Ecuador is an outlier; the country only semi-regularly submitted from 1994-2005, and since 2005 has only submitted one report. Bolivia submitted from 1999-2009 except for 2007. (United Nations Register of Conventional Arms, n.d.).

where the weapons went, and consequently halted all Register submissions (Holtom, 2010). Holtom wrote his paper three years after this occurred — to this day, Kenya has not submitted another report (United Nations Register of Conventional Arms, n.d.).

A third rationale that might explain why some countries stop reporting is if they feel ignored or feel that the Register was not doing all it could to best represent its constituent countries. Our example here was Cuba, who stopped Register submissions in 2006. Since the creation of the Register, Cuba had been an active participant and consistently gave extra advice for the continued improvement and development of the Register. One such recommendation was the inclusion of WMDs in Register submissions (United Nations Secretary-General, 1998). With each update of the Register, however, this suggestion was ignored time and time again. Cuba finally ceased all submissions in 2006, claiming that the exclusion of WMDs was “insufficient and discriminatory”. They do, however, occasionally continue to provide recommendations, primarily still pushing for WMD inclusion (United Nations Secretary-General, 2016).

Finally, we speculate that a major political party shift can change the whole government’s agenda, and thus could cause suspension of Register submissions. In 2013, Iceland submitted their last report to the Register (United Nations Register of Conventional Arms, n.d.). This same year also marked the return to power of Iceland’s independence party (“Iceland vote”, 2013). Similarly, in 2013 Norway elected a prime minister from the Conservative party -- the previous 8 years the position was held by the Labor party (“Norway election”, 2013). This also marks the year after Norway stopped submitting reports. We propose that, given these events’ coinciding with the ceasing of Iceland’s and Norway’s reports, a shift in political ideology can be added to our list of causes.

There are surely other factors contributing to a country's willingness to report besides threatening nearby powers, criticism for inaccurate reporting, and a change in ruling ideology. For example, Indonesia stopped submitting to the Register in 2009, however we found no compelling motives to justify this abrupt withdrawal (United Nations Register of Conventional Arms, n.d.). This exception demonstrates that our hypotheses are not exhaustive and may not apply for every case, so the categorizations for countries aside from Georgia and Kenya are speculatory. However, this is still worth considering as understanding the reasoning behind why countries stopped reporting can help shift transparency advocacy strategies towards improving reporting rates.

As our transparency indicator was cumulative from 1992 to 2020, we were unable to interpret reporting habits over time directly from our map. To reveal these patterns, future teams could incorporate a time lapse feature like our import and export maps. For a more robust representation of a

country's transparency, researchers could consider supplementary indicators through the fraction of missing or estimated data in SIPRI reports, number of ATT reports, and number of ATT Baseline Assessment Project (ATT-BAP) survey responses. Given more time to develop new transparency indicators, we would not combine them into a single index as this would subjectively define each indicator's importance to a country's overall transparency; providing separate indicators would remove personal biases altogether.

4.4. Transparency and Uniformity of Arms Control Data

Our team discovered unexpected challenges during the data collection phase of our project that are worth noting. We noticed that not every organization within the arms control community provides accessible tabulated data, and that there is no definitive standard for categorizing large conventional weapons. Complications from these factors arose when we arranged the data for mapping; these required additional manual work to resolve. This section details general data management and arrangement problems that some organizations have as well as steps that others have taken to resolve them.

Data from both SIPRI and UNROCA were used to generate the maps for this project. While SIPRI's databases are good examples of OSINT and can be downloaded in parts, UNROCA's website is unconducive for data analysis despite its professional design. Automating data extraction from UNROCA would require advanced programming skills in reading numbers from HTML files; this implies that UNROCA's data is not designed to be interpreted and mapped by external researchers. Additionally, UNROCA and SIPRI do not use the same standard for categorizing munitions: UNROCA has eight separate categories for munitions (stylized as "7 + 1") (United Nations Office for Disarmament Affairs, 2017), while SIPRI has eleven categories for large conventional weapons (Sources and Methods, n.d.). These incompatible categorizations increase the difficulty of comparing individual data points between these two sources. Since our imports/exports and stockpiles maps use data from different organizations, their hover texts show different categorizations of weapons; this may confuse potential website end-users.

Unlike SIPRI and UNROCA, the ATT-BAP and the Uppsala Conflict Data Programme (UCDP) are two key organizations that excel in data accessibility.[11] The UCDP's website organizes conflicts and

[11] Data from the ATT-BAP and the UCDP were not used in this project. These organizations' databases may prove useful for building on our transparency indicator in the future.

fatalities by state-based, non-state, and one-sided violence for each country. Conflict data for an individual country can be added to a download list and obtained as a CSV file. Alternatively, UCDP's entire database can be accessed in multiple different formats (CSV, XLSX, R, STATA, and Codebook); this wide array of common file formats allows UCDP's data to be read by most (if not all) popular data science tools. The UCDP also provides an API so that programs can easily fetch the most up-to-date data on conflicts (Uppsala Conflict Data Program, n.d.). The ATT-BAP hosts survey data about steps that UN member states have taken to follow the Arms Trade Treaty. Examples of such steps include details on arms control legislation and whether countries regularly report to UNROCA. Sections of the ATT-BAP's database can be downloaded for each country's survey profile or for all countries' responses to individual questions. Like the UCDP, the ATT-BAP's entire survey results can also be downloaded as an XLSX file (Arms Trade Treaty Baseline Assessment Project, n.d.).

It could be considered ironic that organizations that promote transparency within the arms control community are inconsistent at publishing their data in accessible formats and have not yet adopted an open-source standard for categorizing weapons. To fix data accessibility issues, organizations should provide CSV, XLSX, ODS, or similar computer-parseable files in bulk to accelerate the data collection process instead of solely providing PDF files that prove difficult for extracting data. Alternatively, organizations could develop APIs or programming libraries that can automate fetching the most up-to-date data available. To fix cross-organization data compatibility issues, organizations should adopt well-defined standards already used by the UN or maintained by the International Organization for Standardization (ISO), only deviating from these if necessary. Given these adjustments, complications when comparing, contrasting, and/or joining data from multiple organizations would be significantly reduced.

5. Conclusion

The proliferation of large munitions severely threatens global security and stability through its influence in armed conflicts and escalation in arms races. Although several disarmament organizations and governments are working to track the movement of weapons, several challenges have slowed progress. Countries providing inaccurate and incomplete reports or strategically concealing them from other states have caused discrepancies in stockpile data. For weapons transfers, there are also inconsistencies from different reporting methods between trading states. Organizations focused on weapons transparency differ in their commitment to providing accessible data and do not implement standardized categories for conventional weapons. To convey these issues and promote transparency, our team developed visualization tools for the *Global Weapons Tracking* website depicting indicators of a country's transparency along with large weapon trades and stockpiles. We also solicited feedback for the website by surveying organizations adjacent to the arms control community.

The feedback from organizations listed on *Global Weapons Tracking* helped shape the website's content, navigability, and responsive design. From the conducted surveys and interviews, we received relevant context for the prevailing challenges involved with transparency in relation to GCD; these anecdotes are evidenced by incomplete data in the maps we developed. Interviewees also provided end-user perspectives which helped us tailor the website towards those uninformed, although the intended audience remains somewhat open to interpretation.

Using stockpile and trade reports from OSINT databases, our team developed multiple interactive maps for *Global Weapons Tracking*. We converted trade data into cumulative imports and cumulative exports over time. Our time lapse maps introduce a contrast of publicly available data: weapons trade evidence is much more discoverable than stockpile amounts by country.

Using self-reports submitted to UNROCA, we created a transparency indicator to objectively identify which countries are willing to report and which are not. Our transparency indicator traces the frequency of each country's reports, thereby facilitating discussion and investigation into countries' lack of transparency. Comparing the results of our transparency indicator to contemporary worldwide events, we hypothesized that countries that rank higher on the World Freedom Index report more frequently than their lower-ranked counterparts. Our team also found anecdotes linking countries' halting reports to adjacent conflicts, criticisms, neglect, and domestic politics.

Global Weapons Tracking offers a small step towards increasing weapons transparency by raising concerns about insufficient and inaccurate self-reporting. If the world ever did reach global

transparency, unintended consequences could arise. Would countries with weak militaries become vulnerable? Conversely, would countries with strong militaries become arrogant or brutish? Considering these questions, we must determine what measures the United Nations could implement to hold countries accountable for weapons transparency without creating new issues.

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Appendix A: List of Relevant Conventional Disarmament Treaties

Entered Into Force	Treaty Name	Brief Description
October 5, 1978	Convention on Environmental Modification Techniques (ENMOD)[12]	Bans harmful environmental modifications for the purposes of war
December 2, 1983	Convention on Certain Conventional Weapons[13]	Framework treaty for regulations on conventional weapons
November 9, 1992	Treaty on Conventional Armed Forces in Europe (CFE)[14]	Regulates conventional weapon categories in Europe
December 3, 1997	Anti-Personnel Mine Ban Convention (Ottawa Treaty)[15]	Comprehensive landmine ban
July 1, 1998	Inter-American Convention on Firearms[16]	Treaty to combat illegal weapons manufacturing and trade in the Americas
2001	Program of Action[17]	Guidelines for countries to reduce illegal arms trade
January 1, 2002	Treaty on Open Skies[18]	Promotes transparency by allowing aerial surveillance between airspace of signatory states
November 21, 2002	Inter-American Convention on Transparency[19]	Treaty to increase transparency in conventional weapons trade in the Americas
2005	International Tracing Instrument[20]	Builds upon Program of Action by requiring record keeping and marking of small arms, and encourages cooperation between countries
August 1, 2010	Convention on Cluster Munitions[21]	Ban on cluster munitions

[12] (Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD), 1977)
[13] (Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May Be Deemed to Be Excessively Injurious or to Have Indiscriminate Effects, 1981)
[14] (United Nations Office of Disarmament Affairs, n.d.)
[15] (Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on Their Destruction, 1999)
[16] (United Nations Office of Disarmament Affairs, n.d.)
[17] (Report of the United Nations Conference on the Illicit Trade in Small Arms and Light Weapons in All Its Aspects, 2001)
[18] (United Nations Office of Disarmament Affairs, n.d.)
[19] (United Nations Office of Disarmament Affairs, n.d.)
[20] (International Instrument to Enable States to Identify and Trace, in a Timely and Reliable Manner, Illicit Small Arms and Light Weapons, 2005)
[21] (United Nations Office of Disarmament Affairs, n.d.)

December 24, 2014	Arms Trade Treaty[22]	Traces arms trades via self-reporting
March 8, 2017	Kinshasa Convention[23]	Control of small arms in Central Africa
January 1, 2002	Treaty on Open Skies[24]	Free flight of surveillance aircraft over signatory states' territory

[22] (Arms Trade Treaty, 2013)

[23] (United Nations Office of Disarmament Affairs, n.d.)

[24] (United Nations Office of Disarmament Affairs, n.d.)

Appendix B: Organizations in the Arms Control Community

Name of Organization
Amnesty Citizen Evidence Lab
Armed Conflict Location & Event Data Project (ACLED)
Arms Control Association*[25]
Arms Trade Treaty-Baseline Assessment Project (ATT-BAP)*[26]
Bellingcat
Bureau of Investigative Journalism
Campaign Against the Arms Trade
ConflictID
Datayo
Engine Room
EU Arms Project
Federation of American Scientists (FAS)
FlightRadar24
Forensic Architecture
FreedomLab
Human Rights Center, Berkeley
International Committee of the Red Cross (ICRC)*[27]
International Institute for Strategic Studies (IISS)*[28]

[25] (Arms Control Association, n.d.)
[26] (Arms Trade Treaty-Baseline Assessment Project, n.d.)
[27] (International Committee of the Red Cross, n.d.)
[28] (International Institute for Strategic Studies, n.d.)

James Martin Center for Nonproliferation Studies
Lighthouse Reports
MarineTraffic
N2YO
New York Visual Investigations Unit
Open Nuclear Network
Organization for Security and Co-operation in Europe (OSCE)
OSINT Combine
Peace Research Institute Frankfurt (PRIF)*
Peace Research Institute Oslo (PRIO)*[29]
PlaneFinder
Stanford Center for International Security and Cooperation
Stockholm International Peace Research Institute (SIPRI)*[30]
Syrian Archive
United Nations Development Programme (UNDP)*
United Nations Register of Conventional Arms (UNROCA)*[31]
Uppsala Conflict Data Program (UCDP)*
Verification Research, Training and Information Centre (VERTIC)
Xinjiang Data Project

*Added to the list by our team.

[29] (Peace Research Institute Oslo, n.d.)

[30] (Stockholm International Peace Research Institute, n.d.)

[31] (UNROCA, n.d.)

Appendix C: Survey Protocol

You are being asked to participate in a research study, your responses will be held confidential. However, the study investigators will be able to inspect and have access to confidential data that identify you by name. Any publication or presentation of the data could identify your organization. The data will be held exclusively by our research team. By agreeing to take this survey you are agreeing to represent your entire organization. Please sign your name below to agree to these terms.

_____

The purpose of the Global Weapons Tracking website is to act as a central hub to help gather, connect, and present information on weapons tracking as well as promote transparency of weapon stockpiles. This survey should take about 10 minutes.

With this survey, we intend to improve the current SCRAP Global Weapons Tracking website to more accurately portray the organizations listed and enhance user experience. Please take five minutes to look at our platform: https://weaponsystemsinfo.wpcomstaging.com/

Q1. This time can be used to engage with our interface and find your organization under one of the four main tabs: "Weapons Tracking," "Weapons and Human Rights Violations," "Think Tanks, Training, and Services," or "Tracking Tools."

Q2. What is the full name of the organization?

_____

Q3. Do we have your permission to include your organization in the website?

- ○ Yes
- ○ No
- ○ I am not authorized to grant permission. Here is another point of contact to reach out to regarding this (name and email address): _____

Q4. Our website links to organizations based on four categories located on our homepage. Which category do you feel best fits your organizational mission?

- ○ Weapons Tracking (where weapons are located and where they are being sent)
- ○ Weapons and Human Rights Violations (monitoring weapons use in human rights abuses)
- ○ Think Tanks, Training, and Services (open-source research services)
- ○ Tracking Tools (research tools for air and shipping movements)

○ None of these categories quite fit my organization (please explain)
_____

Q5. How accurate is the profile description of your organization on the SCRAP website?

○ Very accurate

○ Somewhat accurate

○ Inaccurate

Q6. How can the description of your organization be better portrayed?
_____

Q7. The intention of our website is to act as a central hub to help gather, connect, and present information on weapons tracking as well as promote transparency of weapon stockpiles.
How can we improve this website to better achieve the goal of the website? Areas may include homepage design, navigability, or content. Please explain.

_____

Q9. Are there any website features that your organization may benefit from having on this website? This may include visuals, data, forums, news, or anything else.

_____

Q10. Can you think of any other organizations that we should include on the website?

_____

Appendix D: Interview Protocol

Weapons Tracking and Disarmament Organizations

The purpose of this research is to advance the current Strategic Concept for the Removal of Arms and Proliferation (SCRAP) website to bring awareness to the general public on arms control and promote transparency on weapons stockpiles and trade around the globe.

By completing this survey, you understand and agree to have this information collected and be used to identify you. Individual responses may be disclosed for research purposes.

In the following questions, please inform us about your organization's work and mission, and how the in-progress "Global Weapons Tracking" website may be improved.

1. From what organization are you representing?
2. Do we have your permission to include your organization on the website?
    a. If yes, how can the description of your organization be portrayed better?
3. What are the biggest challenges your organization faces in regard to transparency and open-source information of weapons stockpiles and trade?
4. What current projects or campaigns is your organization currently focusing on in regard to arms control, transparency of information, or weapons stockpiles and trade?

Please visit our website in progress: https://weaponsystemsinfo.wpcomstaging.com/

And take some 5-10 minutes to look through the different categories and interface, and to find a description of your organization under one of the four categories: "tracking weapons," "weapons and human rights violations," "think tanks, training, and services," or "tracking tools."

As this website is not fully public, your organization may not be included in the final version if you so wish.

5. Do we have your permission to include your organization on the website?
    b. If yes, how can the description of your organization be portrayed better?

We are proposing to add an interactive map on the global stockpiles of major conventional weapons to the website by compiling data from various sources.

6. Does this sound like a feature that could be of any use to your organization?
    c. If yes, how could this aid your organization's current work or mission?
    d. If not, what new feature could be implemented to help your organization?
    e. How could this be useful to other target audiences such as governments, policy makers, or the general public?

The intention of our website is to act as a central hub to help gather, connect, and present information on weapons tracking as well as promote transparency of weapon stockpiles.

7. How can we improve this website to better achieve the goal of the website? Areas may include homepage design, navigability, or content. Please explain.
8. Are there any website features that your organization may benefit from having on this website? This may include visuals, data, forums, news, or anything else.
9. Are there any other general comments on the website design to improve?
10. Please list any related organizations you may know about working on similar goals of weapon tracking and disarmament.
11. Do we have your permission to quote any material used in these questions?
    f. If so, may we identify responses with your name or organization?

Thank you for your time and feedback on the website.

For any questions please email: gr-VAM-IQP@wpi.edu