



*A Modern History of Armed Conflicts*

*from 1946 to 2013*

# Process Book

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# Table of Contents

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[Table of Contents](#)

[Introduction](#)

[Motivation](#)

[Objectives](#)

[Outline](#)

[Data](#)

[Data source](#)

[Cleanup and processing](#)

[Exploratory Data Analysis](#)

[Pre-Design Analysis](#)

[Desired Features](#)

[Must-have features](#)

[Conflict map](#)

[Temporal plots](#)

[Statistical graph](#)

[Filter section](#)

[Optional features](#)

[Design Evolution](#)

[Initial design](#)

[Conflict timeline](#)

[Combining map and timeline](#)

[Conflict map](#)

[Statistical graph](#)

[Questions' evolution](#)

[Final design](#)

[Implementation](#)

[Filter section](#)

[Evaluation](#)

[Learning from the data](#)

[Results' validation](#)

[Features implemented](#)

[Areas for improvement](#)

[Conclusion](#)

# Introduction

## Motivation

Hundreds of armed conflicts have occurred worldwide since World War II (WWII). Being aware of these conflicts and understanding them is important. It forces us to delve into essential questions concerning human relations, and it can collectively help us finding ways of resolving future conflicts without recourse to violence. However, given the large amount and scope of data available on armed conflicts, it is difficult to reach such an understanding without appropriate data and effective analysis tools.

## Objectives

This project aims to produce an interactive visualization that will effectively convey information on modern armed conflicts. It will allow its users to answer various questions, such as:

- Where in the world (countries and regions) have armed conflicts occurred since WWII?
- When did these conflicts occur? How long did they last?
- What nations or parties were involved?
- What caused the conflicts?
- How many deaths resulted from them?
- Are there any downward or upward trends in the number of armed conflicts?
- Do these trends, if any, differ depending on the type, intensity, or region of the conflict?

We will design the visualization with a general, non-specialist audience in mind. Nevertheless, we believe our tool will be useful to military historians, defense analysts, and other readers who may already be familiar with some of the underlying data.

## Outline

This process book will expand on the [proposal](#) we made before starting this project. First, we will describe how we obtained the [data](#) we needed and how we did some [exploratory analysis](#) on it. We will then describe the [analysis process](#) we followed to come up with our design and list the [features](#) we wanted it to have. Next we will describe the [evolution](#) of our design and discuss its [implementation](#). Finally, we will [evaluate](#) how well it met our objectives.

# Data

## Data source

The most appropriate set of data we found is the [Armed Conflict Dataset](#)<sup>1</sup> compiled by the [University of Uppsala Conflict Data Program \(UCDP\)](#) and the International Peace Research Institute, Oslo (PRIO). It covers armed conflicts that occurred from 1946 to 2013 (unfortunately, the data for 2014 have not yet been released by UCDP). According to [UCDP](#), this dataset is “one of the most accurate and well-used data sources on global armed conflicts and its definition of armed conflict is becoming a standard in how conflicts are systematically defined and studied.” A [codebook](#) produced by UCDP explains the dataset and defines all data attributes.

On top of the armed conflict dataset, we originally considered using the [Uppsala Conflict Database Categorical Variables](#) and other datasets, such as a dataset on [Sexual Violence in Armed Conflict](#), to add more dimensions to our data. But we found that our core dataset was rich enough not to tap into additional data sources.

We used [topoJSON data from Mike Bostock](#) to draw a world map.

## Cleanup and processing

Initially, it seemed that not much data cleaning would be required. However, we had to fill some gaps. For instance, the end dates of conflicts did not appear in all rows and we had to build a reduced data set fixing this gap in order to build the conflict timeline.

We also had to georeference the conflicts' locations by adding the latitudes and the longitudes of the locations to the data set. This was done by using an [Excel geocoding tool](#).

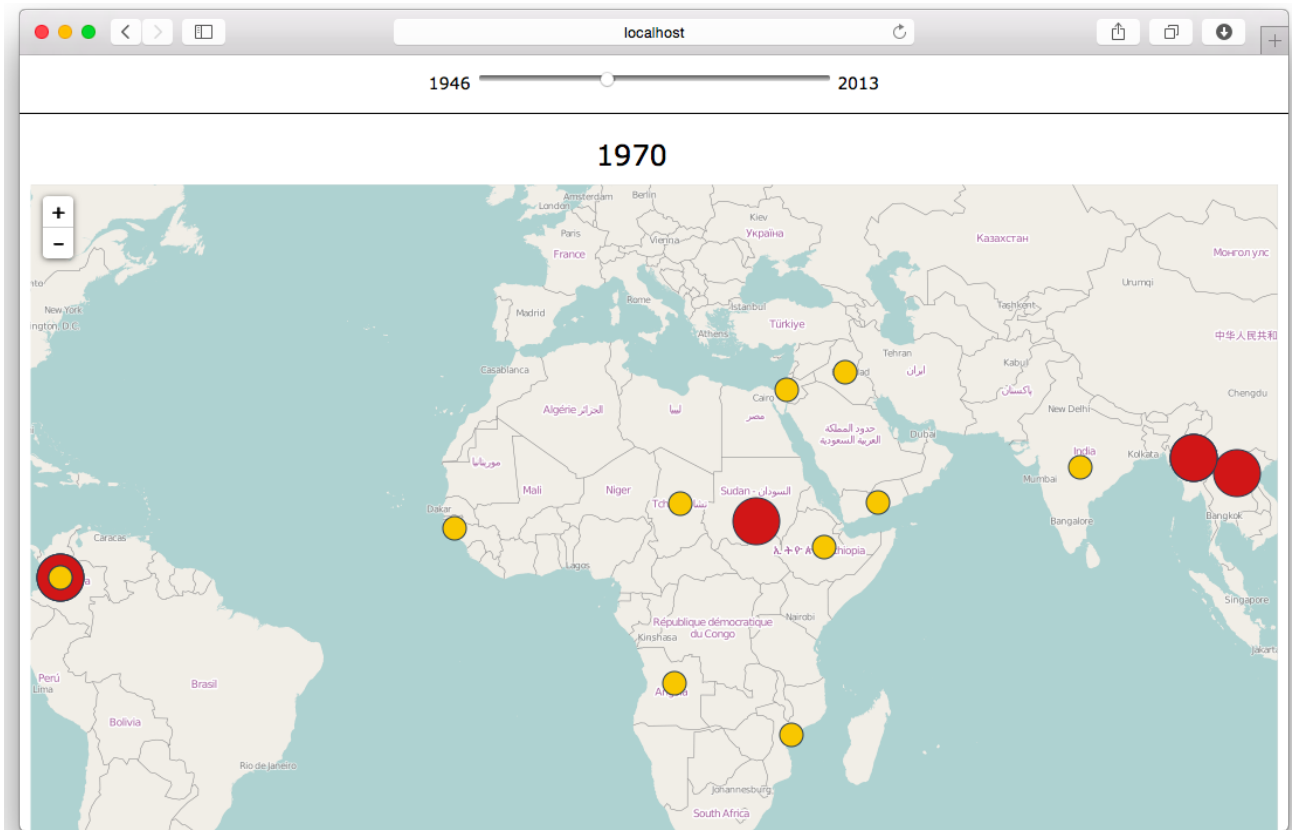
## Exploratory Data Analysis

To explore our data, we used standard Excel capabilities. We also built a simple [Leaflet](#) visualization that displayed the location of conflicts over time and their magnitudes (Figure 1). This gave us an overview of the spatial and temporal distributions of conflicts. It convinced us that the dataset contained a lot of interesting information worth presenting through a more sophisticated visualization.

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<sup>1</sup> UCDP/PRIO Armed Conflict Dataset v.4-2014, 1946 – 2013

**Figure 1:** Leaflet-based prototype for exploratory analysis



## Pre-Design Analysis

To guide the design of our visualization, we made a list of the data attributes that we wanted to display, based on the [questions](#) we wanted to answer. We determined how important we thought each attribute was on a high/medium/low scale, and thus how prominently it should appear in our design. We then identified potential means of displaying each attribute, taking into consideration that the most important variables should be encoded as efficiently as possible. We also identified potential means of filtering data against each attribute in our visualization. The results of this analysis are summarized in Table 1.

**Table 1:** Pre-design analysis

Data attribute of interest	Relative importance (prominence)	Potential means of displaying data	Potential means of filtering based on attribute
Conflict locations	High	Circles on map, names on a list	Country pulldown, search box, or other
Conflict periods	High	Timeline or gantt chart	Brushing/scrolling
Countries or parties involved	High	Mouseover pop-up text box, or arcs from involved countries centroids to conflict location	Country pulldown or search box
Region of the world	Medium	Region highlighted or zoomed on	Pulldown menu or other method
Conflict intensity (# of deaths)	Medium	Size of circles on map	Pulldown menu or other method
Conflict type (intl, intrastate, etc)	Medium	Color of circle on map, other encoding, or simply not shown when filtered out	Pulldown menu or other method
Conflict source (incompatibility)	Medium	Other encoding, or simply not shown when filtered out	Pulldown menu or other method
<b>Statistics derived from data set</b>			
Number of conflicts over time	High	Area plot, or horizontal heat map	N/A
Other statistic (e.g., number of conflict-years per country)	Low	Separate bar chart	N/A

## Desired Features

Based on our analysis, we came up with the following is the list of “must-have” and “optional” features that we aimed to include in our visualization.

### Must-have features

#### *Conflict map*

- World map with country lines, suitable projection, zoom and drag functionality
- Conflict locations as circles (two sizes, depending on conflict intensity)
- Mouseover function to display countries/parties involved in conflicts
- Map filtered according to events and filters from other elements/sections

#### *Temporal plots*

- Curve or area plot showing number of conflicts over time
- Timeline showing conflict durations over time.
- Brushable area for period filtering
- Plot filtered according to events and filters from other elements/sections

#### *Statistical graph*

- Bar chart (or other chart type) showing at least one key statistic derived from the data
- Chart filtered according to events and filters from other elements/sections

#### *Filter section*

- Conflict intensity filter (likely a pulldown menu)
- Conflict type filter (likely a pulldown menu)
- Conflict source filter (likely a pulldown menu)
- Conflict region filter (likely a pulldown menu)
- Conflict location filter (pulldown menu, search box, or other)

### Optional features

- Additional encoding of information. For instance, upon some action event, the conflict types could be encoded by coloring circles on the map and/or the bars on the timeline.
- Additional statistics derived from data and displayed
- Additional filters introduced, e.g., through the bar chart or the timeline.
- Additional curve or area plot showing estimated number of deaths over time
- Some visual feature focusing on adversarial or allied countries (e.g., pairs of countries that have conflicted with each other the most often during a given period)

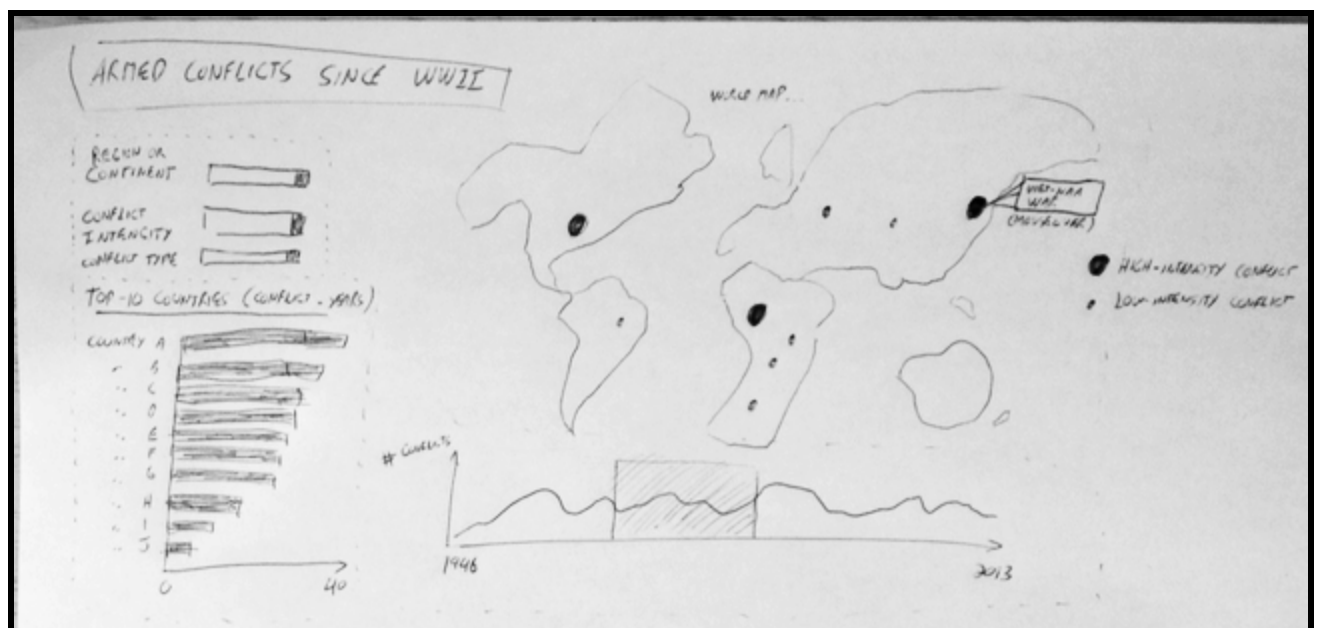


# Design Evolution

## Initial design

Our very first design (Figure 2), which was done in parallel with our [pre-design analysis](#), included a world map displaying conflicts that matched filter criteria, a plot displaying the number of conflicts over time, and a bar chart displaying other statistics derived from the data. Temporal filtering of the data would be done through brushing.

**Figure 2:** Initial design



## Conflict timeline

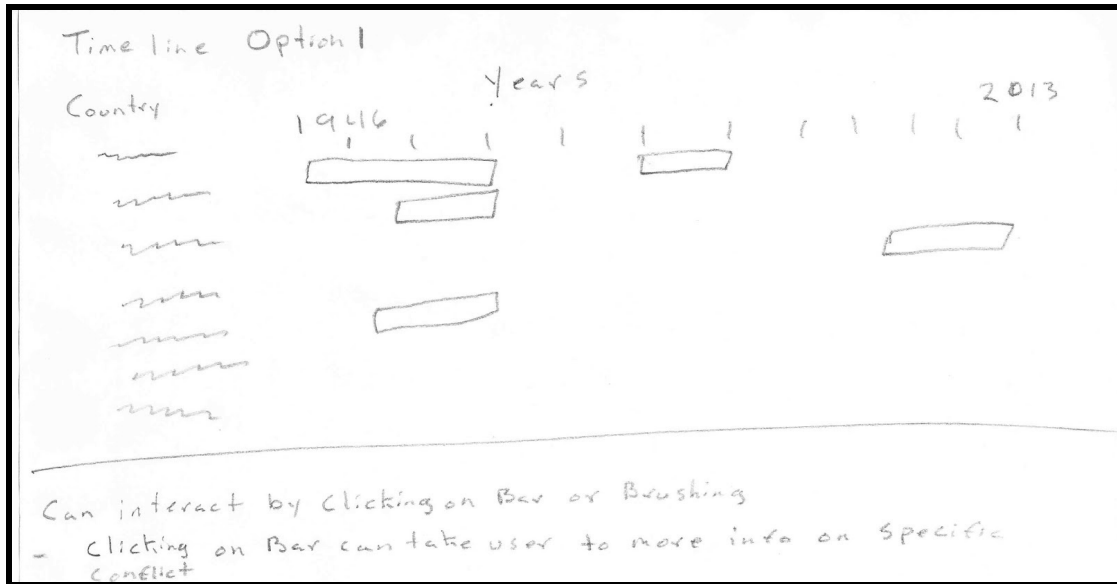
During the analysis phase, a member of the team suggested to add a conflict timeline to the visualization. A couple of options were considered. In the first one, the timeline would be presented in a traditional, Gantt chart form (Figure 3). Many examples of such type of charts were found on the web, including a [D3 implementation](#).

The second timeline design, inspired from an online [visualization of scientific journal publications](#), would present the timeline in the form of a bubble chart (Figure 4). We went as far as making a prototype implementation of it in D3 (Figure 5). In the end however, we did not pursue this option as we decided that a more traditional design similar to Figure 3 would work better.

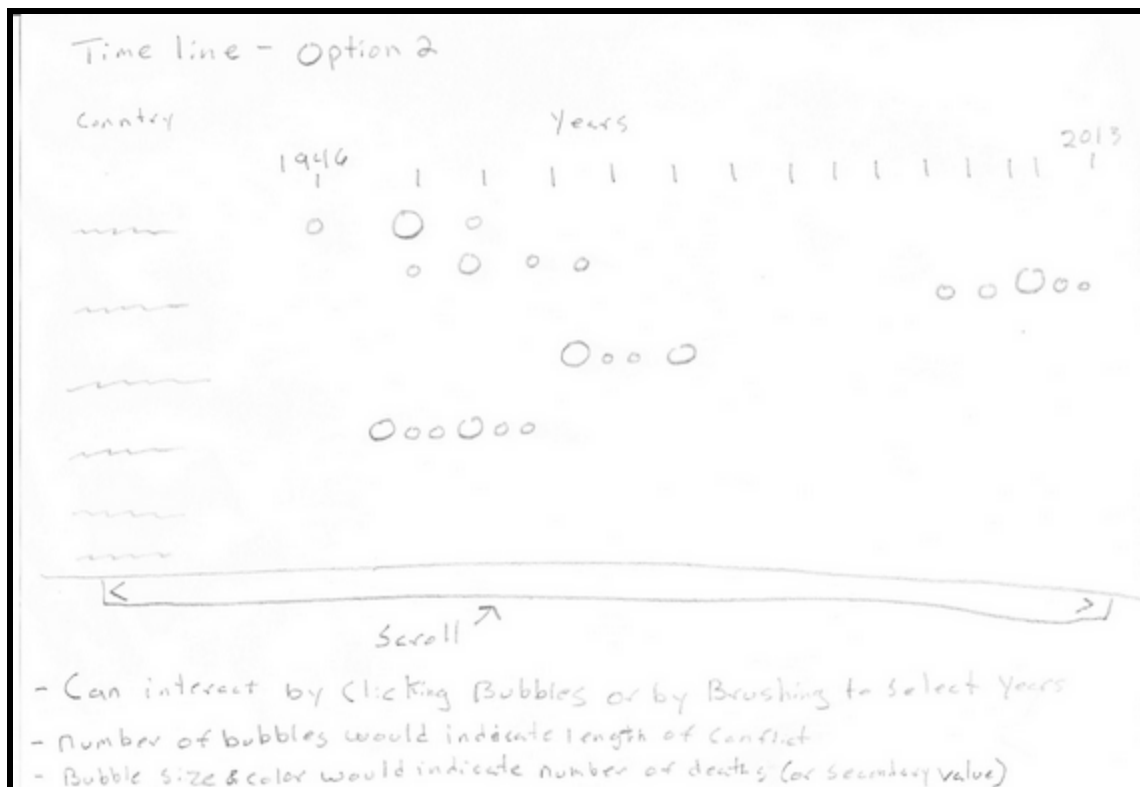
Our challenge was then to find a convenient and intuitive way of introducing the timeline in the overall design.



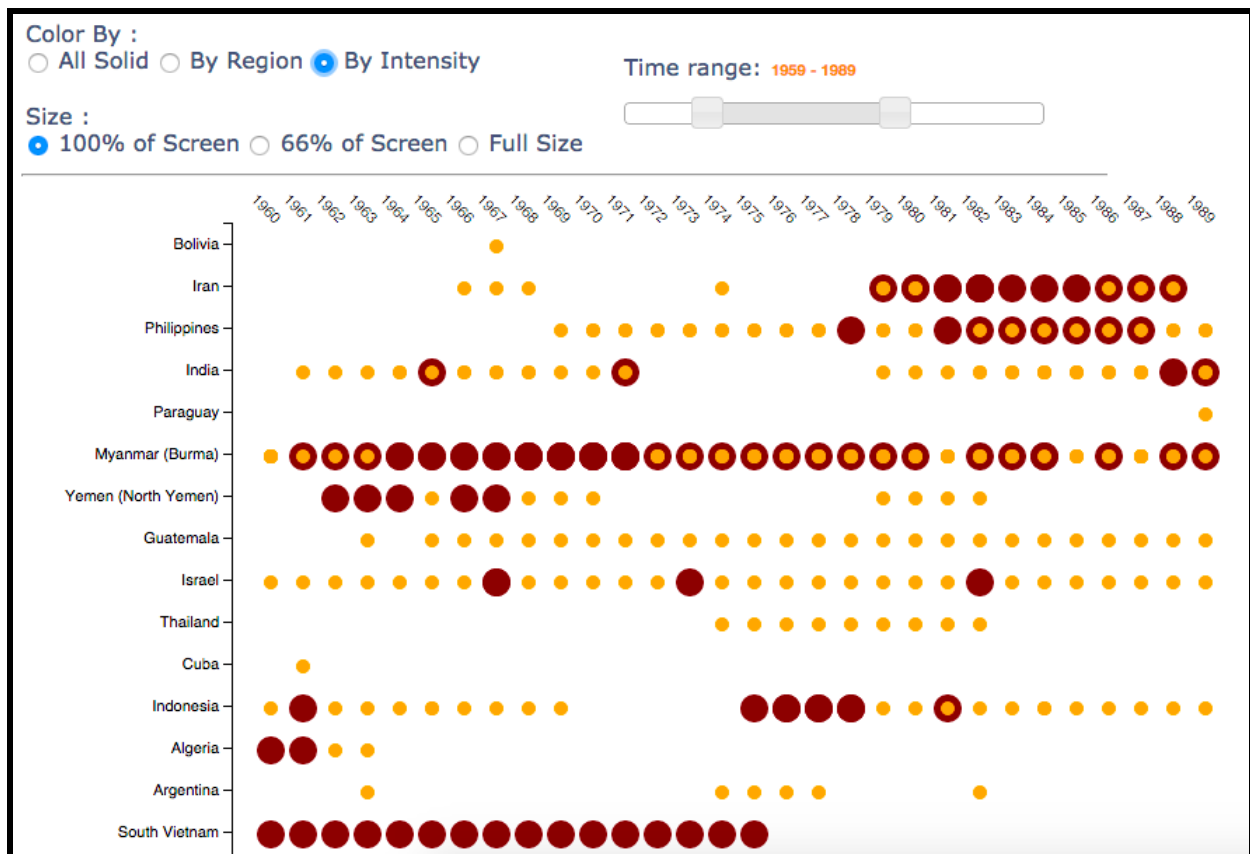
**Figure 3: First timeline design**



**Figure 4: Second timeline design**



**Figure 5:** Prototype D3 implementation of second timeline design

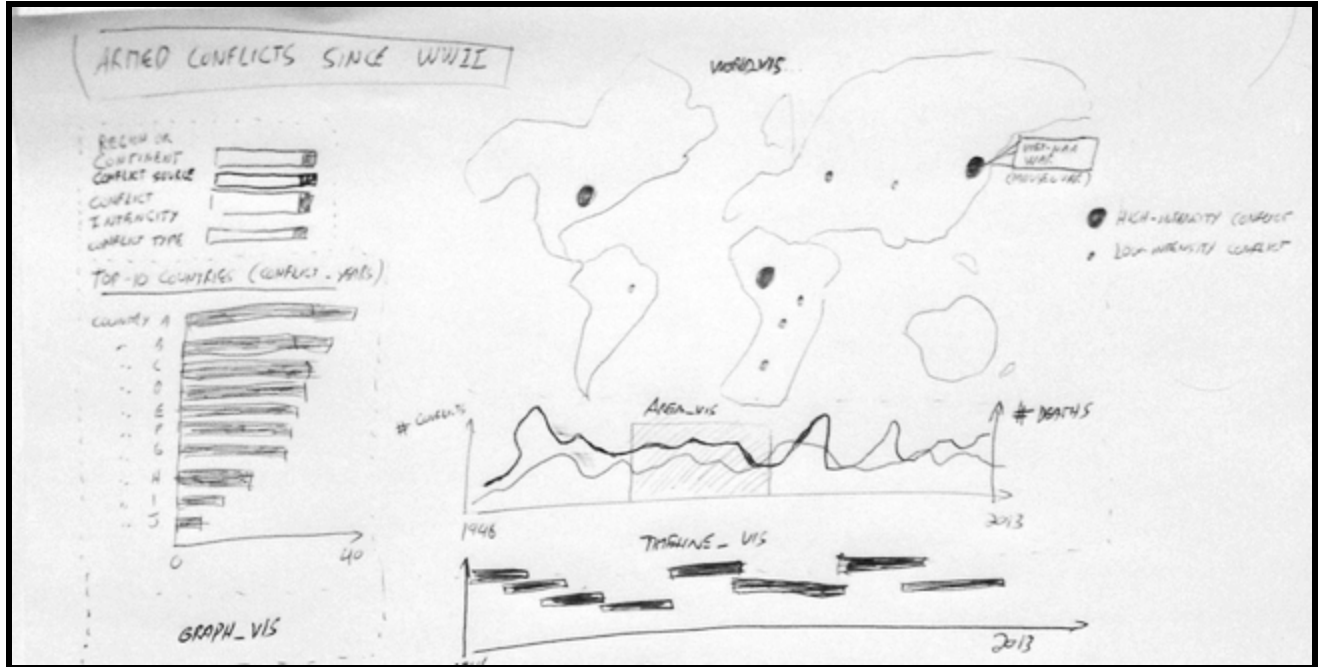


## Combining map and timeline

At this point, we had two ways of presenting essentially the same information: a map and a timeline. For a while, we considered having the users to switch between the two views, and not see the two simultaneously. But we thought this was not desirable, and that the two views should be seen as complementary. In fact, we found many online [examples](#) of “timemaps” that elegantly combine temporal and spatial information.

We played with the [Timemap.js](#) library using our conflict data. It was easy to use and allowed us to explore our data in a new way. However, we were concerned that by using this library we would not have full control on our design. It would be difficult to tie the timemap to other elements of our visualization, and the look-and-feel might differ as well from one element to another. As a result, we decided to implement our own timemap in D3. We started to refine our design by introducing the timeline underneath the world map, as shown in Figure 6.

**Figure 6:** Introducing the timeline below the map.



At this point, we were still considering to keep the plot showing the number of conflicts over time below the map as well. But this created two problems. First, the timeline would be very compressed vertically, making it difficult to see a reasonable number of conflicts at the time without scrolling. Second, the plot presenting the number of conflicts over time would also be very compressed vertically, making temporal patterns hard to identify and analyze.

Our decision was to move the area plot showing the number of conflicts over time to the left-hand side. This had a few advantages. Temporal variations in the number of conflicts would be clearer by not stretching the graph horizontally. Furthermore, since the brushed area would act as the main temporal filter, it was more logical and intuitive to locate this chart on the left hand side, where other filters were expected to reside.

## Conflict map

We thought that spatial information was important enough to add a map to our design. The conflicts displayed would be filtered through other elements of the visualization. This example on [meteor observations](#) inspired us in terms of the cross-filtered mapping capability we wanted to achieve.

For the map's projection, we chose to use the Winkel tripel projection. As we learned in class, it minimizes distortions in terms of areas, distances, and direction, and has become the standard for projecting world maps in many geography textbooks. From a more practical perspective, the projection is relatively compact and not too stretched horizontally (unlike the Mercator projection), and thus was more convenient to fit into our layout.

## Statistical graph

Our last challenge was to produce a graph displaying at least one key statistic related to the data. Our initial idea was to have a single bar chart in the bottom left corner of the layout. A potential statistic we considered showing with this graph was the top 10 countries with the most conflict-years (for conflicts matching the filter criteria set by the pulldown menus).

This approach would have been easy to implement, but after some thought, we imagined a more sophisticated and interactive design: each of the four pulldown menus for the filters could be replaced by a small bar chart showing the distribution of conflicts with respect to the criterion of interest for the filter (i.e., conflict type, source, intensity, or region). Clicking on a particular attribute value (e.g., “Europe” for the conflict region) would cross-filter other bar charts, as well as the rest of the visualization (conflict map and timeline).

Accordingly, instead of presenting a single, static bar chart, we would have four small bar charts that could be used to filter the data and interact with the rest of the visualization.

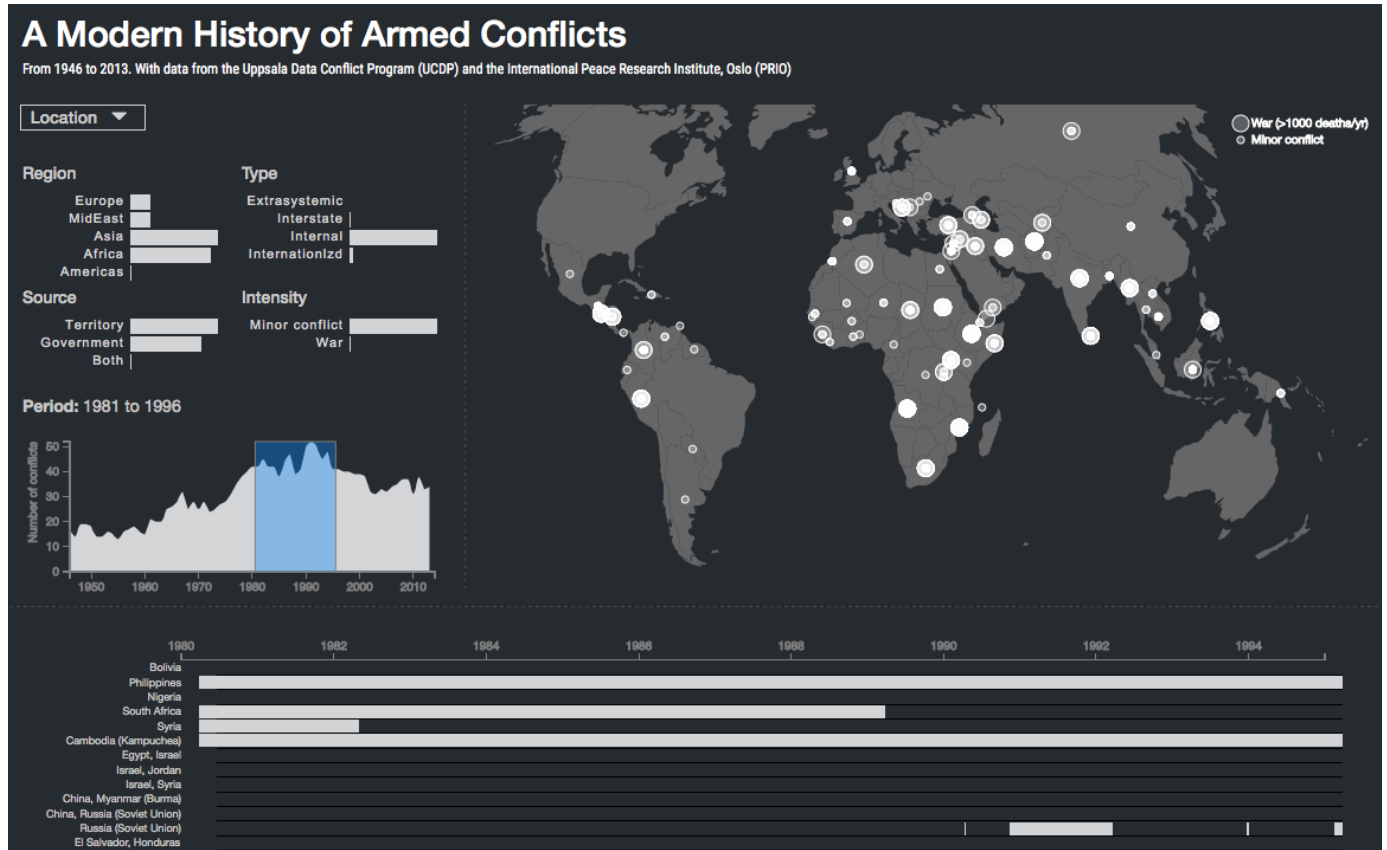
## Questions’ evolution

As a result, we abandoned the idea of presenting the top 10 countries with the most conflict years, which was a low-priority item in our [analysis](#) anyway. Instead, we would try to get a deeper understanding of conflicts’ distributions over time, regions, conflict types, conflict sources, and intensities. The cross-filtering capability of our design would also allow to answer very specific questions, such as: “are there any upward or downward temporal trend in the number of *intrastate* armed conflicts occurring in *Africa* and related to *territorial* incompatibilities?”

## Final design

A screenshot of our final design is shown in Figure 7.

Figure 7: Final design



## Implementation

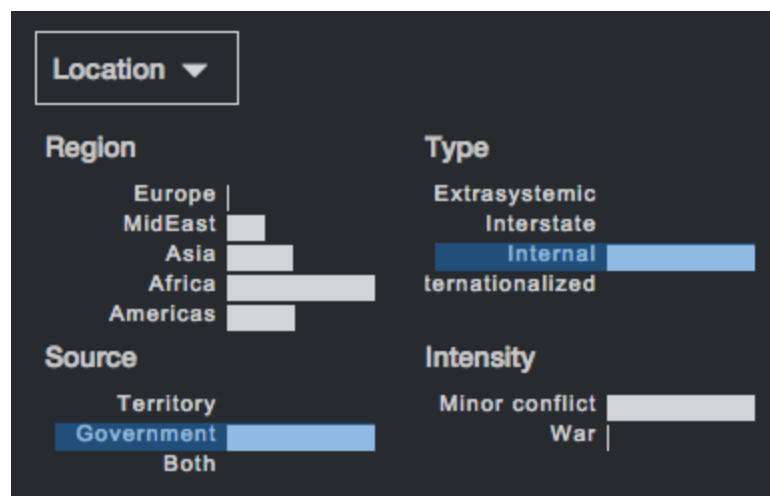
Our design is fully implemented in HTML, CSS and javascript, using D3 for visualization and data processing, and JQuery for event handlers.

### Filter section

The top-left corner includes bar charts presenting the distribution of conflicts over regions, types, sources, and intensities. Clicking on a bar (e.g. “internal” for conflict type) filters the data according to the attribute of interest and updates other parts of the visualization accordingly. The bar remains highlighted in blue to make it clear that a filter is applied. When hovering on a bar without clicking on it, the conflicts matching the attribute of that particular bar are highlighted on the map.

A pulldown menu also appears in this section to filter conflicts based on their specific locations. It is also highlighted in blue when a filter is applied.

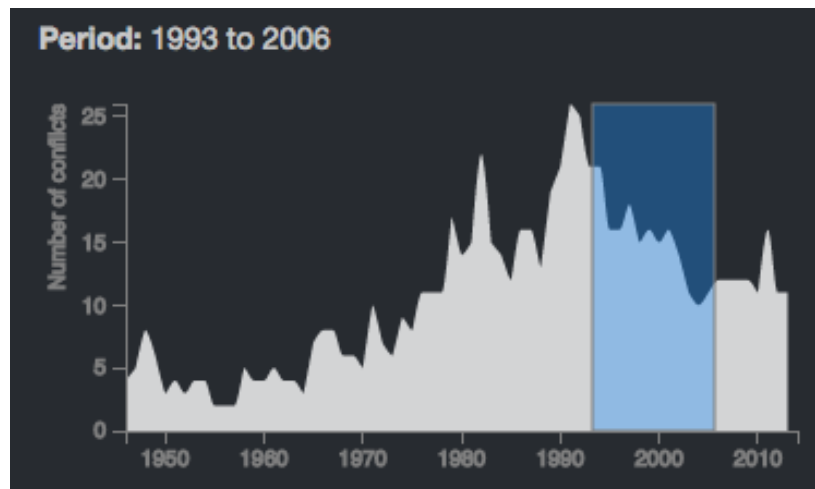
**Figure 7:** Filter section



### Area graph

The middle-left portion of the layout is an area chart presenting the number of conflicts over time. The data used to produce this chart is based on the filters previously described. A brush can be applied as an additional, temporal filter. It serves to focus the data on a particular time frame and is also highlighted in blue for consistency with other filters. Note that the extent of the timeline matches the extent of the brush, and any change in the brushed area size or position also changes the displayed portion of the timeline.

**Figure 8:** Area graph



## Conflict map

The world map displays all conflicts matching the filter criteria previously mentioned. The conflict locations are represented by circles of two different sizes, based on their intensities (minor conflicts or wars). If a user is interested in a particular region and clicks on the associated bar chart filter, the map will zoom in automatically on the region of interest. The user can also zoom in or out on any area of interest that is not pre-defined.

Placing the mouse's cursor over a circle triggers a tooltip providing details of the conflicts and parties involved, as well as the territory disputed (if any). Clicking on the circle opens up a new browser window redirecting the user to relevant entries in the [UCDP Conflict Encyclopedia](#), where detailed information about the country of interest and all the conflicts it went through since 1946 can be found.

The world map also displays, to some extent, information about conflict frequencies and durations. Because the circles are not fully opaque, if multiple conflicts occur at the same location during the time frame of interest, or if a conflict lasts for several years, it will appear whiter than a single, short conflict. This opacity variation is only a secondary means of displaying conflict frequency/duration, so even if the encoding is not very efficient, we decided to keep it.



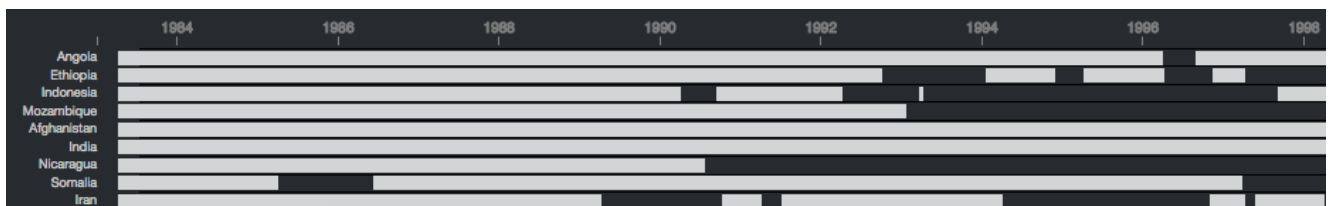
**Figure 9: Conflict map**



### Conflict timeline

The primary means of displaying conflict frequencies and durations is the conflict timeline, shown at the bottom of the map. The timeline groups on the same row all conflicts occurring in the same location.

**Figure 10: Conflict timeline**



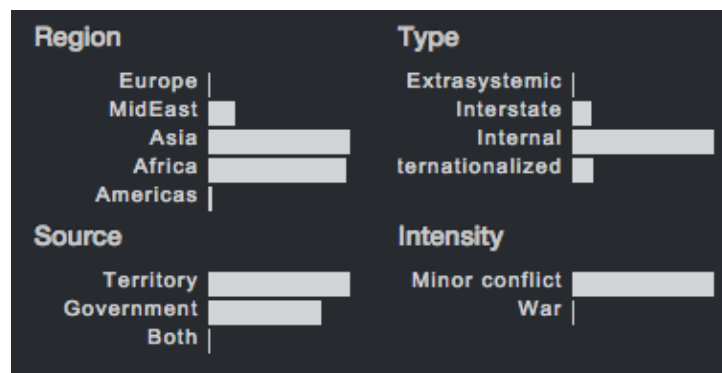
# Evaluation

## Learning from the data

Without doing a comprehensive data analysis, our visualization revealed a few interesting patterns. Simply looking at the bar charts (Figure 11), before using them as filters, we can see that:

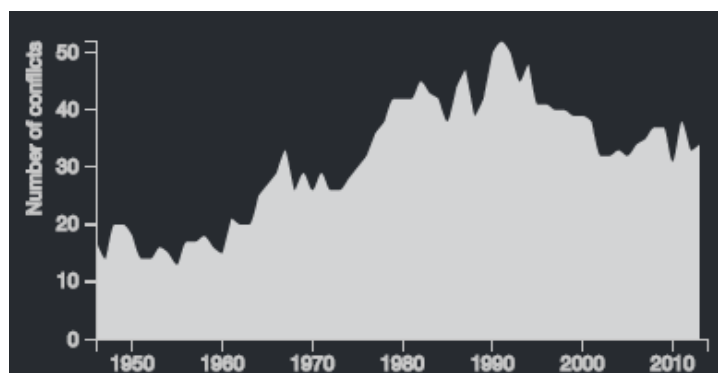
1. The large majority of armed conflicts that occurred since WWII were in Africa and Asia.
2. The large majority of armed conflicts that occurred since WWII were *internal* conflicts, i.e., conflicts occurring between the government of a state and one or more internal opposition group(s), without intervention from other states.
3. The source of an armed conflict (i.e., what parties are fighting over) generally concerns government or territory, rarely both.
4. Minor conflicts (with 25-999 deaths per year) are much more frequent than wars (with 1000 deaths or more per year).

Figure 11: Bar charts



From a temporal perspective, the number of armed conflicts worldwide has increased relatively steadily after WWII, and then started to decrease after the end of the Cold War in the early 90s (Figure 12).

Figure 12: Number of conflicts over time (all categories)



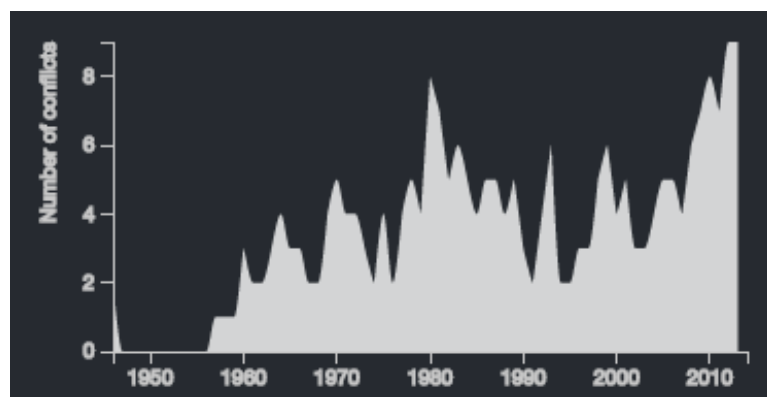
This temporal pattern generally repeats itself when looking at specific regions of the world. However, when looking at specific conflict types, there are notable differences. For example, the number of *extrasystemic* armed conflicts (occurring between a state and a non-state group outside its own territory, such as colonial and imperial wars, where a government is fighting to retain control of an outside territory) has decreased to zero in the decades following WWII (see Figure 13).

**Figure 13:** Number of extrasystemic conflicts over time



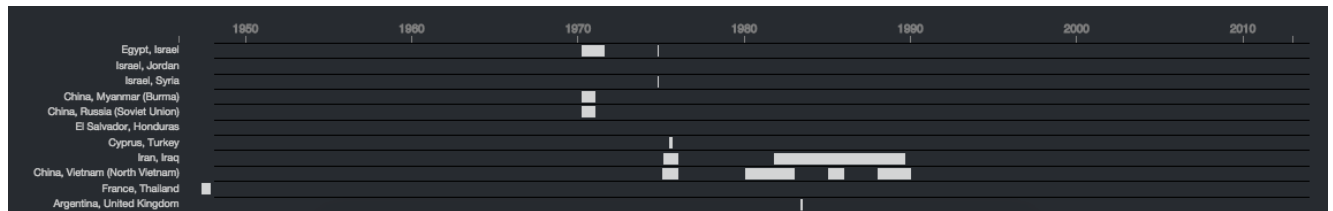
On the other hand, *internationalized* conflicts (occurring between the government of a state and one or more internal opposition group(s), but with intervention from other states) are on the rise (Figure 14). An example of such conflict is the international coalition fighting against al-qaida.

**Figure 14:** Number of internationalized conflicts over time



From a different perspective, the timeline also revealed some interesting patterns. For instance, some types of conflict, such as interstate conflict (typically involving only two nations) appear to be very short in general (Figure 15). Other types of conflicts, such as internationalized conflicts, appear to remain active for years or even decades (Figure 16)..

**Figure 15:** Timeline with a sample of interstate conflicts



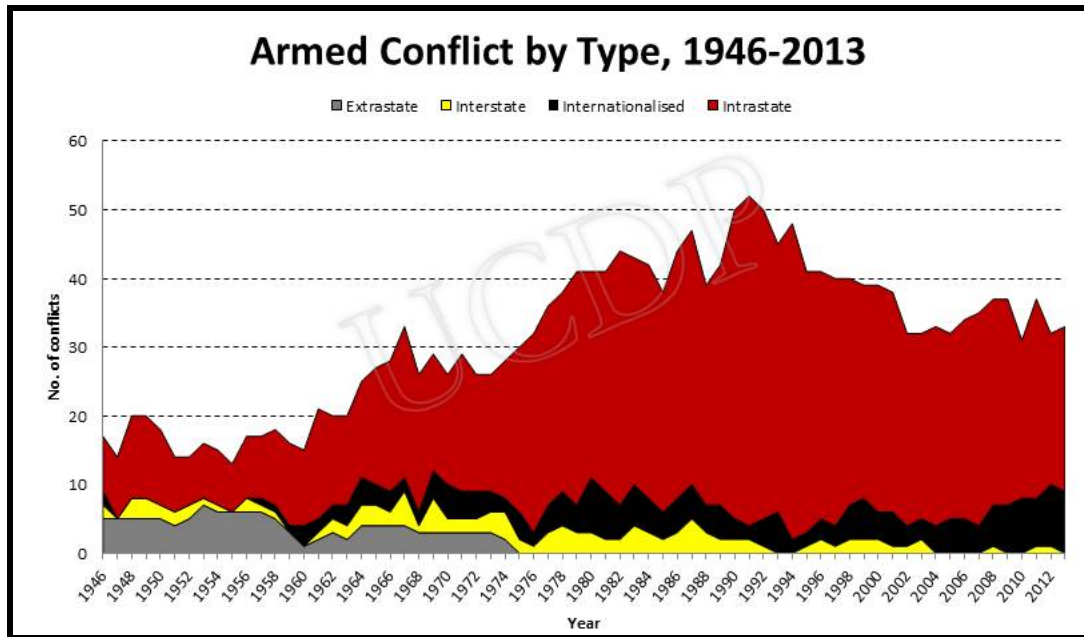
**Figure 16:** Timeline with a sample of internationalized conflicts



## Results' validation

To validate our calculations and some of our graphs, we compared our own results to [charts](#) published in academic journals by the Uppsala Data Conflict Program. For example, Figure 17 shows published results for the number of conflicts over time, by type. Results in this graph are consistent with results from Figures 12, 13, and 14. However, we find that the interactivity provided by our visualization tool makes it easier to read results by focusing on specific conflict types or other conflict attributes.

**Figure 17:** Number of conflicts of each type over time<sup>2</sup>



## Features implemented

We successfully implemented all of the [must-have features](#) we originally wanted and they are all functional. In addition, we implemented a few more features that we originally considered optional or had not originally anticipated:

- The pulldown filters were converted to small interactive bar chart filters. They replace the single statistical graph (bar chart) we originally planned to do. They provide additional statistics with respect to the distribution of conflicts, and add a lot of interactivity to the design through cross-filtering.
- We implemented a mouseover function on the bar chart filters that triggers additional, color-based encoding of the conflict map and conflict timeline.
- We implemented mouseover tooltips in the map that display not only parties, but the territory being disputed (if any).
- We implemented an auto-zoom functionality on the conflict map when a particular region is selected on the bar chart.
- Circles on the map include hyperlinks to the UCDP Conflict Encyclopedia.

<sup>2</sup> Themnér, Lotta & Peter Wallensteen, 2014 "Armed Conflict, 1946-2013." *Journal of Peace Research* 51(4).

## Areas for improvement

Overall, our visualization answered all the questions we expected it to answer. However, it could still be improved in many ways.

For example, our current design mainly focuses on the primary actors of the conflicts and the countries where the conflicts occurred. Secondary actors on the side of the government or on the side of the opposition are only displayed in tooltips. It would be possible to display them more clearly in the map, through some additional encoding of information (e.g., on the map, highlighting all countries involved in a conflict when place the mouse over a circle), or present some statistics about them in a new chart.

There is also a lot of opportunities for deriving and presenting more statistics from the data. For example, we could derive an estimate of the number of deaths per conflict, per country, or per period. We could also identify the total number of conflicts each country was involved in, or the number of conflict-years per country.

It might also be interesting to find a way to identify countries that have *not* been involved in any conflicts over time.

## Conclusion

Although our design could still be improved, we successfully implemented all of the features we wanted to implement, and more. Our tool provides a very effective means of navigating through the data and understanding the nature of modern armed conflicts. We hope the users will enjoy it and learn from it.