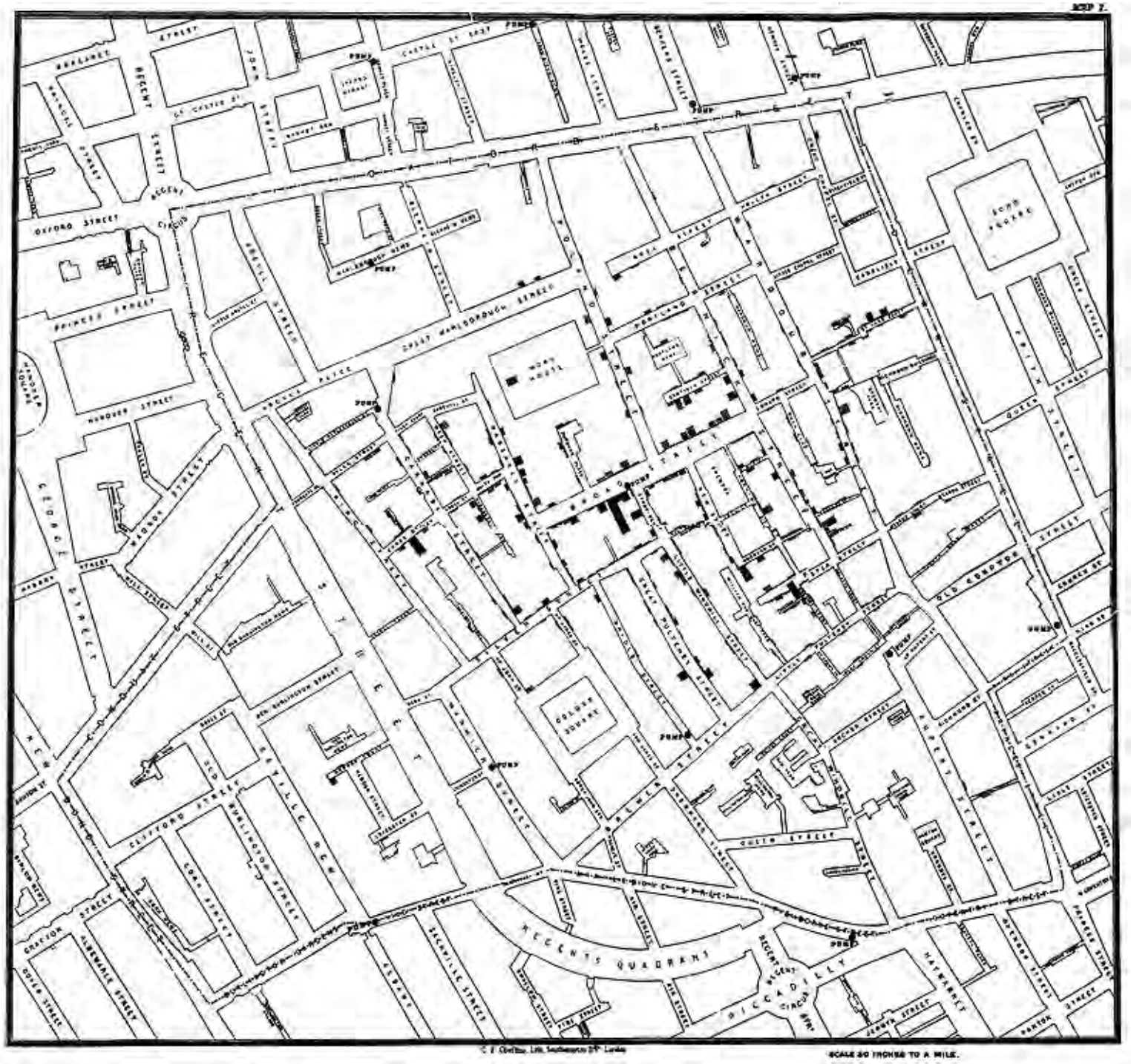
# INTRODUCTION

"Discovery is no longer limited by the collection and processing of data, but rather management, analysis, and visualization."

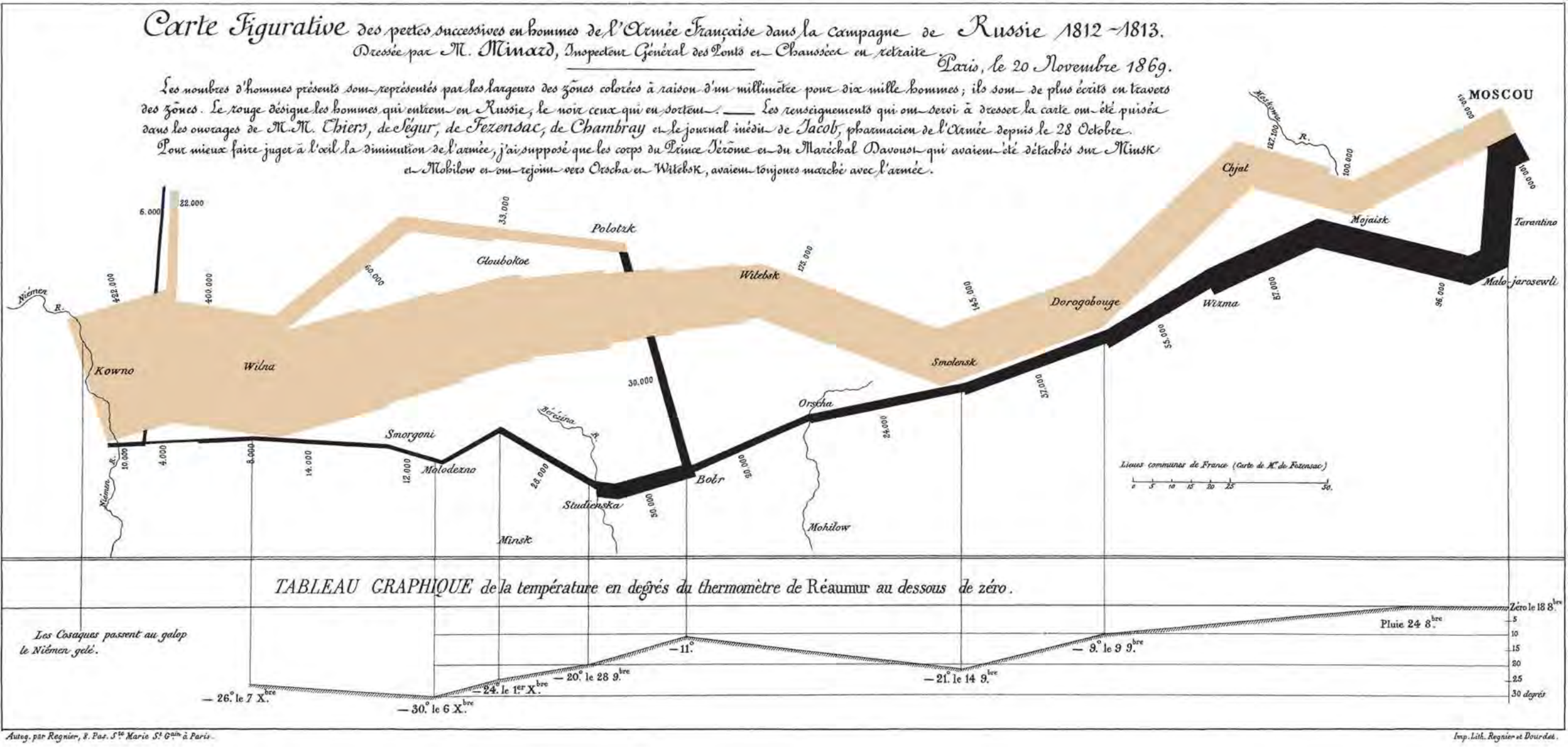
@DamianMingle

## London's Cholera Outbreak of 1854

Physician John Snow links the outbreak to a contaminated well by plotting number of cases on a map, jump-starting the science of epidemiology.

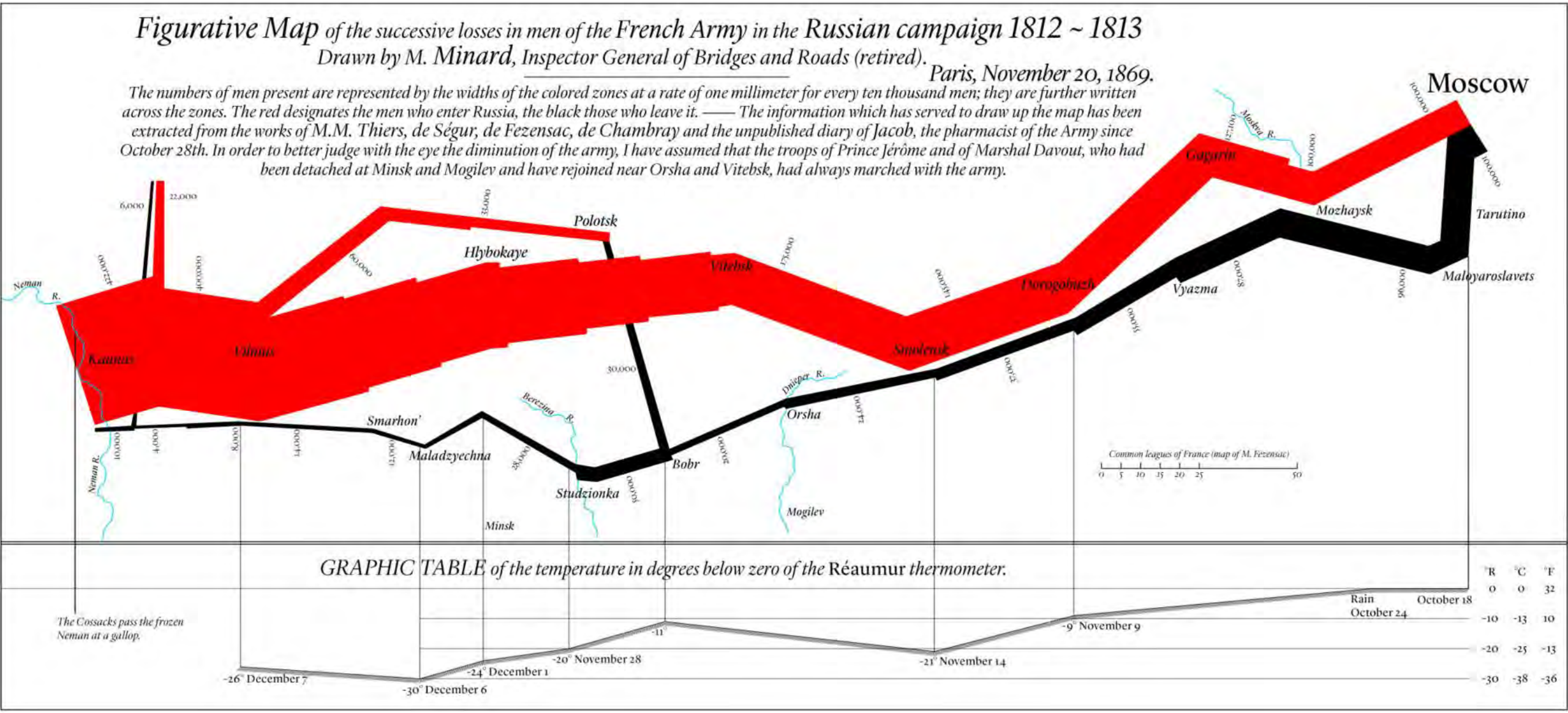


[Minard, 1869]




# Minard's March to Moscow

[DAL Podcast #3 – https://youtu.be/tS_2_IQ5gRw]




# Minard's March to Moscow

[J.P. Blackard]

# INFOGRAPHICS

Created for **story-telling** purposes (**subjective**)

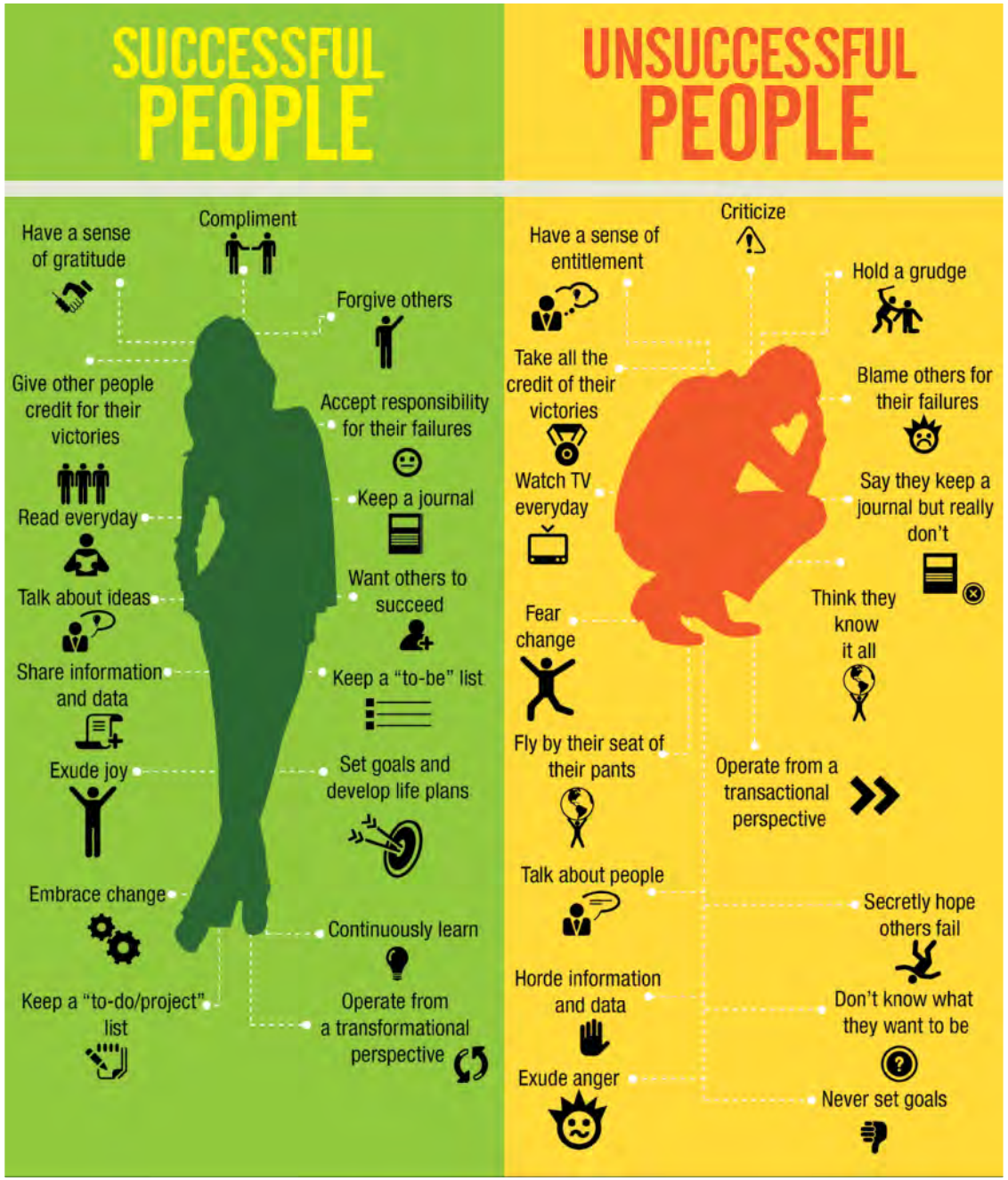
Intended for a **specific** audience

**Self-contained** and discrete

Graphic design aspect is key

Cannot usually be re-used with other data

Can incorporate **unquantifiable** information




IDLEWYLD Sysabee DAVHILL

# DATA VISUALIZATION

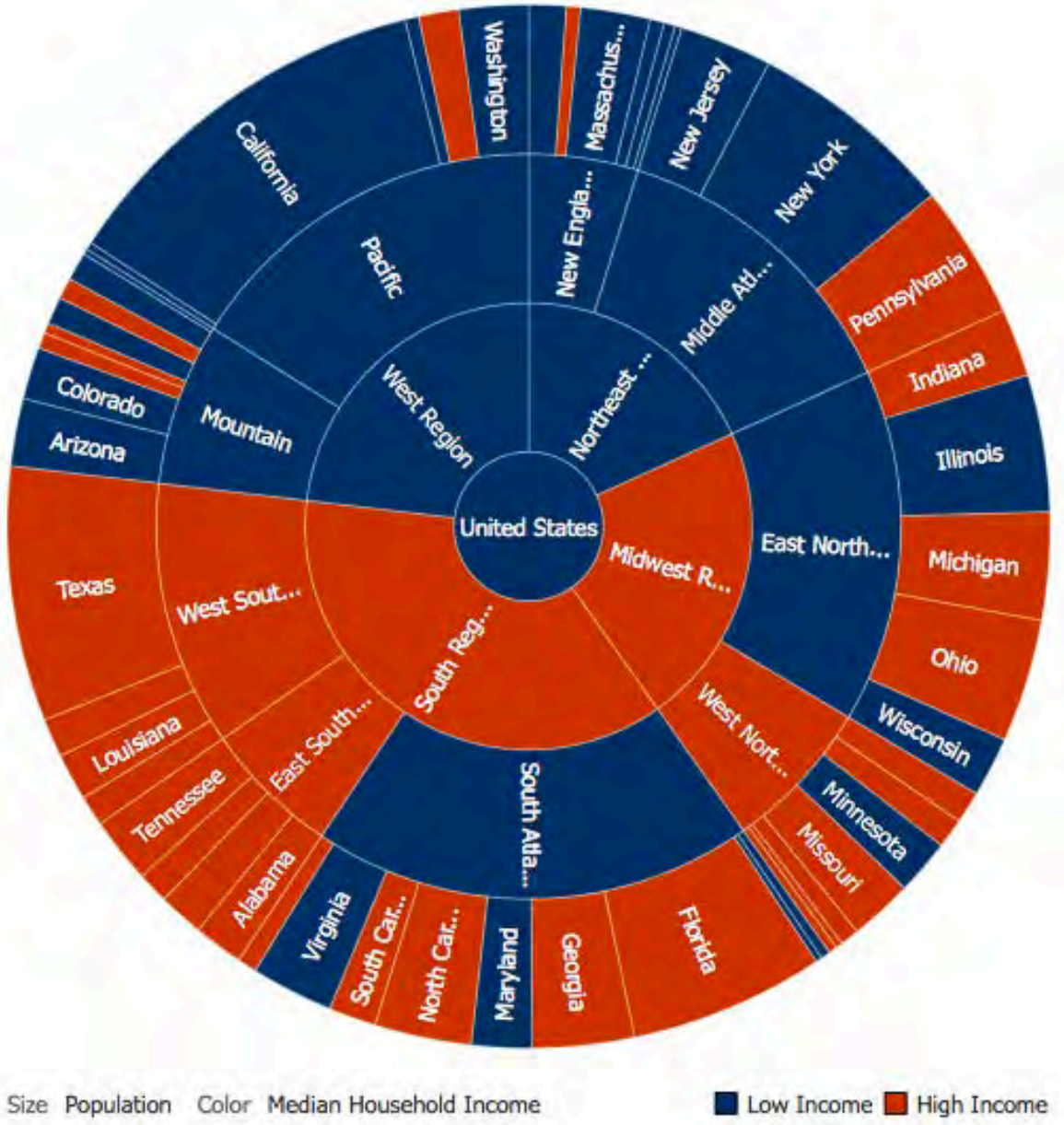
A **method**, as well as an item (**objective**)

Typically focuses on the **quantifiable**

Used to make sense of the data or to make it **accessible** (datasets can be massive and unwieldy)

May be generated automatically

The look and feel are less important than the **insights conveyed** by the data



# DATA UP TO THE 20TH CENTURY

In the 20th century, data problems were mostly related to

- **engineering** (design of machines)
- **sciences** (formulation of theories)

Problems were solved **empirically**, **theoretically**, or through **computation**.

# DATA UP TO THE 20TH CENTURY

Engineers equipped machines with sensors ⇒ used data to assess if the machines behaved as expected & to improve designs.

Scientists set up experiments ⇒ used data to test the validity of theories.

- Experiments are expensive; relatively few data points are generated.

Data contained additional information which is often ignored.

- Example: Mendel's experimental data, analyzed by Fisher, found to be too good to be true.

# DATA IN THE 21ST CENTURY

In the 21st century, there is:

- there is **more data**
- it's mostly **digital**
- it's mostly **observed** (rather than generated by designed experiment)

Problems are solved **empirically**, **theoretically**, through **computation** and/or **data exploration/visualization**.

# DATA IN THE 21ST CENTURY

**Empirically:** observe and describe what happens

**Theoretically:** generalize and build models and generalizations to understand what happens

**Computationally:** design computer simulations to better understand what happens

**Data Exploration/Visualization**: the new approach to understanding

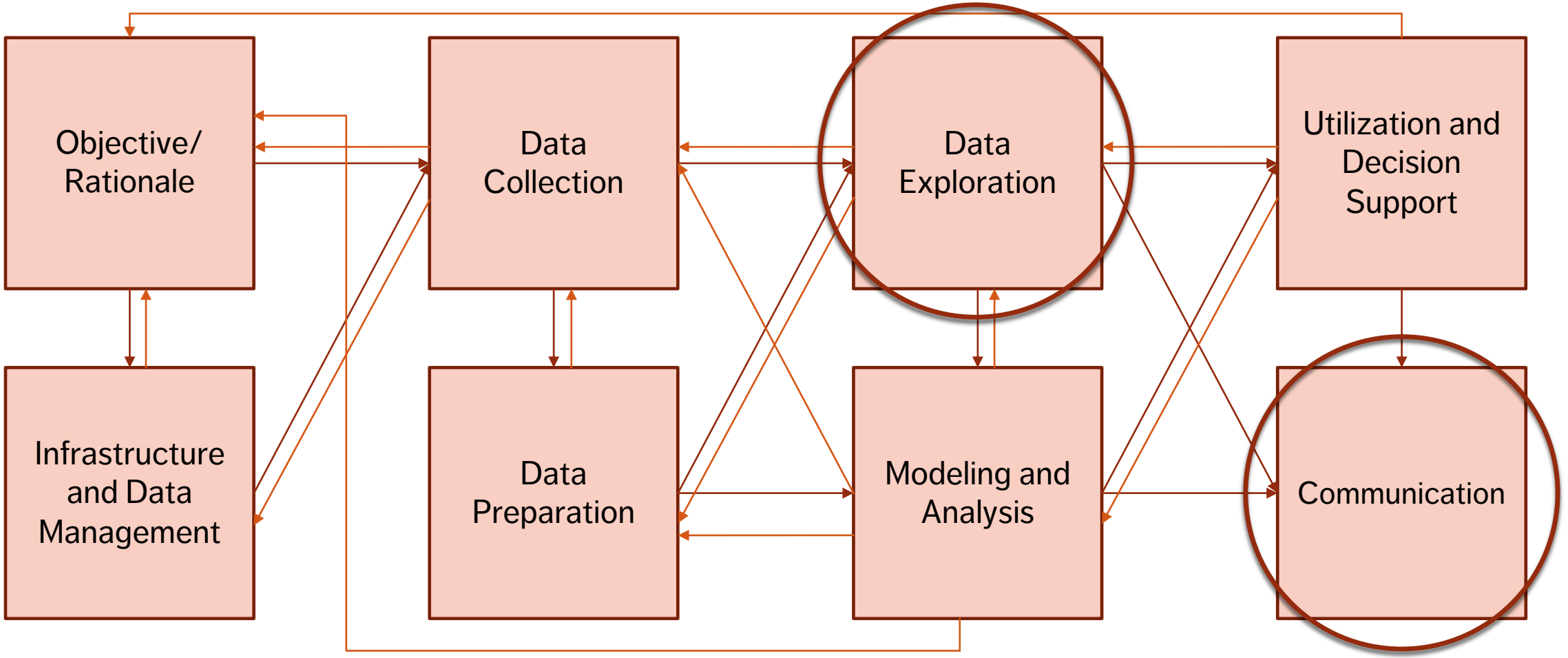
# EXERCISE

In teams or individually, identify a few data visualizations that appeal to you (professionally, esthetically, or both).

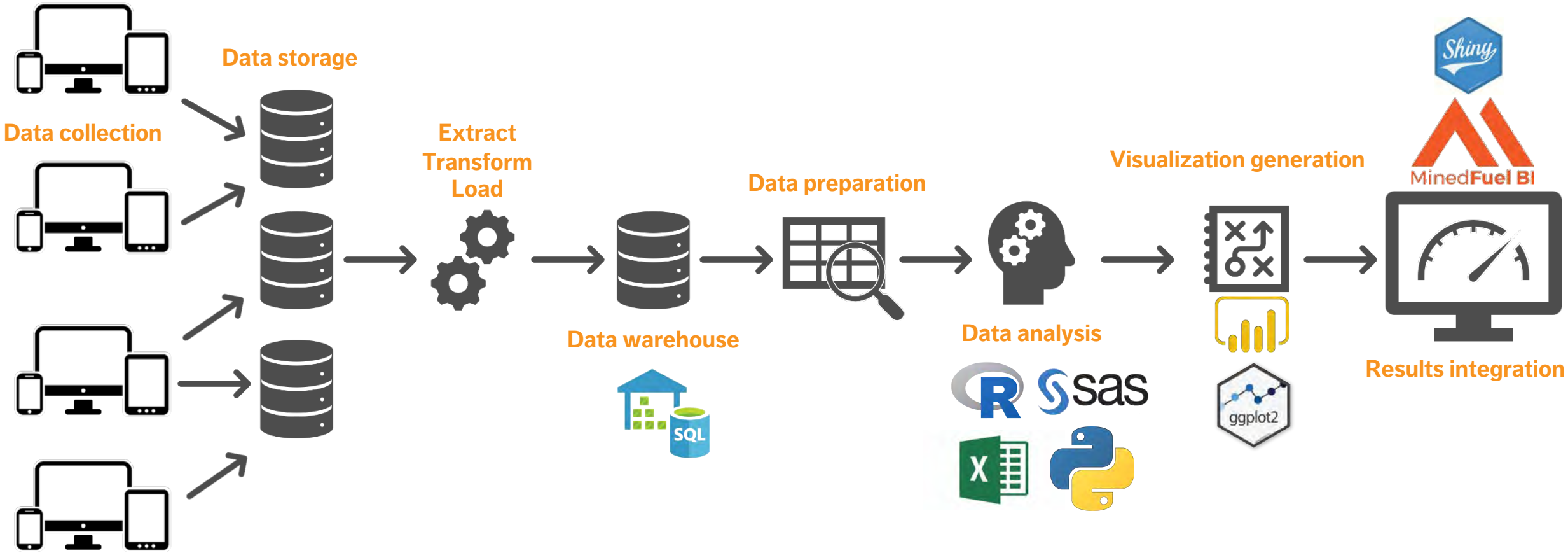
What is the story being told by the visualization?

What kind of data is needed to build these visualizations?

# THE (MESSY) ANALYSIS PROCESS



# DATA ENVIRONMENT




**Visualizations account for only ~10% of the process.**

# EXERCISE

In teams or individually, identify work scenarios for which data visualization could prove useful.

What insight could be drawn from such visualizations?

Would such visualizations get a buy-in from your supervisors/employers?

How much work would be required to get from design to completion? Are the obstacles mostly of a technical nature? Related to data procurement?

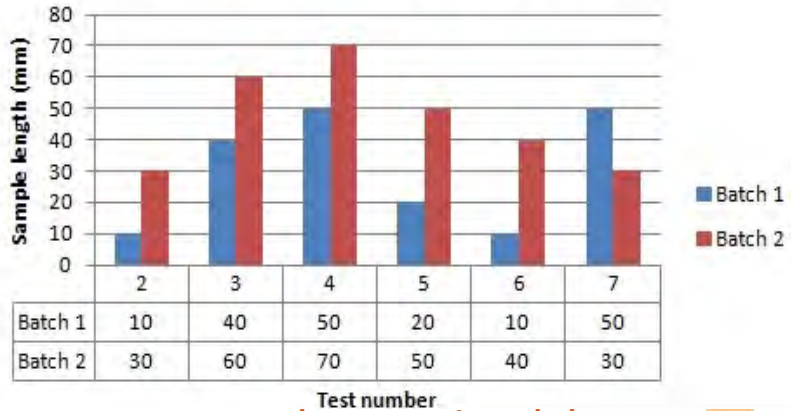
# VISUALIZATION AND DATA EXPLORATION

# OVERVIEW

The past is **data-driven:**

- mostly Excel (or reporting tools like Cognos)
- mostly numbers, tables and non-interactive graphs
- distributed on desktop computers, by email, in PowerPoint presentation
- static, mostly backwards looking (lagging indicators)
- KPIs and dashboards were somewhat contrived

| Region | Jan-06 | Feb-06 | Mar-06 | Apr-06 | May-06 | Jun-06 | Jul-06 |
|---|---|---|---|---|---|---|---|
| **Actuals** | | | | | | | |
| Seattle | 111 | 653 | 1,598 | 3,411 | 3,972 | 5,092 | 5,2 |
| Boise | 26,779 | 27,867 | 29,153 | 30,557 | 33,402 | 35,400 | 35,4 |
| Portland | 33,078 | 34,401 | 37,535 | 39,916 | 41,357 | 45,306 | 46,6 |
| Spokane | 25,417 | 26,669 | 28,092 | 29,020 | 29,674 | 30,501 | 30,8 |
| North Region | **199,841** | **211,053** | **226,789** | **242,957** | **256,605** | **273,640** | **277,7** |
| **Plan** | | | | | | | |
| Seattle | 693 | 468 | 790 | 1,383 | 2,205 | 3,180 | 4,2 |
| Boise | 29,525 | 26,062 | 27,088 | 28,269 | 29,536 | 30,821 | 32,1 |
| Portland | 32,276 | 34,708 | 36,737 | 38,857 | 41,066 | 43,364 | 45,7 |
| Spokane | 30,500 | 26,644 | 27,987 | 29,430 | 30,994 | 32,594 | 34,2 |
| North Region | **191,783** | **203,916** | **216,524** | **230,474** | **246,390** | **263,378** | **281,2** |
| **Variance** | | | | | | | |
| Seattle | -582 | 185 | 808 | 2,029 | 1,767 | 1,912 | 1,0 |
| Boise | -2,746 | 1,805 | 2,064 | 2,288 | 3,866 | 4,578 | 3,2 |
| Portland | 802 | -307 | 798 | 1,059 | 291 | 1,942 | 9 |
| Spokane | -5,082 | 25 | 105 | -410 | -1,320 | -2,093 | -3,3 |

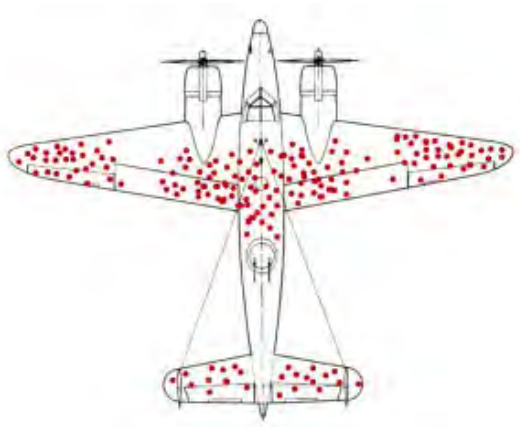


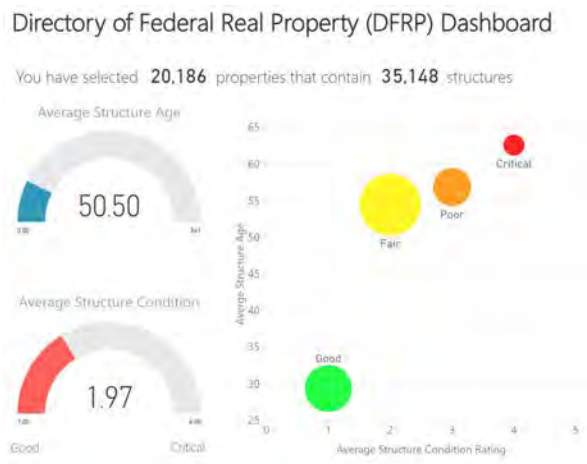
# OVERVIEW

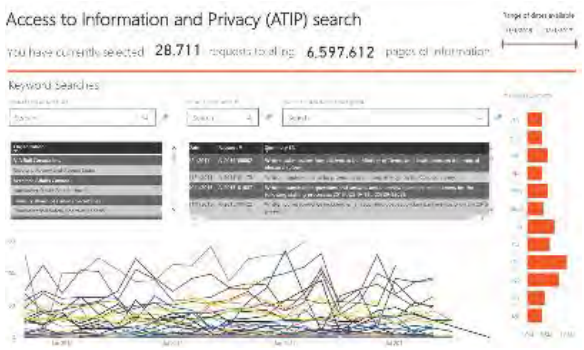
The future is **story-driven:**

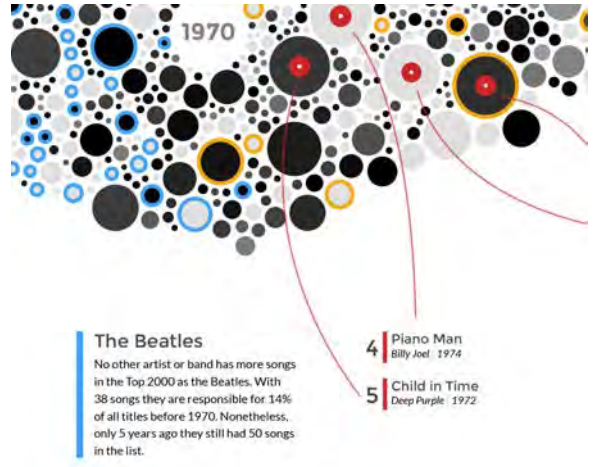
- new tools: Power BI, R, Qlickview etc.
- mostly visualizations, occasional numbers and tables
- distributed on the web (internal and external)
- dynamic and both backwards and forwards looking (leading and lagging indicators)
- data for everyone

# DEFINING CONTEXT






**Seconds** | **Minutes** | **Fraction of Hour** | **Hours**

← **Infographics/Data Viz** →

← **Dashboards** →

← **Reports** →

← **Data Art** →

IDLEWYLD Sysabee DAVHILL

data-action-lab.com

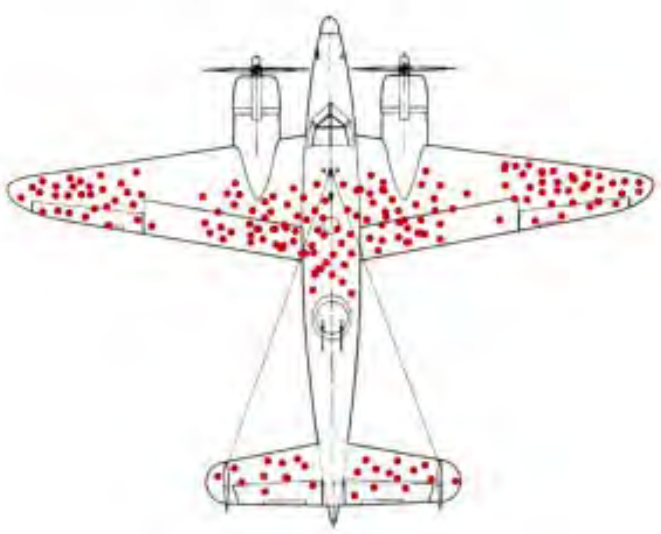
# EXPLORATORY VS. EXPLANATORY ANALYSIS

**Exploratory:** understanding the **DATA** (associated with reports)

**Explanatory:** communicating a **STORY** (associated with dashboards and data viz)


**Exploratory**

vs.



**Explanatory**

# SOME BASIC QUESTIONS

What system does your data represent – objects, attributes, relationships?

**How** does it represent this system – i.e. the data model?

Who made this dataset? When? For what purpose?

Assuming a flat file – what do the rows represent? What do the columns represent?

Do you even have enough information (e.g. **metadata**) to answer these questions? Where can you find more information?

# NON-VISUALIZATION BASED SUMMARIES OF YOUR DATASET

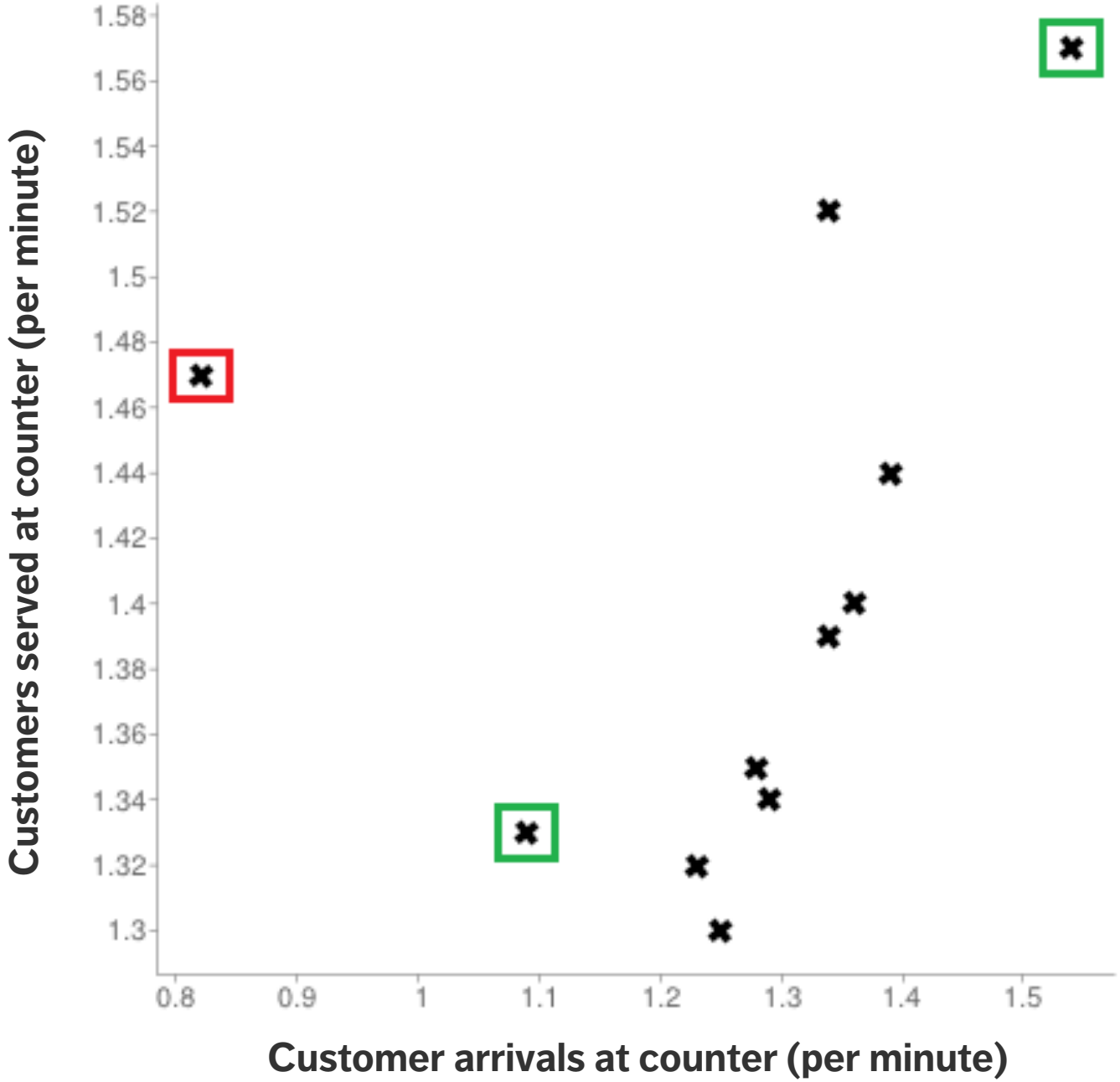
```
       Cl              NO3              NH4
Min.   :  0.222   Min.   : 0.000   Min.   :    5.00
1st Qu.: 10.994   1st Qu.: 1.147   1st Qu.:   37.86
Median : 32.470   Median : 2.356   Median :  107.36
Mean   : 42.517   Mean   : 3.121   Mean   :  471.73
3rd Qu.: 57.750   3rd Qu.: 4.147   3rd Qu.:  244.90
Max.   :391.500   Max.   :45.650   Max.   :24064.00
NA's   :16        NA's   :2        NA's   :2

   season
Length:340
Class :character      autumn spring summer winter
Mode  :character          80     84     86     90
```

# PRE-ANALYSIS USE

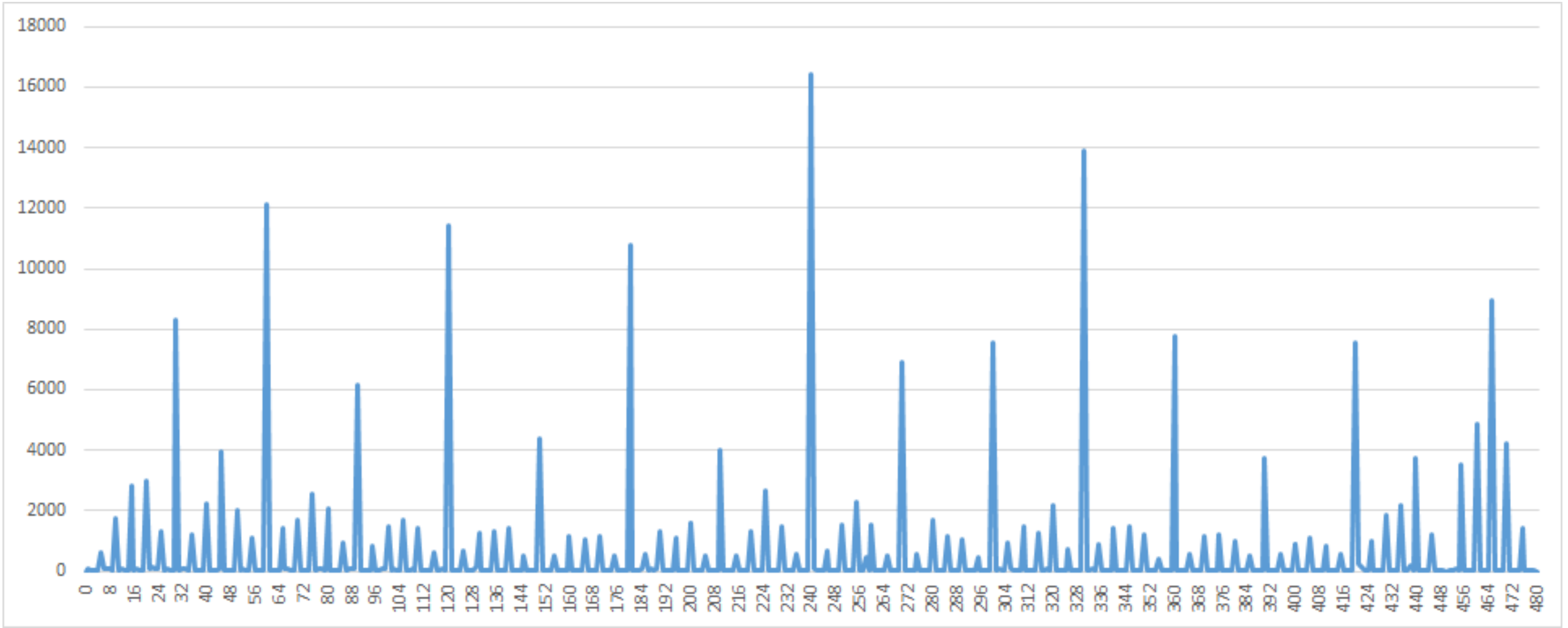
Data visualization can be used to set the stage for analysis:

- **detecting anomalous entries**
  invalid entries, missing values, outliers
- **shaping the data transformations**
  binning, standardization, Box-Cox transformations, PCA-like transformations
- **getting a sense for the data**
  data analysis as an art form, exploratory analysis
- **identifying hidden data structure**
  clustering, associations, patterns informing the next stage of analysis

[Personal dataset]

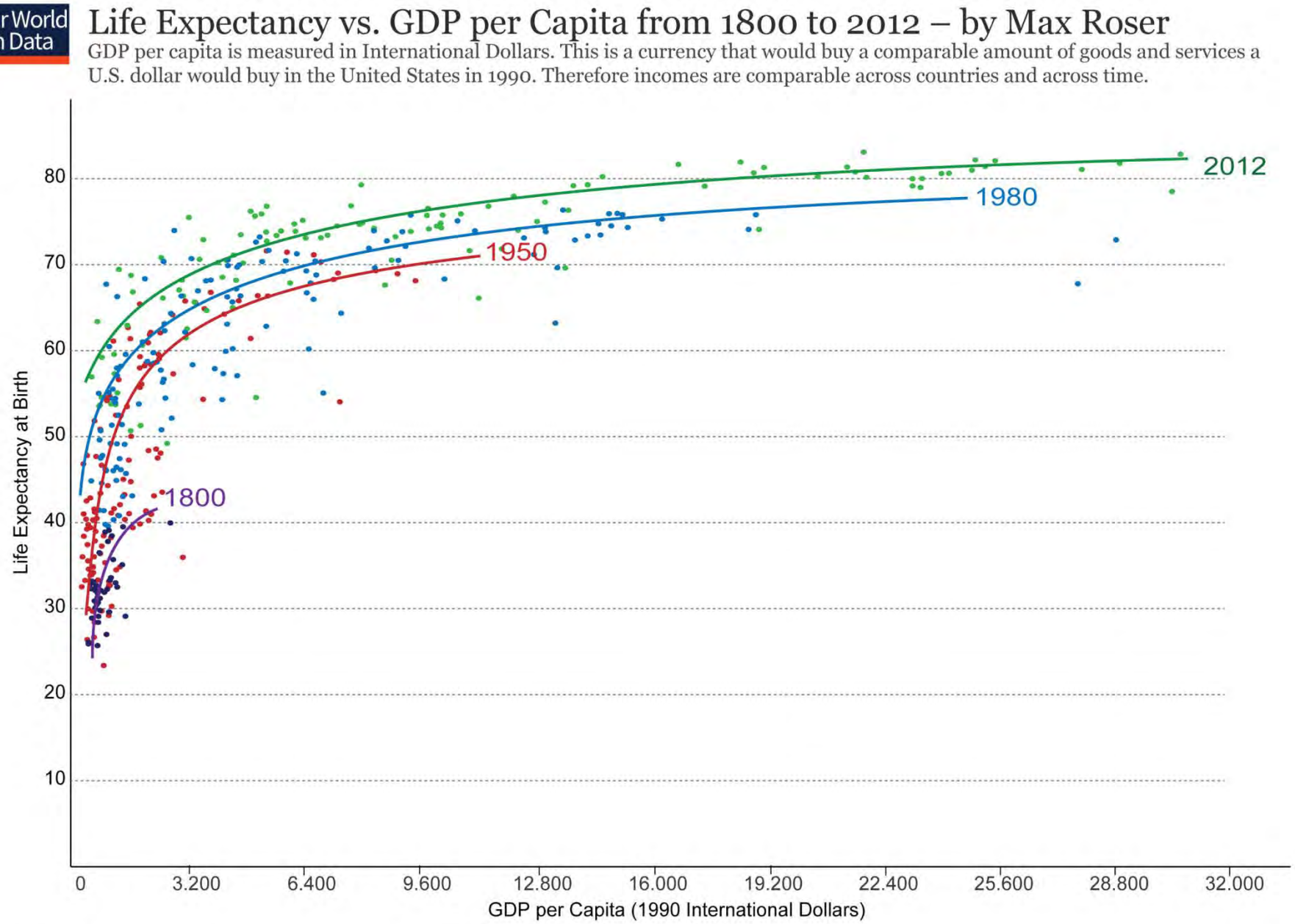


[Personal dataset]




**Self-reported work hours (mins)**

[https://ourworldindata.org/life-expectancy]



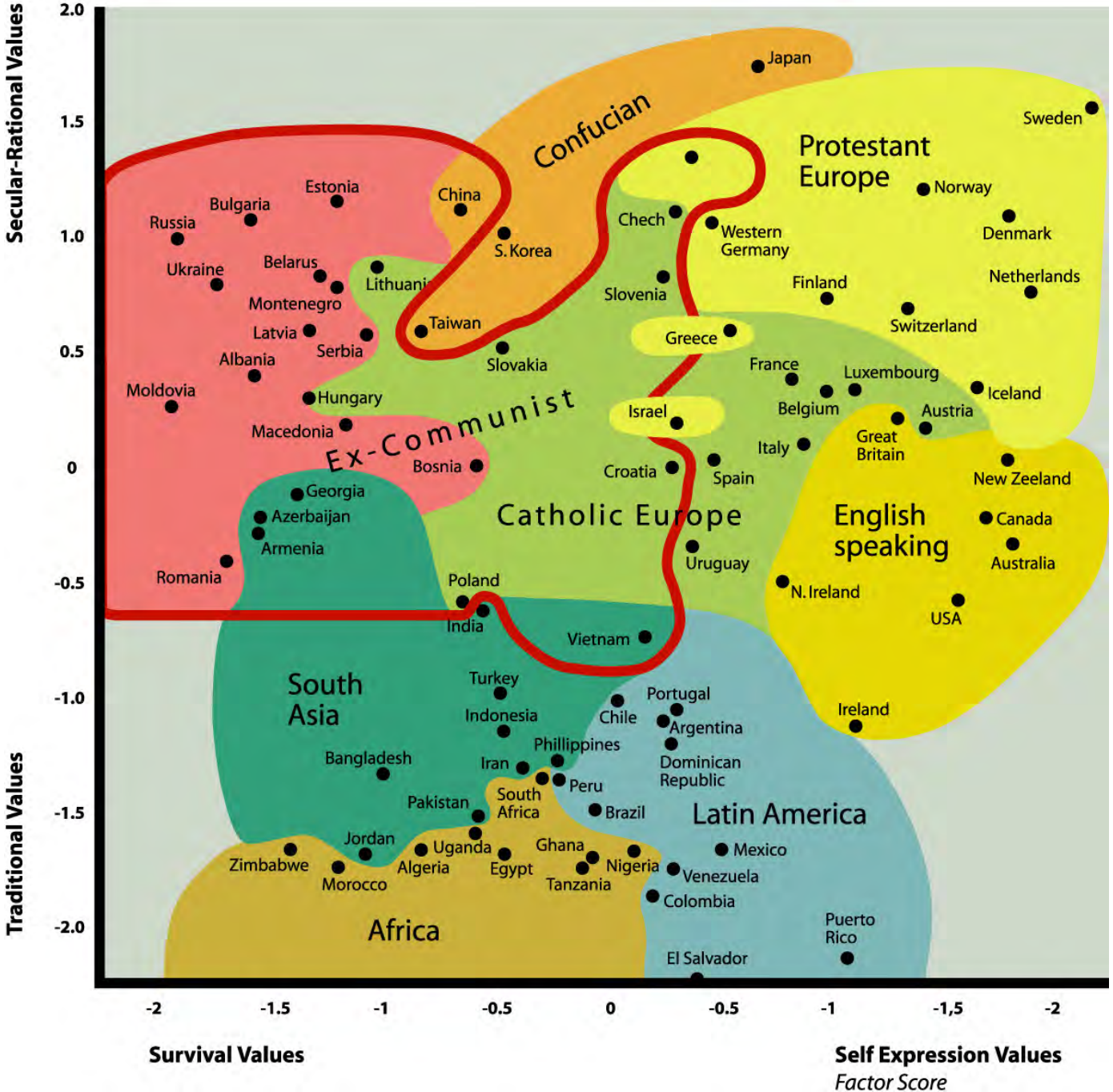

This graph displays the correlation between life expectancy and GDP per capita.

Countries with higher GDP have a higher life expectancy, in general.

The relationship seems to follow a logarithmic trend: the unit increase in life expectancy per unit increase in GDP decreases as GDP per capita increases.

# Inglehart-Welzel's Global Cultural Map (2010-2014)

[https://en.wikipedia.org/wiki/World_Values_Survey]




**Traditional values**
importance of religion, parent-child ties, deference to authority and traditional family values.

**Secular-rational values**
less emphasis on religion, traditional family values and authority.

**Survival values**
emphasis on economic and physical security.

**Self-expression values**
high priority to environmental protection, growing tolerance of foreigners, gays and lesbians and gender equality

# DISCUSSION

Which of the pre-analysis uses of visualization is most relevant to your work?

# BASICS OF DASHBOARDING

# REPORTING AND DEPLOYMENT

An analysis can only be as good as how it is **communicated** and/or **deployed**.

**Crucial Questions:**

- Who is in receipt of the report(s)?
- How are the workflows deployed into production?
- Can data insights be turned into useful policies?

Automatic reporting should be audited and validated **regularly**.

# REPORTING AND DEPLOYMENT

**Communication** should occur at various stages of the project, not solely upon completion:

- keep sponsors / clients aware of broad lines
- technical details may be avoided, but documented nonetheless

**Ideal scenario:** analysis software is also reporting software

- minimizes human error related to cut-and-paste
- removes the need for keeping analysis and reporting separate
- makes sharing the work with other project member easier

Simplify the process further by deploying directly to the Web.

# DISCUSSION

What are your favourite reporting tools?

How much should you test a product before deployment?

What's the cost of deploying a faulty product?

# DASHBOARDS

A **dashboard** is any visual display of data used to monitor conditions and/or facilitate understanding.

**Examples:**

- interactive display that allows people to explore motor insurance claims by city, province, driver age, etc.
- PDF showing key audit metrics that gets e-mailed to a Department's DG on a weekly basis.
- wall-mounted screen that shows call centre statistics in real-time.
- mobile app that allow hospital administrators to review wait times on an hourly- and daily-basis for the current year and the previous year.

# SOME QUESTIONS TO CONSIDER

In a car's dashboard, a small number of **key indicators** (speed, gasoline level, lights, etc.) need to be understood **at a glance**. A dashboard design that does not take these two characteristics under consideration can have catastrophic consequences.

The following questions need to be answered prior to the dashboard being designed:

- Who is the dashboard's **consumer**?
- What **story** does the dashboard tell?
- What data (categories) will be used?
- What will **appear** on the dashboard?
- How can the dashboard **help** the consumer?

[https://www.geckoboard.com/blog/building-great-dashboards-6-golden-rules-to-successful-dashboard-design]

# DASHBOARD DESIGN GUIDELINES

Nick Smith suggests the following 6 Golden Rules:

- **Consider the audience** (who are you trying to inform? does the DG really need to know that the servers are operating at 88% capacity?)
- **Select the right type of dashboard** (operational, strategic/executive, analytical)
- **Group data logically, use space wisely** (split functional areas: product, sales/marketing, finance, people, etc.)
- **Make the data relevant to the audience** (scope and reach of data, different dashboards for different departments, etc.)
- **Avoid cluttering the dashboard** (present the most important metrics only)
- **Refresh your data at the right frequency** (real-time, daily, weekly, monthly, etc. )

[https://dashboard.edmonton.ca]

TRANSPORTATION | LIVABILITY | ENVIRONMENT | URBAN FORM | ECONOMY | FINANCE

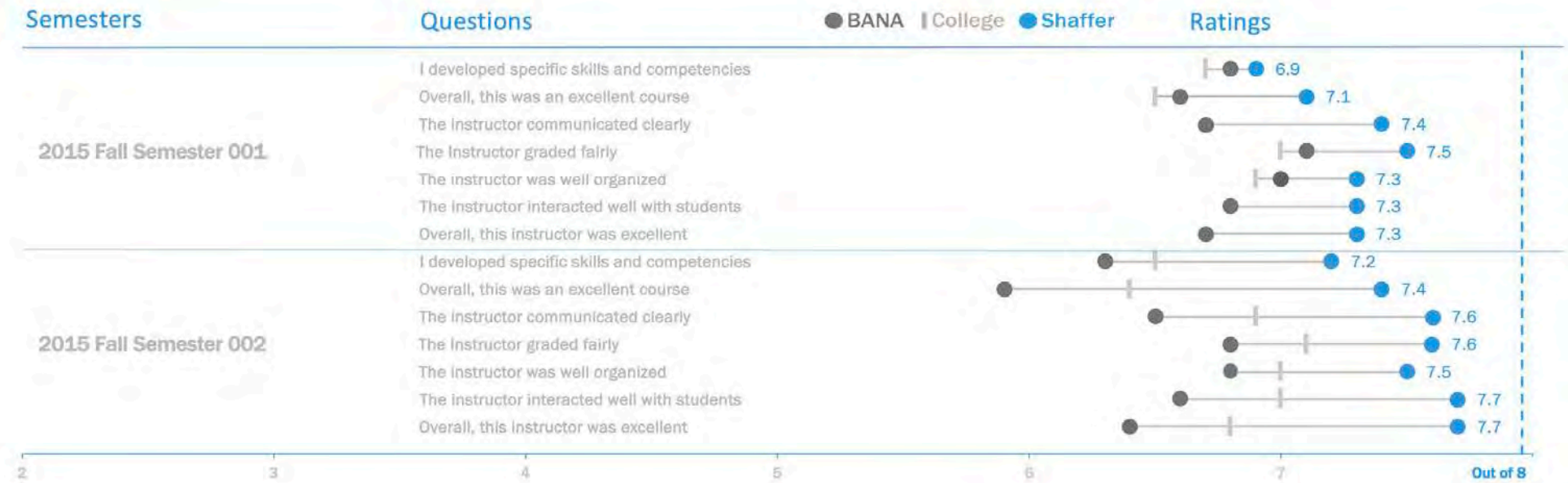

Meets or Exceeds Target | Near Target | Needs Improvement | Measuring | Collecting Data

IDLEWYLD Sysabee DAVHILL

data-action-lab.com

# Course Metrics

[https://bigbookofdashboards.com/dashboards.html]


Course Metrics Dashboard created by Jeffrey A. Shaffer. Data from University of Cincinnati Course Evaluations. Blue indicates the 2 most recent rating periods.

# COURSE METRICS DASHBOARD – STRENGTHS

Easy-to-see key metrics

Simple color scheme

Potential to be static or interactive

Both overview and details are clear

# DISCUSSION

There are no perfect dashboards – no collection of charts will ever suit everyone who encounters it.

All dashboards should be **truthful** and **functional**, but dashboards that are also **elegant** (delightful, enjoyable) will take you further.

All dashboards are **incomplete**. Good dashboards will still lead to dead ends, but they should allow users to ask: “Why? What is the root cause of a problem?”

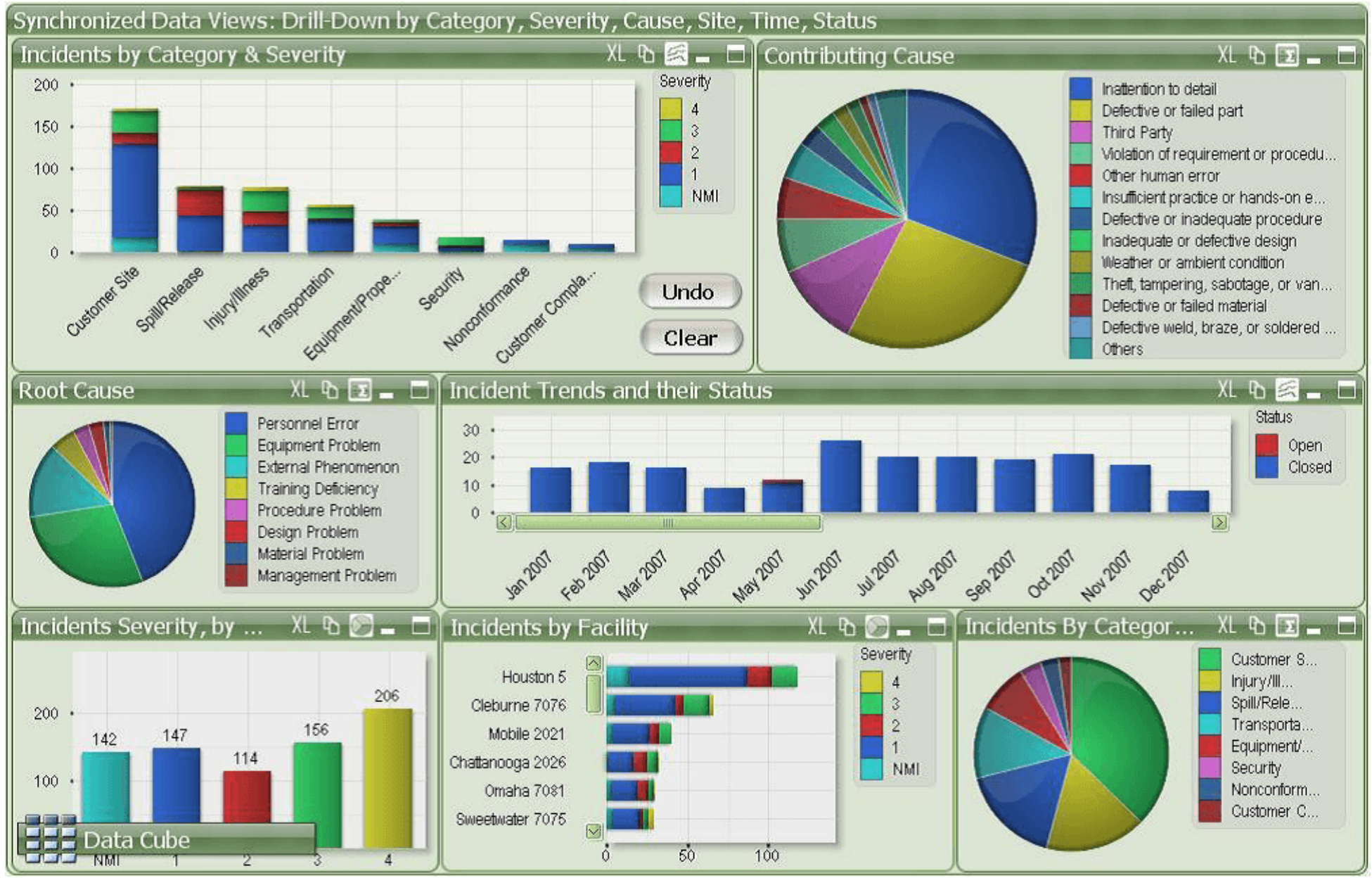
**Tools:** Excel, Power BI, Tableau, R + Shiny, Geckoboard, Matillion, etc.

# EXERCISE

Consider the following dashboards. Can you figure out, at a glance, who their audience is? What are their strengths? What are their limitations?

How could you improve them?

[https://www.matillion.com/wp-content/uploads/2014/11/qlikview-poor-use-of-dashboard-software.png]



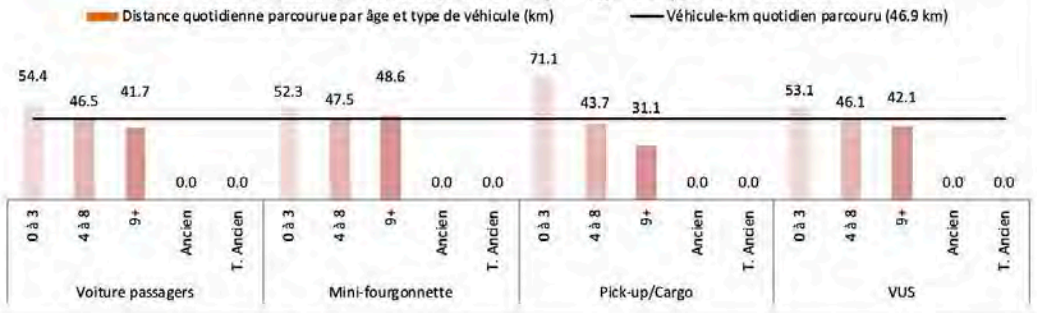
[https://www.geckoboard.com/assets/2-terrible-dashboard-example-min.png]

[Personal file]

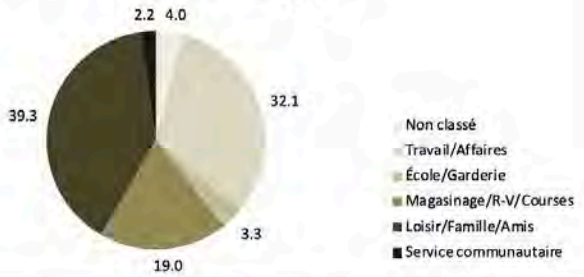
# Ontario – 1er trimestre 2012

## Caractéristiques des déplacements

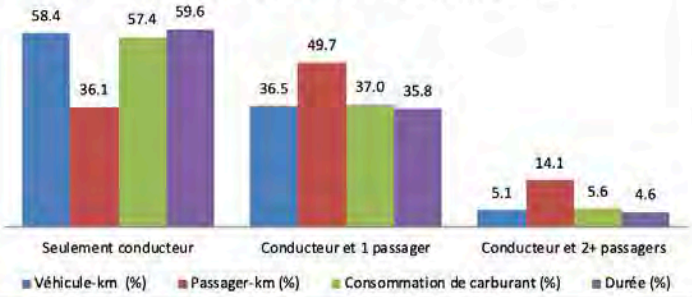
### Véhicule-km quotidien parcouru par âge et type de véhicule



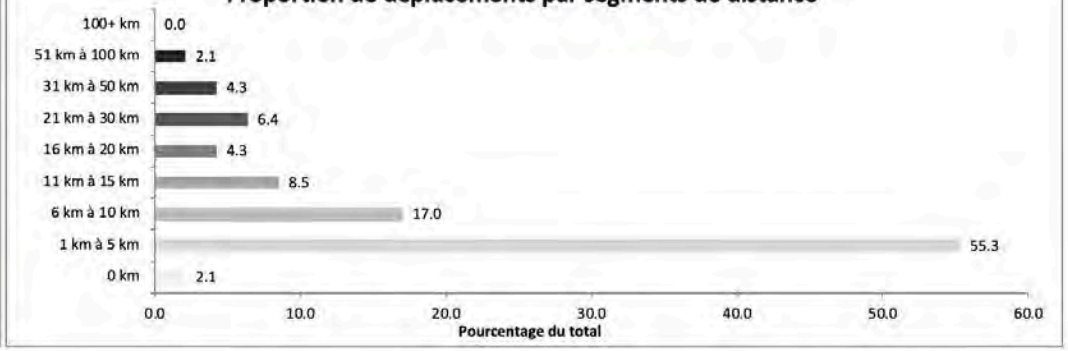

### Passager-km quotidien parcouru par but des déplacements (%)



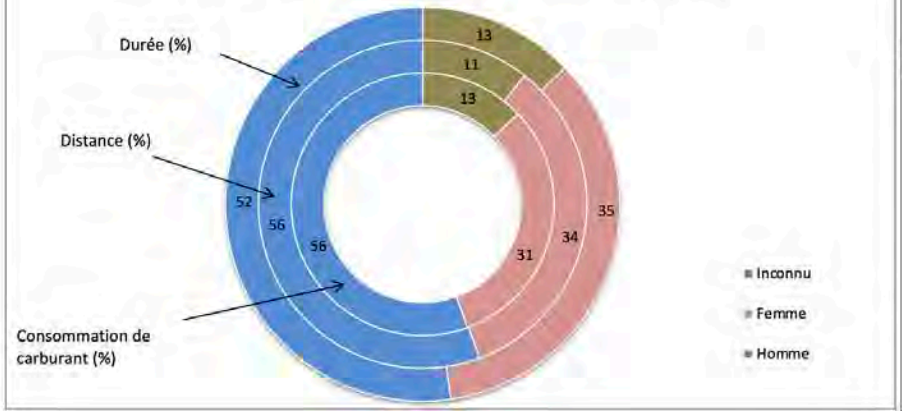

### Distance, passager-km parcouru, durée et consommation de carburant par occupation



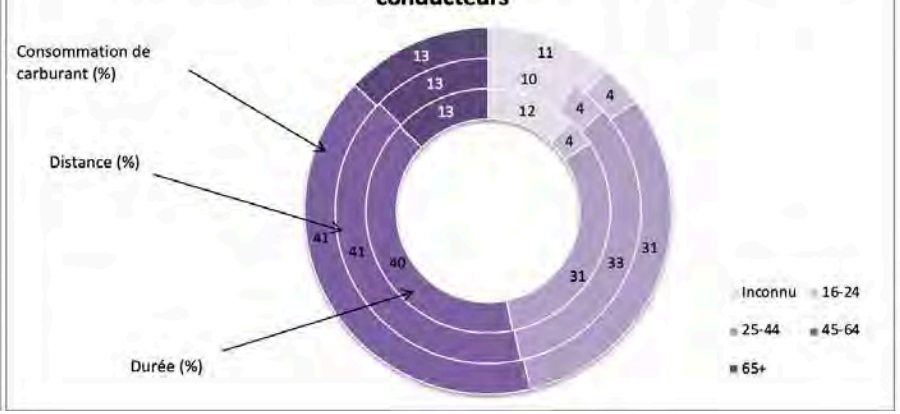

### Proportion de déplacements par segments de distance




### Durée, distance et consommation de carburant par sexe

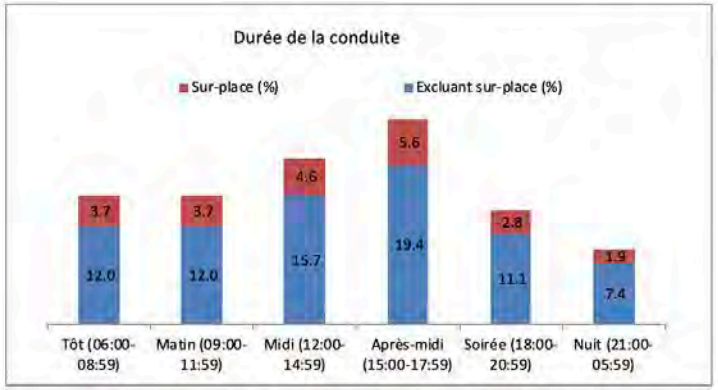


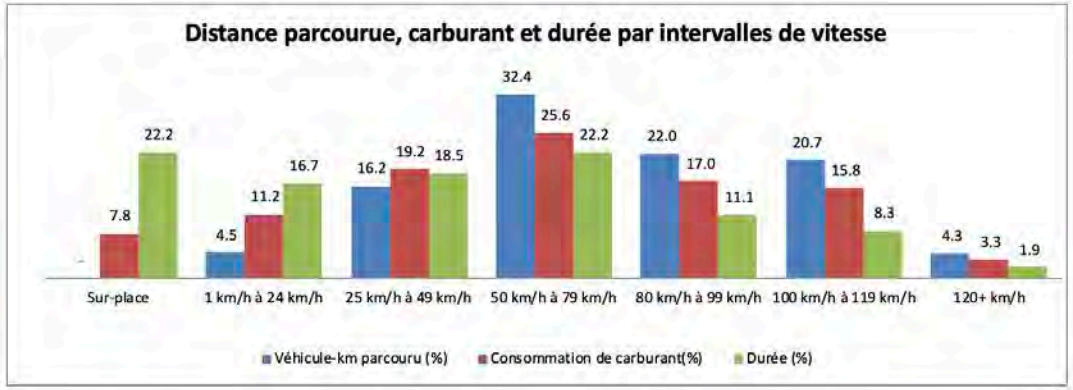

### Consommation de carburant, distance et durée par âge des conducteurs

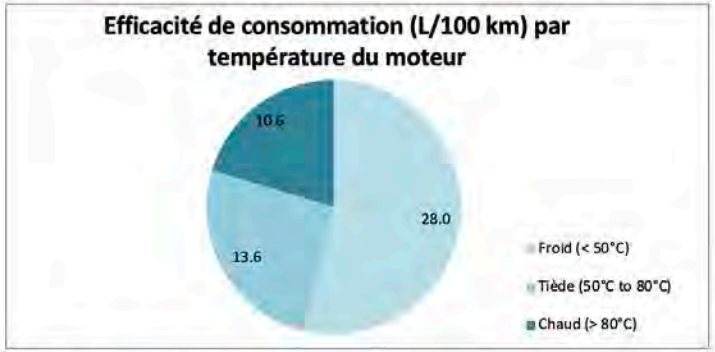


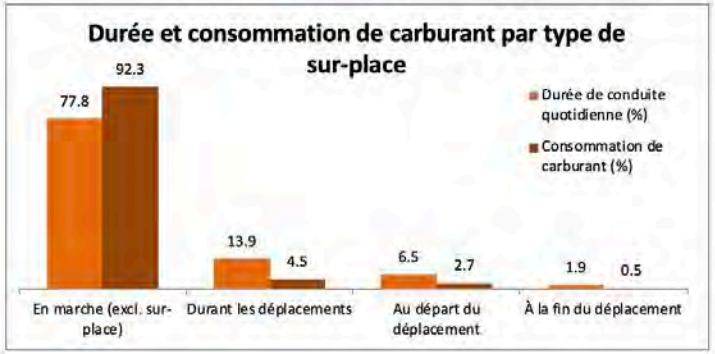
# Ontario – 1er trimestre 2012

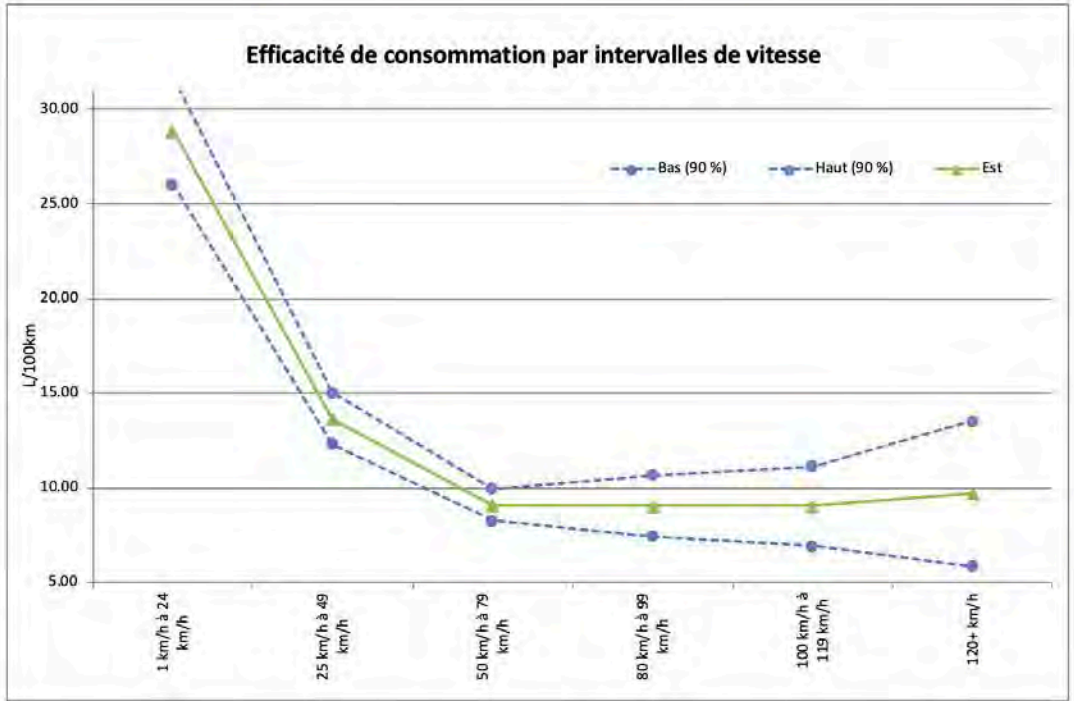
## Sous-caractéristiques des déplacements



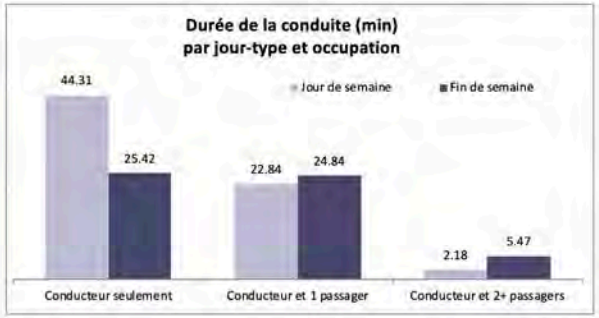



[Personal file]

# Ontario – 1er trimestre 2012

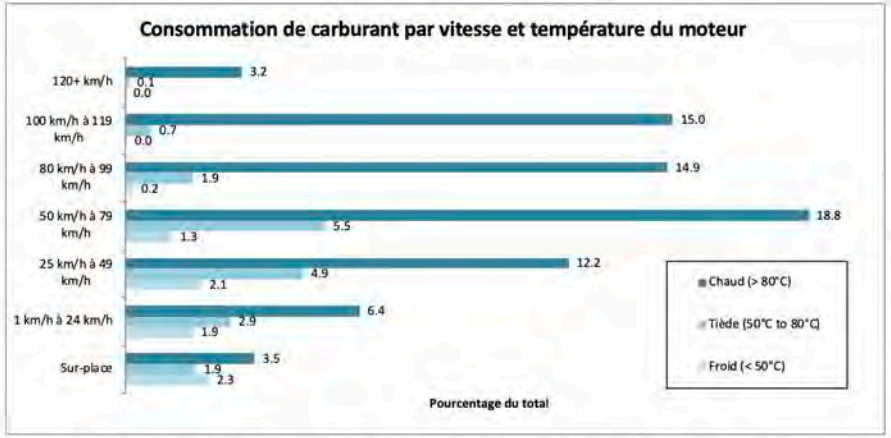
## Caractéristiques mixtes sur les déplacements

### Durée de la conduite (min) par jour-type et occupation

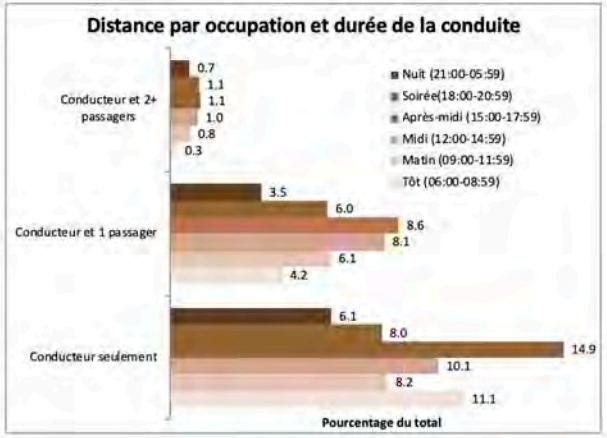



### Durée de la conduite (min) par but et occupation

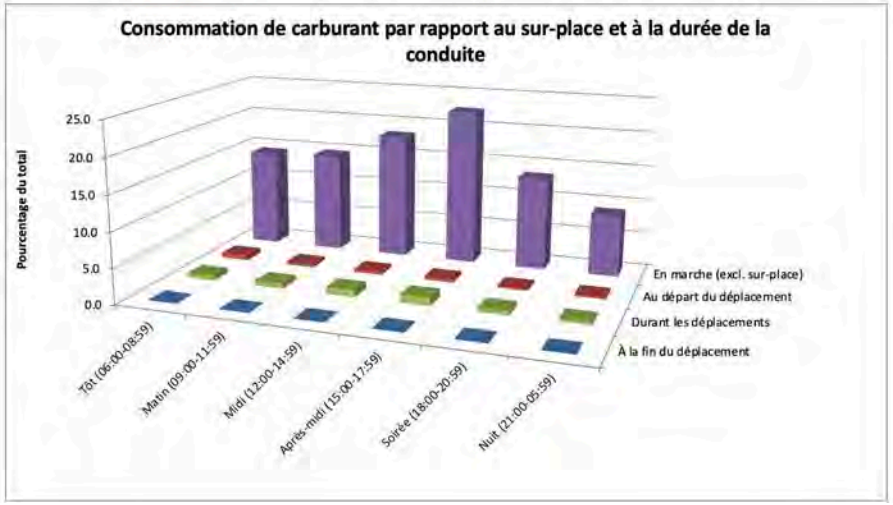

### Consommation de carburant par vitesse et température du moteur




### Distance par occupation et durée de la conduite




### Consommation de carburant par rapport au sur-place et à la durée de la conduite



# LIMITATIONS

Dashboard #1: not glanceable, overuse of colour, pie charts??

Dashboard #2: 3D visualizations, distracting borders and background, lack of filtered data, insufficient labels and context

Dashboards #3: ...

# EXERCISE

In teams or individually, identify a scenario for which a dashboard could prove useful.

Determine specific questions that the dashboard could help answer or insights that it could provide.

Identify data sources and data elements that could be fed into your dashboard.

Design a display (with pen and paper) with mock charts.

What are the strengths and limitations of your dashboard? Is it functional? Elegant?