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INFORMATION
TECHNOLOGY

FIT3179 Data Visualisation

Week 02: Visualisation Analysis & Design I

GROUP OF EIGHT AUSTRALIA

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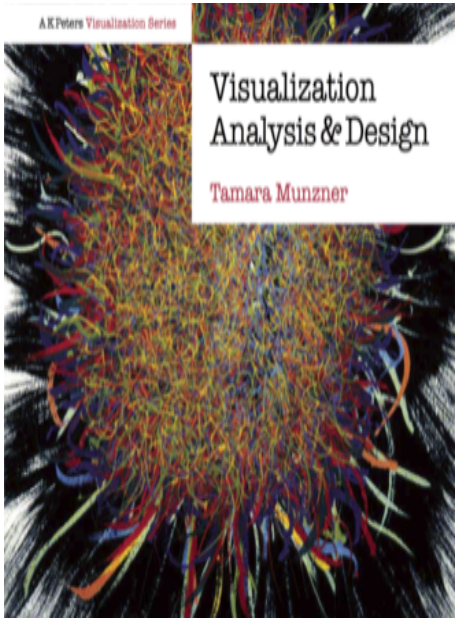
Lecture Overview

- Analysis Framework
  - What? – data abstraction
  - Why? – task abstraction
  - How? – intro to marks and channels
- Five design sheet methodology

Textbook

- For the next four lectures we will be focusing on the early chapters from the text:
  Visualization Analysis & Design
  by Tamara Munzner
- Available to read electronically for *free* from the Monash Library



Defining Visualisation

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Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.

Why have a human in the loop?

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Computer-based visualization systems provide visual representations of datasets designed to **help people carry out tasks more effectively**.

Visualization is suitable when there is a need to augment human capabilities rather than replace people with computational decision-making methods.

Why have a human in the loop?

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Don't need viz when fully automatic solution exists and is trusted

- Many analysis problems ill-specified
  - don't know exactly what questions to ask in advance
- Possibilities
  - long-term use for end users (e.g. exploratory analysis of scientific data)
  - presentation of known results
  - stepping stone to better understanding of requirements before developing models
  - help developers of automatic solution refine/debug, determine parameters
  - help end users of automatic solutions verify, build trust

Why represent all the data?

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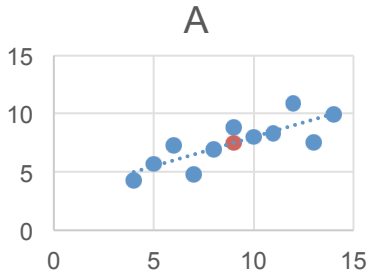
*Computer-based visualization systems provide visual **representations of datasets** designed to help people carry out tasks more effectively.*

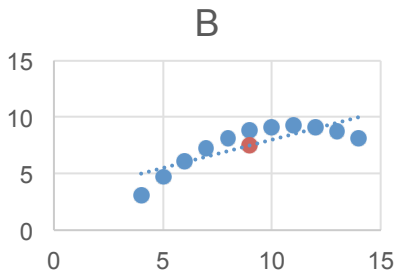
- summaries lose information, details matter
  - confirm expected and find unexpected patterns
  - assess validity of statistical model

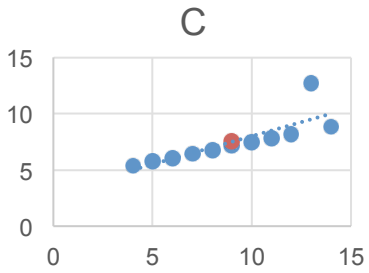
Anscomb's Quartet

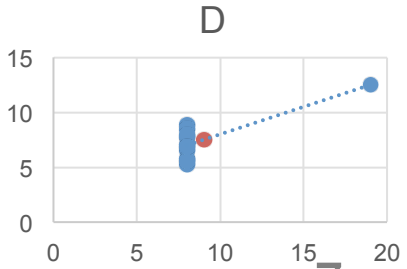
Dataset A		Dataset B		Dataset C		Dataset D	
X	Y	X	Y	X	Y	X	Y
10	8.04	10	9.14	10	7.46	8	6.58
8	6.95	8	8.14	8	6.77	8	5.76
13	7.58	13	8.74	13	12.74	8	7.71
9	8.81	9	8.77	9	7.11	8	8.84
11	8.33	11	9.26	11	7.81	8	8.47
14	9.96	14	8.1	14	8.84	8	7.04
6	7.24	6	6.13	6	6.08	8	5.25
4	4.26	4	3.1	4	5.39	19	12.5
12	10.84	12	9.13	12	8.15	8	5.56
7	4.82	7	7.26	7	6.42	8	7.91
5	5.68	5	4.74	5	5.73	8	6.89

mean	9	7.500	9	7.500	9	7.500	9	7.500
variance	11	4.127	11	4.127	11	4.127	11	4.127
x/y correlation		0.816		0.816		0.816		0.816
regression gradient		0.500		0.500		0.500		0.500

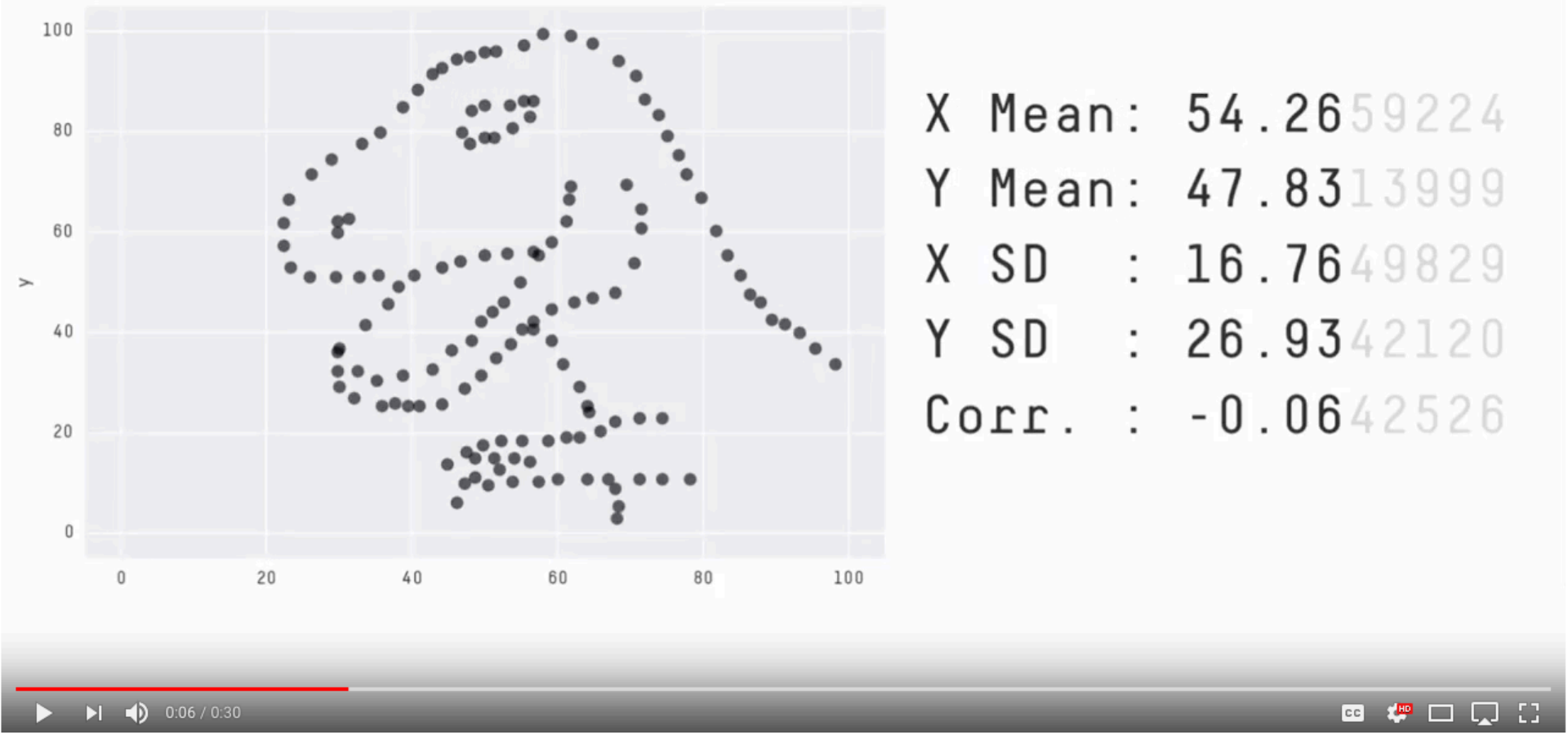








Why represent all the data?



https://youtu.be/It4UA75z_KQ

Matejka, J. and Fitzmaurice, G. 2017. Same Stats, Different Graphs: Generating Datasets with Varied Appearance and Identical Statistics through Simulated Annealing. CHI '17.

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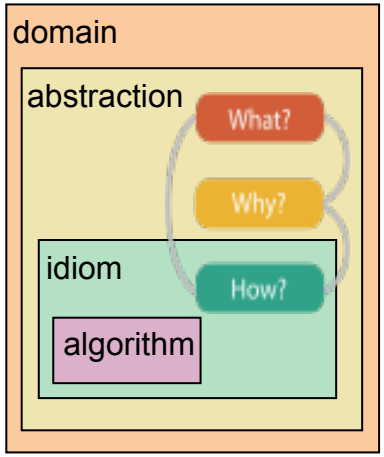
Analysis framework: Four levels, three questions

Textbook chapter 4

Analysis framework: Four levels, three questions

- *Domain: a field of interest of the users*
  - *domain-specific vocabulary, data and workflows*
  - who are the target users?
- *Task and data abstraction*
  - translate from specifics of domain to vocabulary of vis
  - **what** is shown? **Data abstraction**
    - often don't just draw what you're given: transform to new form
  - **why** is the user looking at it? **Task abstraction** from domain-specific to generic task
- *Idiom for visual encoding and interaction*
  - **how** is it shown?
    - **visual encoding idiom**: how to draw
    - **interaction idiom**: how to manipulate
- *Algorithm*
  - efficient computation



A Multi-Level Typology of Abstract Visualization Tasks
Brehmer and Munzner. IEEE TVCG 19(12):2376–2385, 2013.

Textbook chapter 2

Data Attributes

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Attribute Types

- Categorical
- Ordered
  - *Ordinal*
  - *Quantitative*

Ordering Direction

- Sequential
- Diverging
- Cyclic

VAD pg. 32

Dataset Types

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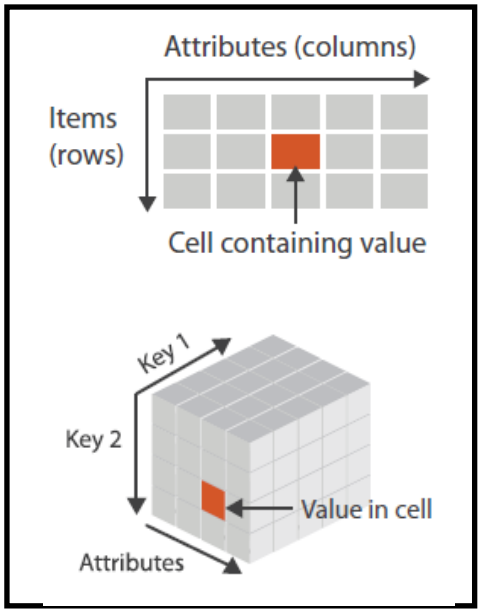
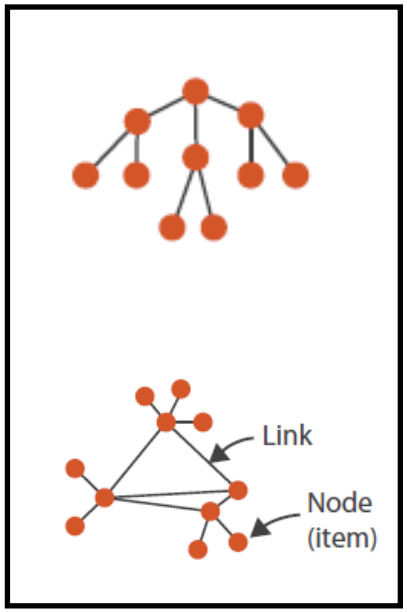
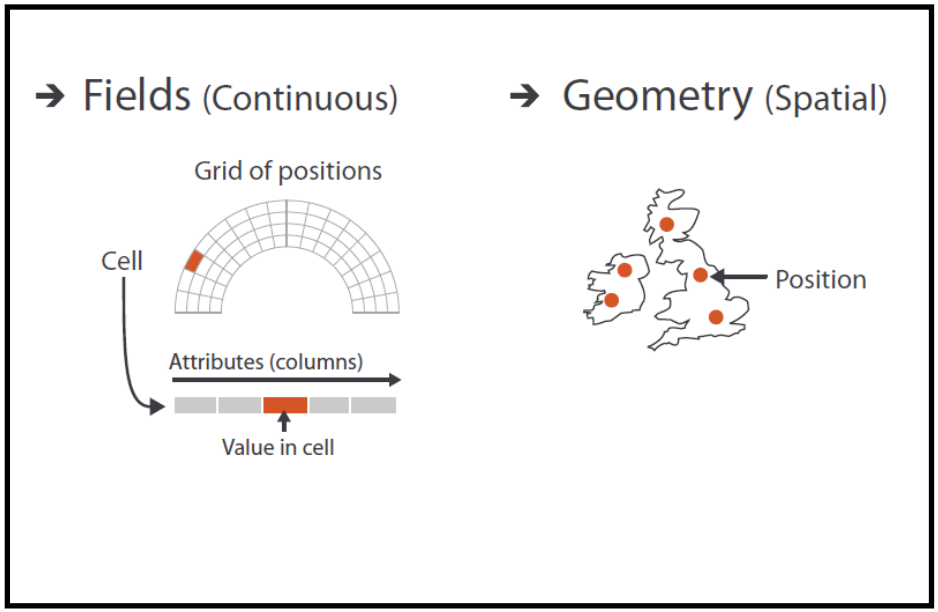
Tables



Trees & Networks



Spatial



Network synonyms
network = graph
node = vertex
link = edge

Uniform grid: implicit geometry and topology
A grid cell can have one or more attributes.
Scalar field: 1 attribute per cell.
Vector field: 2 or more attributes with a direction
Tensor field: many attributes per cell.

A geometry item (point, line or area) can have attributes.

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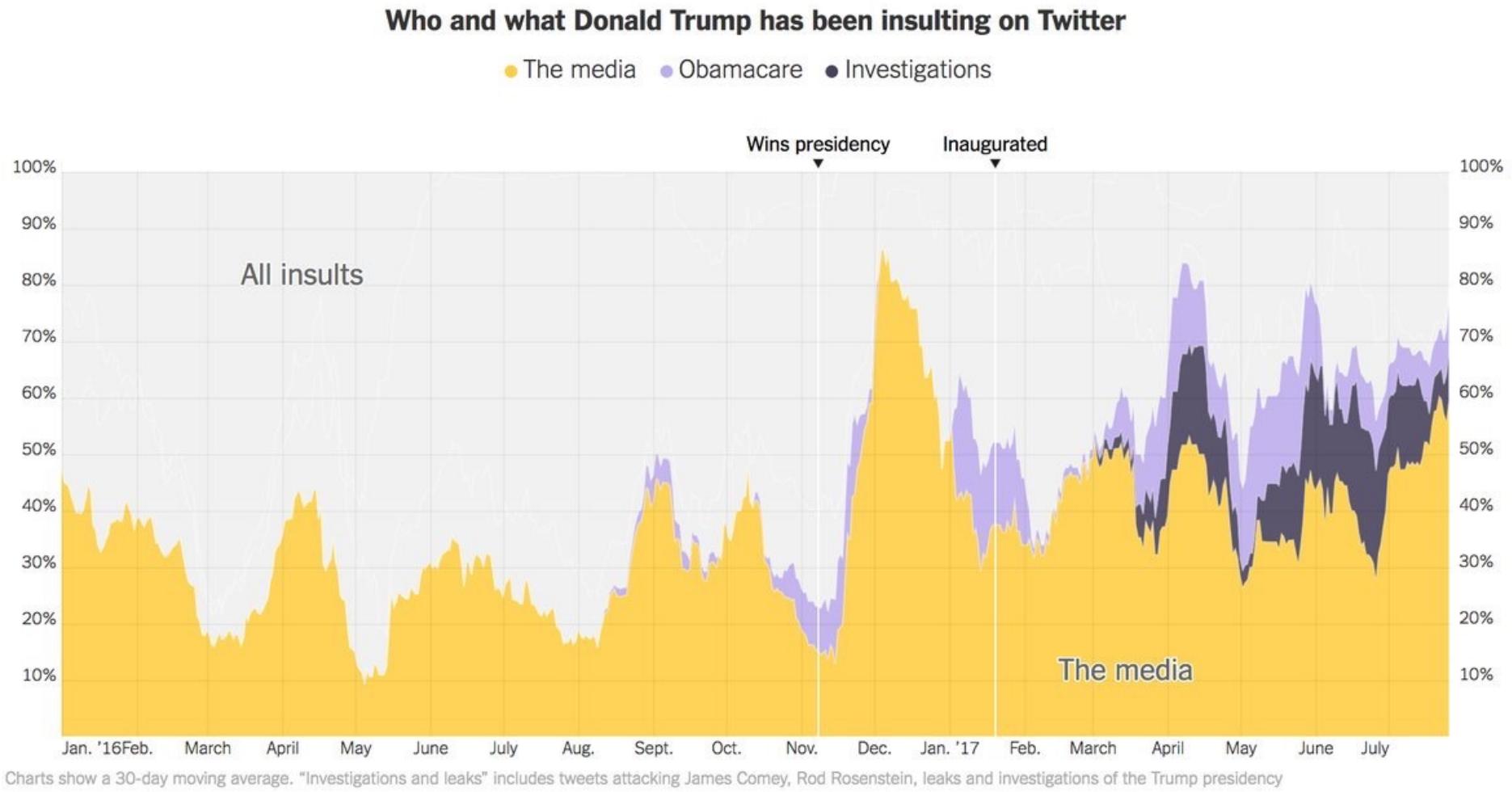
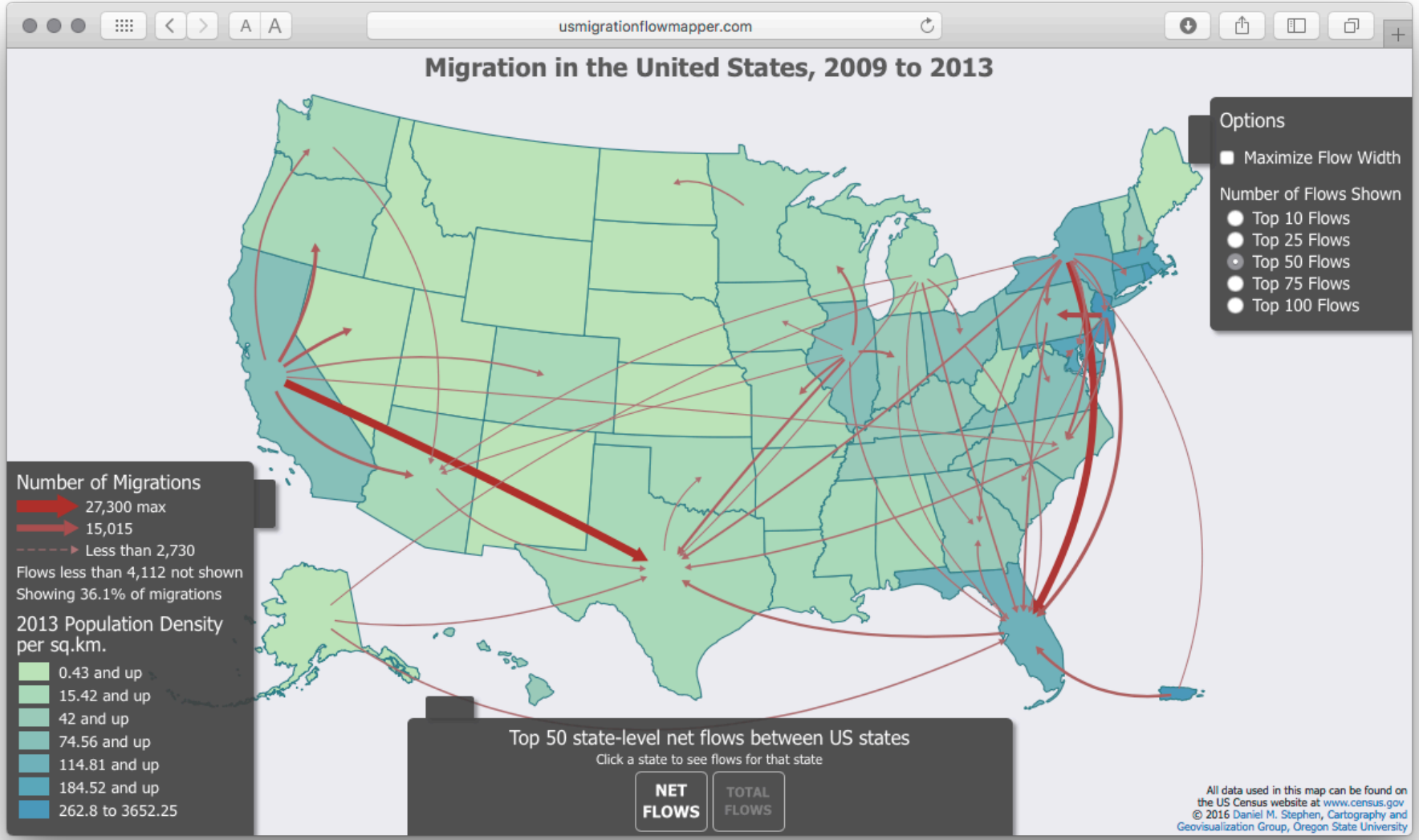
Dataset type? Attribute type?



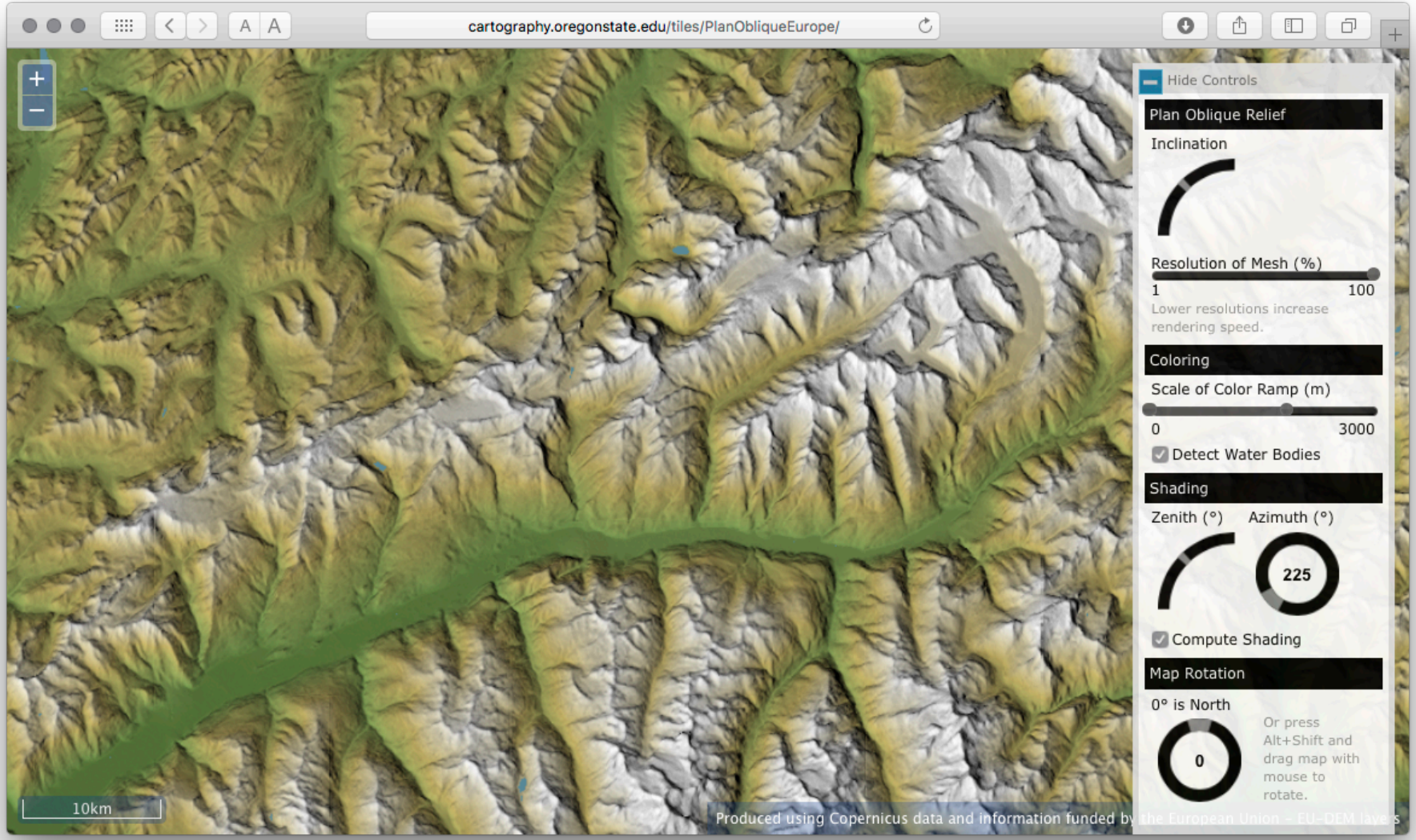
Source: New York Times, 26 July 2017
https://www.nytimes.com/interactive/2017/07/26/upshot/president-trumps-newest-focus-discrediting-the-news-media-obamacare.html

Dataset type? Attribute type?



Source: *http://usmigrationflowmapper.com*

Dataset type? Attribute type?



Source: http://cartography.oregonstate.edu/tiles/PlanObliqueEurope/

Dataset type? Attribute type?

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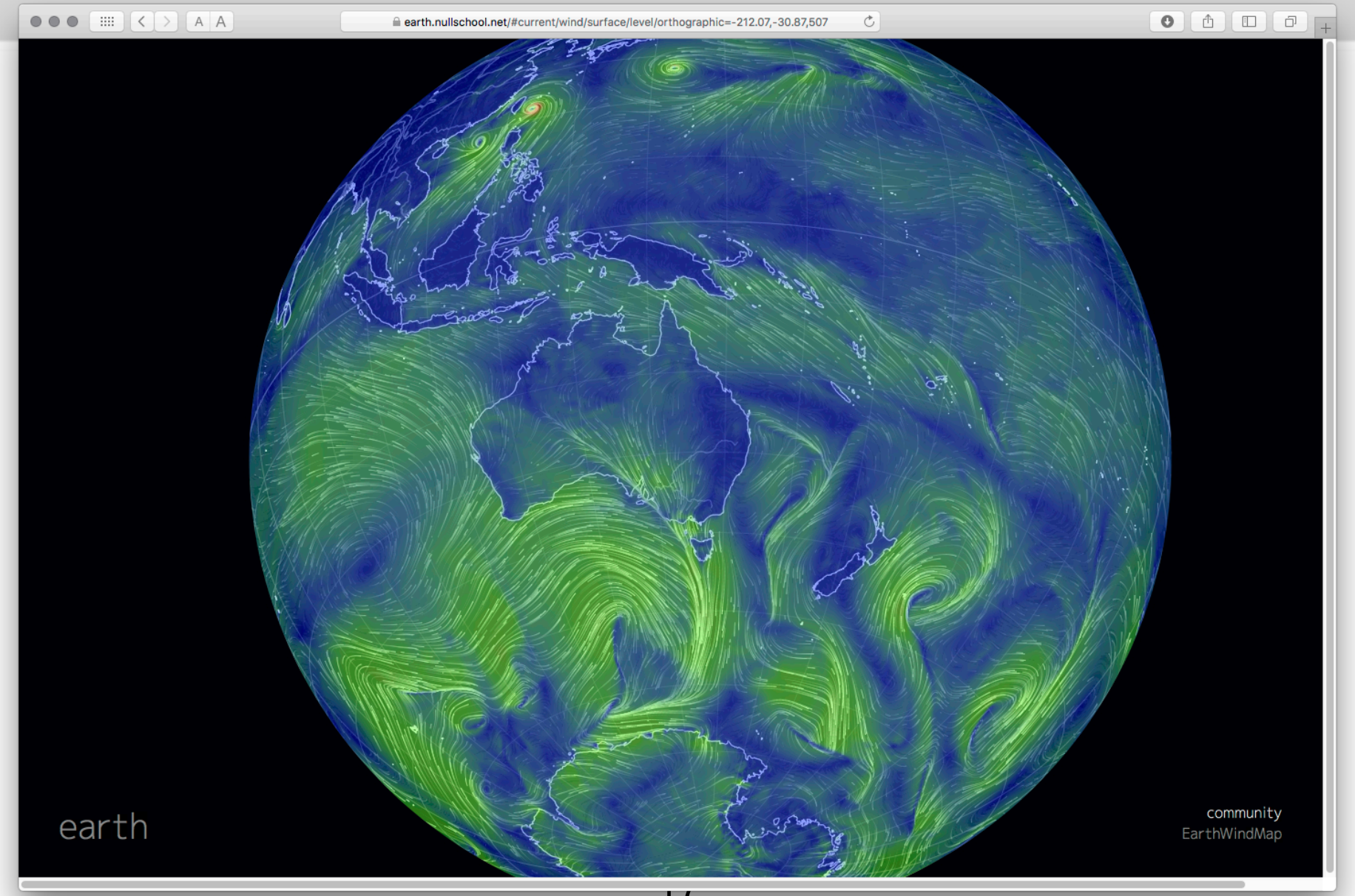
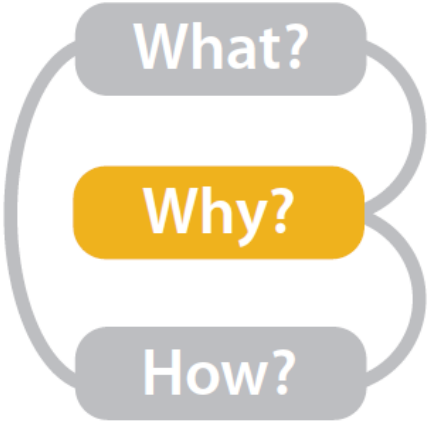


Source: https://earth.nullschool.net

Why?



Textbook chapter 3

Why?

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Actions

Analyze

- Consume
  - Discover
  - Present
  - Enjoy
- Produce
  - Annotate
  - Record
  - Derive

Search

	Target known	Target unknown
Location known	Lookup	Browse
Location unknown	Locate	Explore

Query

- Identify
- Compare
- Summarize

Targets

All Data

- Trends
- Outliers
- Features

Attributes

- One
  - Distribution
  - Extremes
- Many
  - Dependency
  - Correlation
  - Similarity

Network Data

- Topology
- Paths

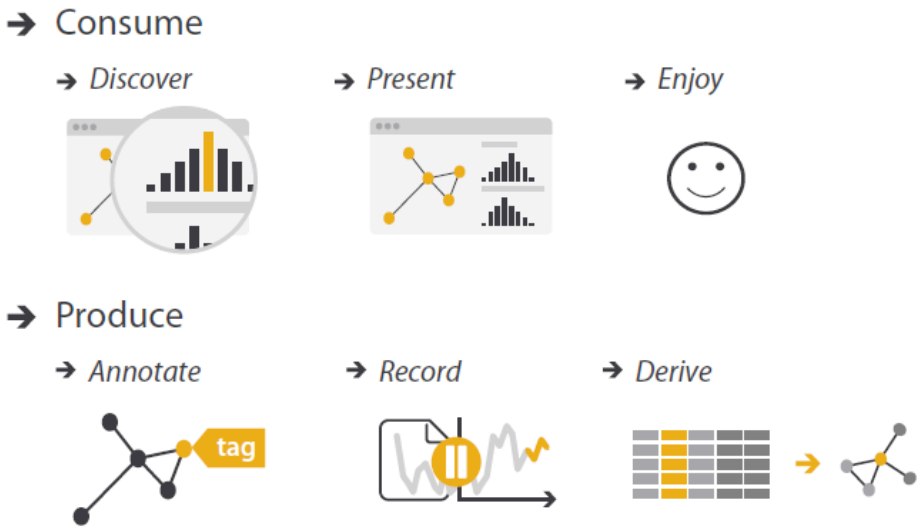
Spatial Data

- Shape

VAD pg. 42

Why? Actions > Analyse

- Analyse > Consume
  - Discover vs. present
    AKA: explore vs. explain
  - Enjoy
    - AKA casual, social
    - AKA storytelling
- Analyse > Produce
  - Annotate, record
  - Derive/transform
    - Crucial design choice



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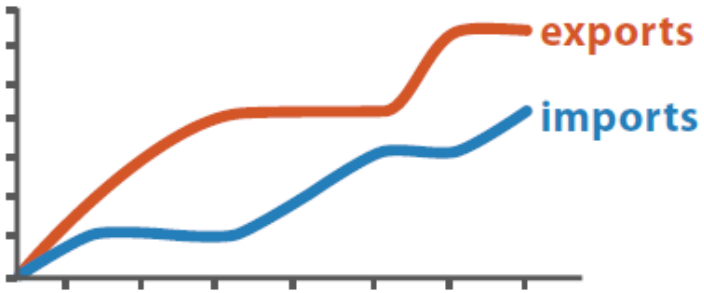
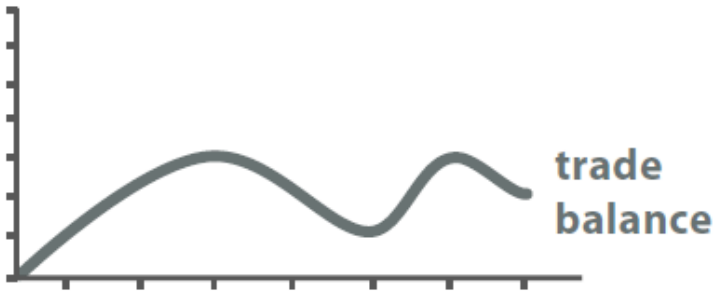
- Don't just draw what you are given
  - Decide what is the right thing to show
  - Create it with a series of transformations from the original dataset
  - Draw that
- One of the main strategies for handling complexity



Original Data



trade balance = exports – imports

Derived Data

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- what does the user know?
  - target, location
- how much of the data matters?
  - one, some, all
- independent choices for each of these three levels
  - analyze, search, query
  - mix and match

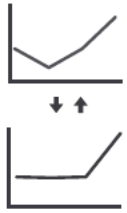
Search

	Target known	Target unknown
Location known	Lookup	Browse
Location unknown	Locate	Explore

Query

→ Identify

→ Compare



→ Summarize

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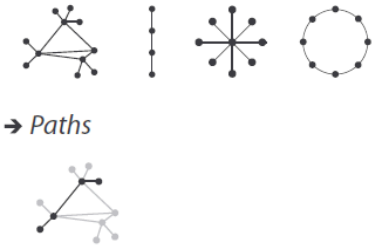
Why? Targets

Target: some aspect of the data that is of interest to the user.

- **All Data**
  - Trends
  - Outliers
  - Features

- **Attributes**
  - One
    - *Distribution*
    - *Extremes*
  - Many
    - *Dependency*
    - *Correlation*
    - *Similarity*

- **Network Data**
  - Topology
    - *Paths*



- **Spatial Data**
  - Shape

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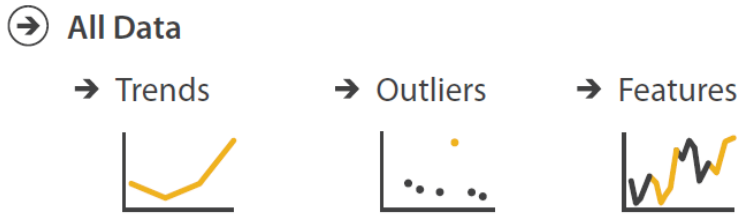
Why? Targets



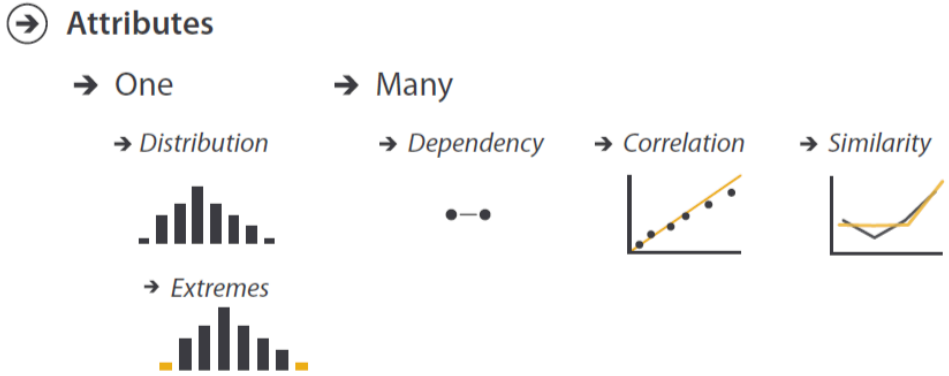
Trend: increases, decreases, peaks, etc.

Outlier: data not aligning with trend

Feature: task dependent

VAD pg. 56

Why? Targets



Attribute = property that can be visually encoded.

Dependency: values of first attribute directly depend on second attribute.

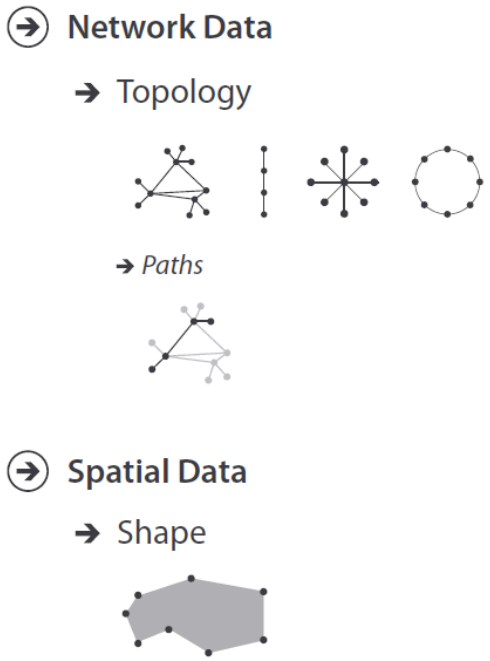
Correlation: tendency of first attribute to be tied to second attribute.

Similarity: quantitative measure of all values of two attributes.

VAD pg. 56

Why? Targets

Topology examples: adjacency of two nodes, shortest path between two nodes, number of connected edges, etc.



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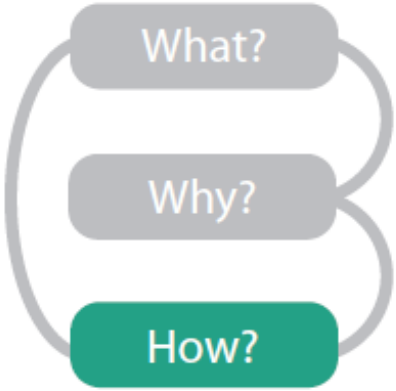
How?



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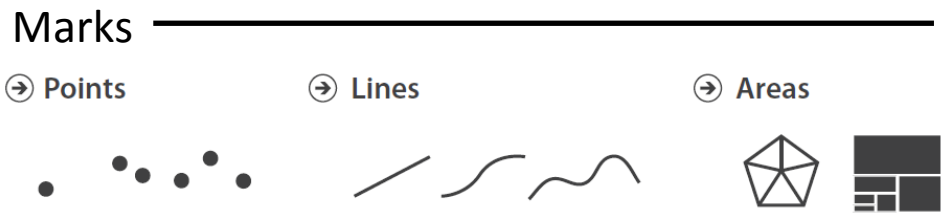
How? Marks and Channels

- Marks
  - Geometric primitives
- Channels
  - Control appearance of marks
  - Can redundantly code with multiple channels



?

Group work:
How can we vary the appearance of marks to encode quantitative and qualitative data? Compile a list of channels.

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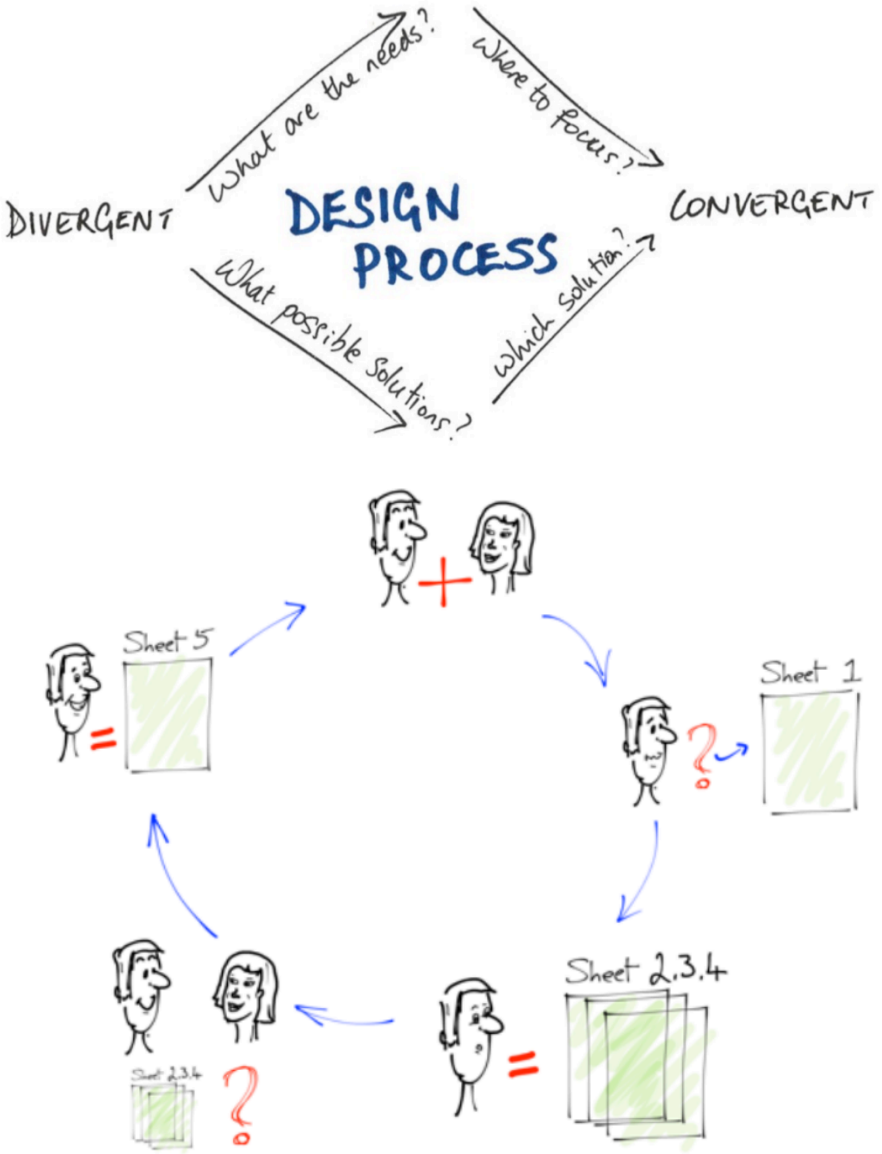
Five Design Sheet Methodology

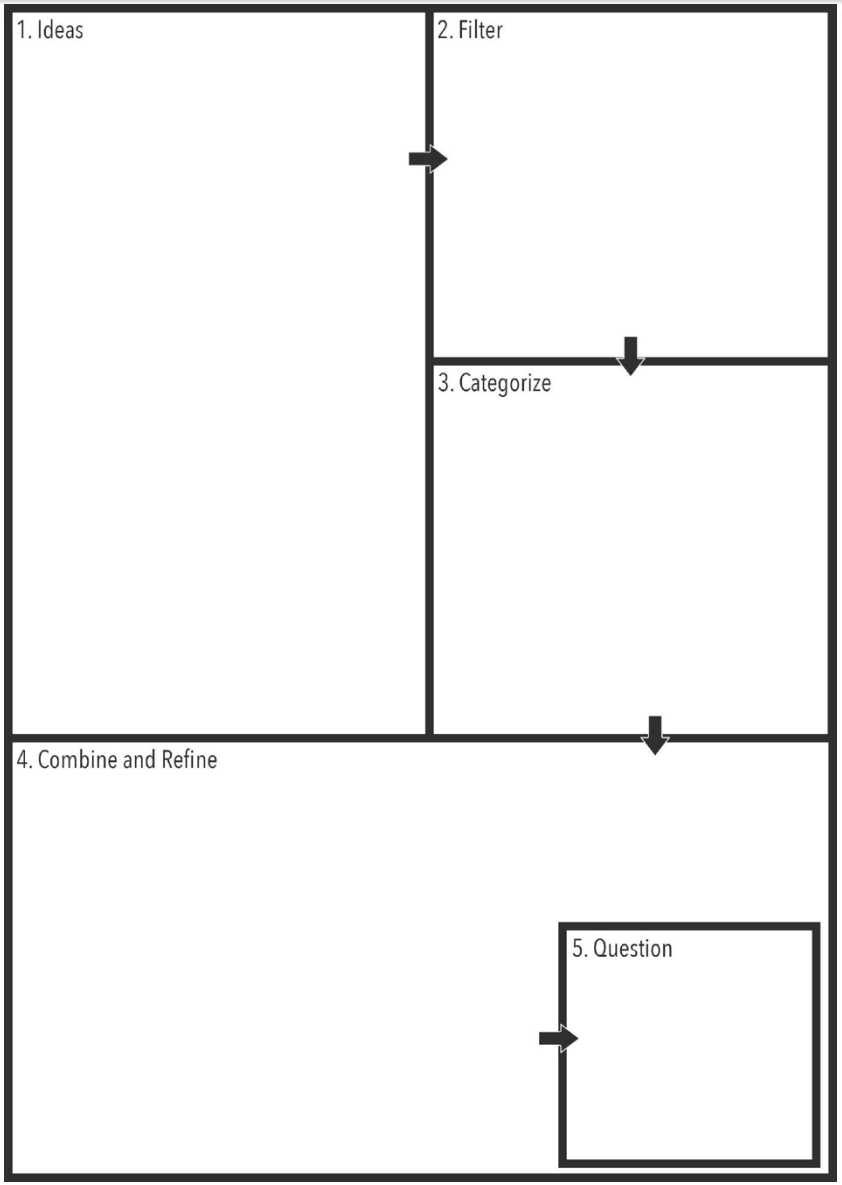
Five Design Sheet Methodology Goals

- The FDS methodology helps us structure our approach to ideation.
- It encourages us to freely, yet systematically explore a design space before converging on a solution.



Five Design Sheet Methodology
Sheet 1 - Brainstorm

1. Sketch and draw as many ideas as you can think of
2. Remove duplication
3. Group similar ideas: sticky notes on a wall are helpful for this
4. Mini-ideas → bigger solutions… perhaps one system with multiple views?
5. Does this solution satisfy the *Why*?



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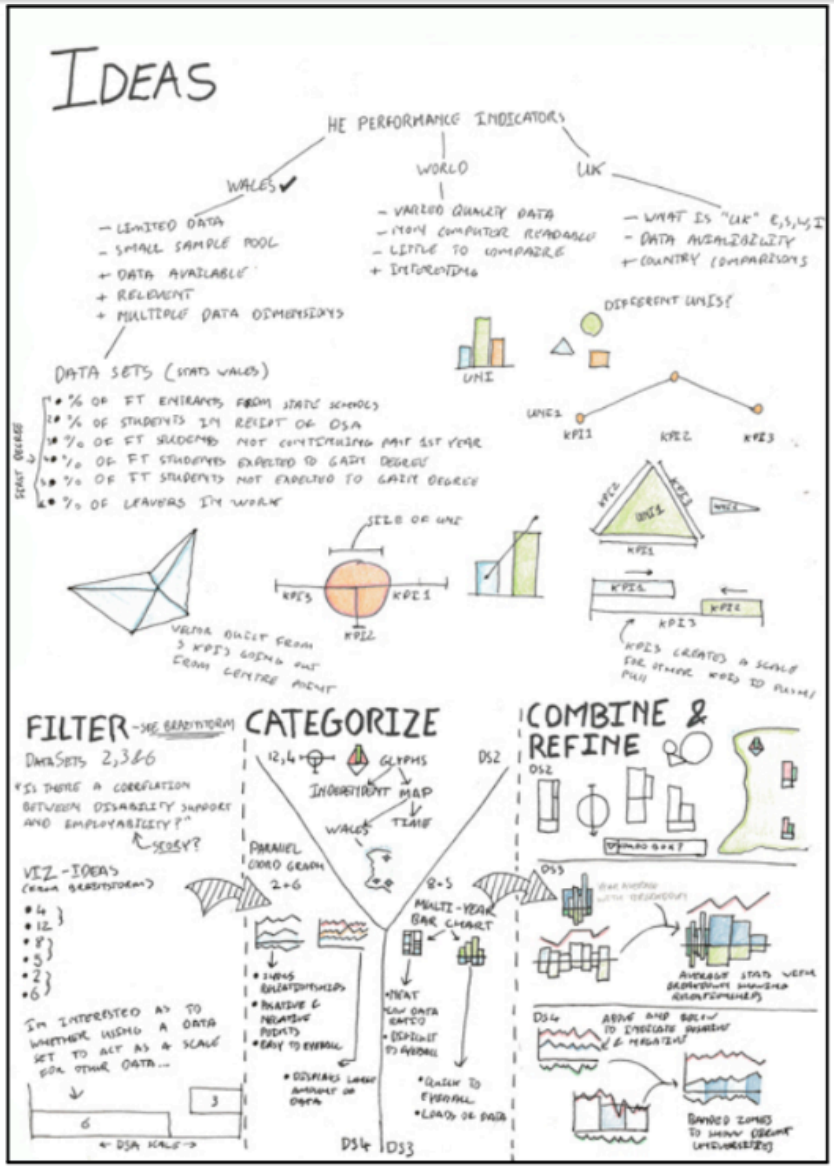

Five Design Sheet Methodology
Sheets 2-4 - Brainstorm

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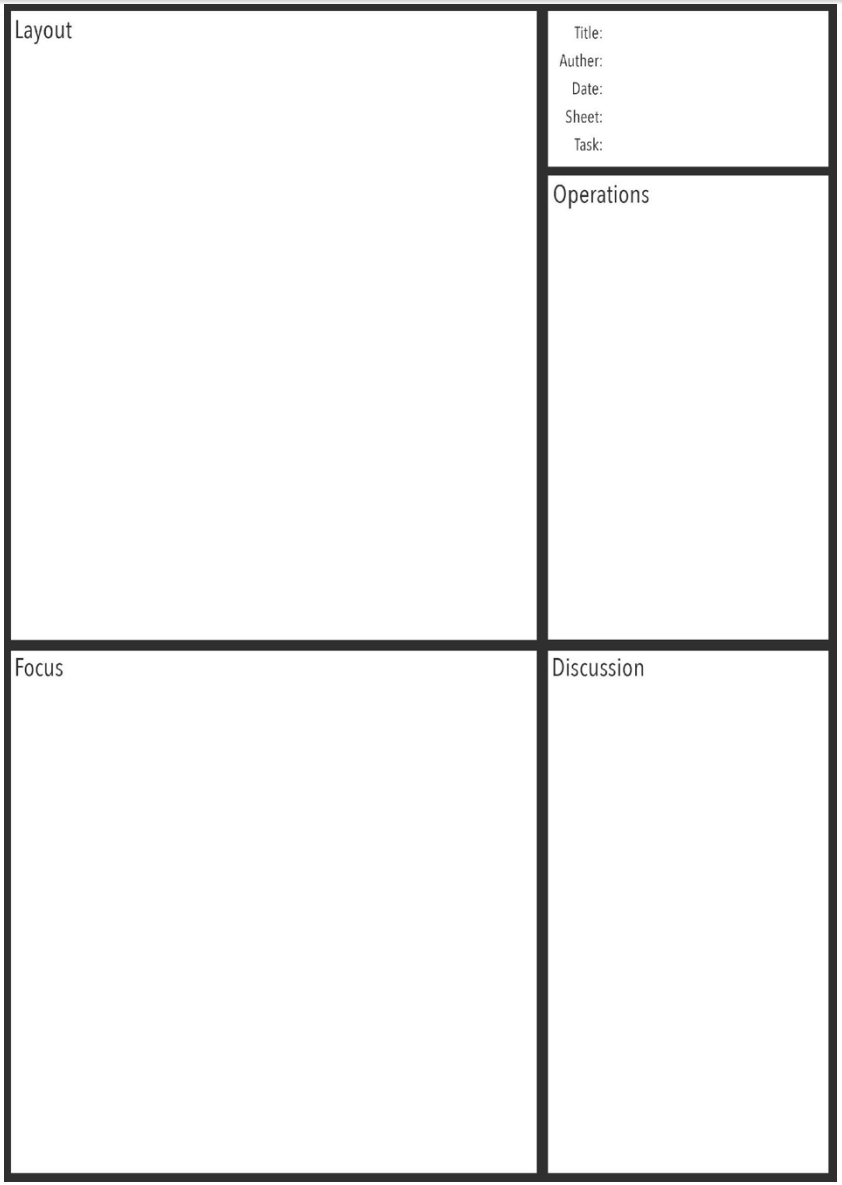
Layout: e.g. sketched screen-shot

Focus: explanations of key/ novel visualisation techniques

Operations: details of key interactions (e.g. a statechart)

Discussion: focus on advantages and disadvantages of the design

Meta-information: title/ author, date, sheet-number, task



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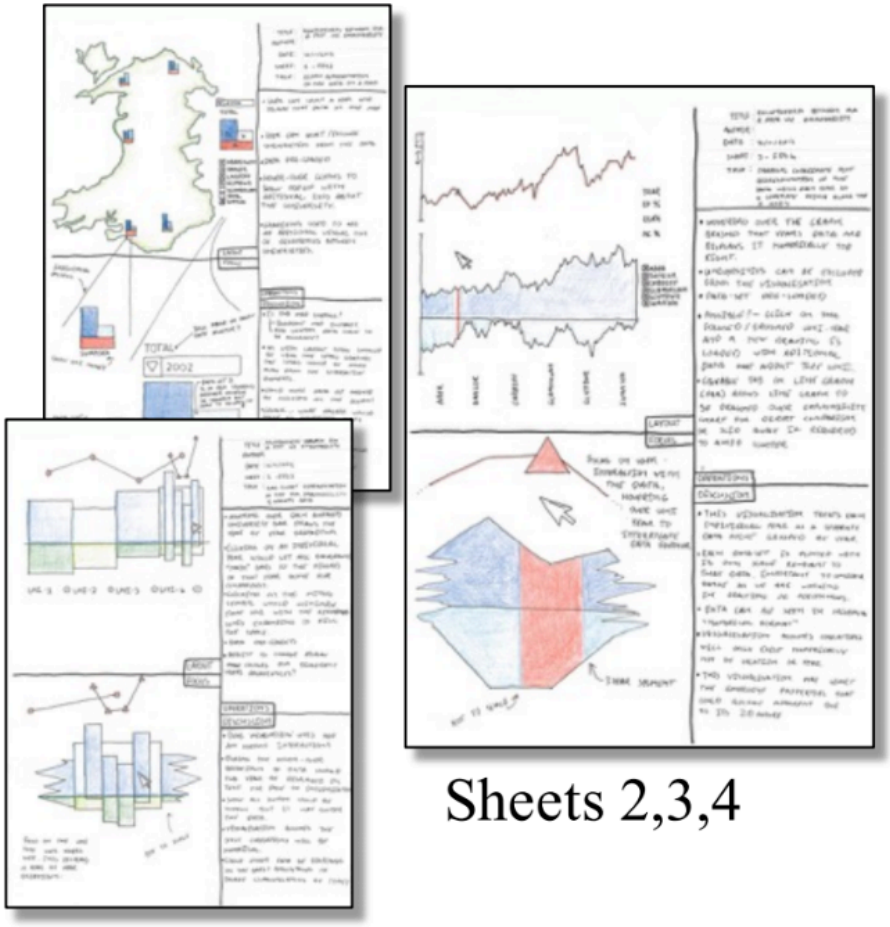
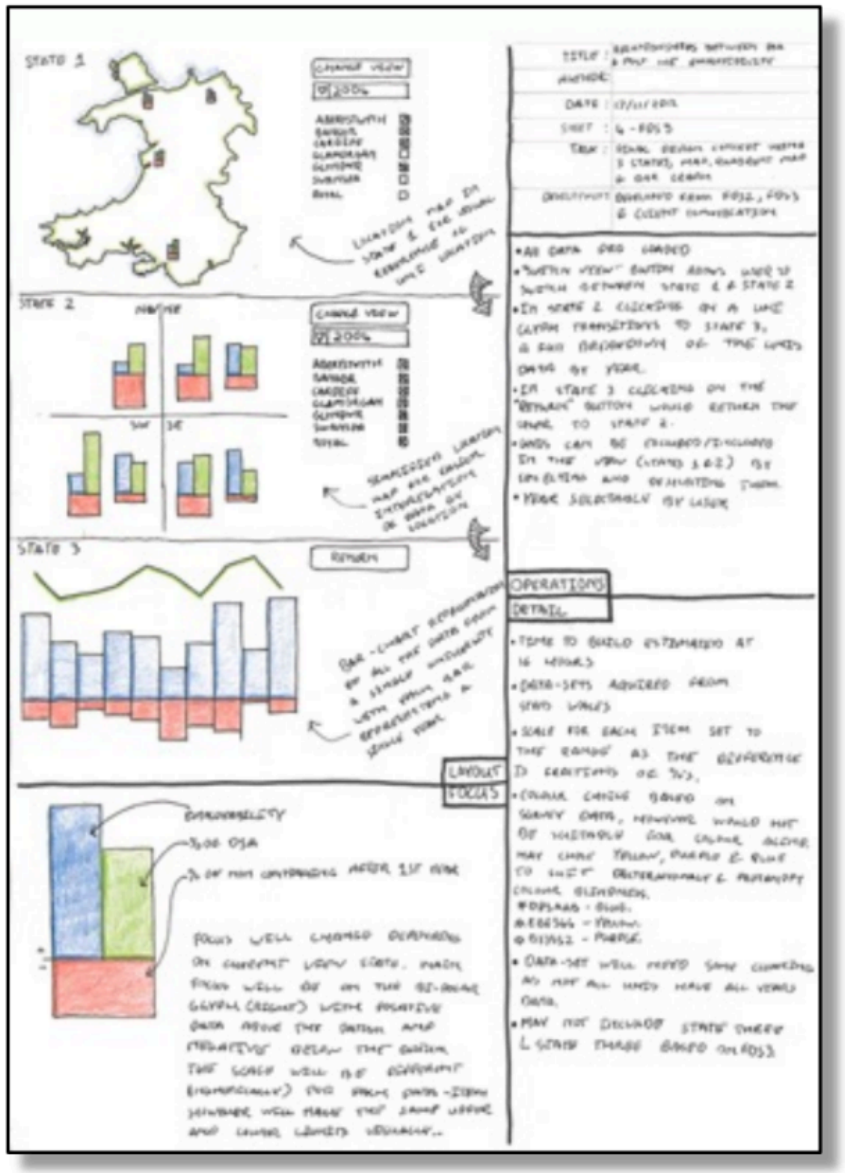


Sheets 2,3,4

Five Design Sheet Methodology
Sheet 5 - Realisation

Take the best of the previous designs and explore in greater detail. Focus on:

1. Description of algorithms / techniques
2. Dependencies: e.g. software libraries, compatibility, etc.
3. Estimate time and effort require to build the solution
4. Specific requirements of materials, hardware (desktop, tablet, phone, etc.)



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Task for next Week!

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Think about the **who**, **what** and **why** of your semester project.

- **Who** are your target users?
- **What** are you showing?
- **Why** is it useful?

Come with a project idea (and if possible data) to the lab in week 3. We will apply the Five Design Sheet Methodology to explore the **how** of your project.

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Presentations next Week!

Presentation Theme

Based on the Allocate+ tutorial class list, the students in the CLAYTON Friday 10AM–12PM lab will be presenting next week.

All students: Please read the instructions on the weekly forum and post your viz. research and analysis there.

- Find a visualisation in a domain of your choice
- Discuss in a few words each the What / Why / How of your chosen Vis following Munzner's framework

Further reading

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- Visualization Analysis and Design. Munzner. AK Peters Visualization Series, CRC Press, Nov 2014.
  - *Chap 1-5: Marks and Channels*
- *On the Theory of Scales of Measurement.* Stevens. Science 103:2684 (1946), 677–680.
- Psychophysics: Introduction to its Perceptual, Neural, and Social Prospects. Stevens. Wiley, 1975.
- *Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods.* Cleveland and McGill. Journ. American Statistical Association 79:387 (1984), 531–554.
- *Perception in Vision*. Healey. http://www.csc.ncsu.edu/faculty/healey/PP
- Visual Thinking for Design. Ware. Morgan Kaufmann, 2008.
- Information Visualization: Perception for Design, 3rd edition. Ware. Morgan Kaufmann /Academic Press, 2004.