Image: Clipart

GEOM90007

SPATIAL VISUALISATION

LECTURE 11:
THE DESIGN PROCESS

VISUALISATION

Exploits human perception (Debiase, 1990)

1. *Visual communication*
   - Information depicted graphically
   - Purpose defines the degree of presentation and exploration

1. *Visual thinking*
   - Exploring spatial data using maps
   - Cognitive process

John Snow example

PUTTING IT ALL TOGETHER

Data graphics

- Visual variables (Bertin)
- Design principles (Tufte)

Cartography

- Cartographic visual variables (MacEachren, Slocum et al.)
- Cartography design principles (Slocum et al.)

Visual Design

Human-computer interaction

- Interface types (Preece et al., 2015)
- Dialogue principles (ISO, 2006)

Interaction Design

(https://youtu.be/mV_hRasXFqY)

USER INTERFACE DESIGN

TYPICAL COMPONENTS

- Display type (e.g., dimensions, resolution)
- Input devices
- Dialogue principles
- Windows, Icons, Menus, Pointers (if applicable)
- Presentation of information - mapped areas, linked data graphics
  - Graphic primitives
  - Visual variables
- User guidance
- Accessibility

VISUALISATION APPROACH

Think back to the start of the semester….

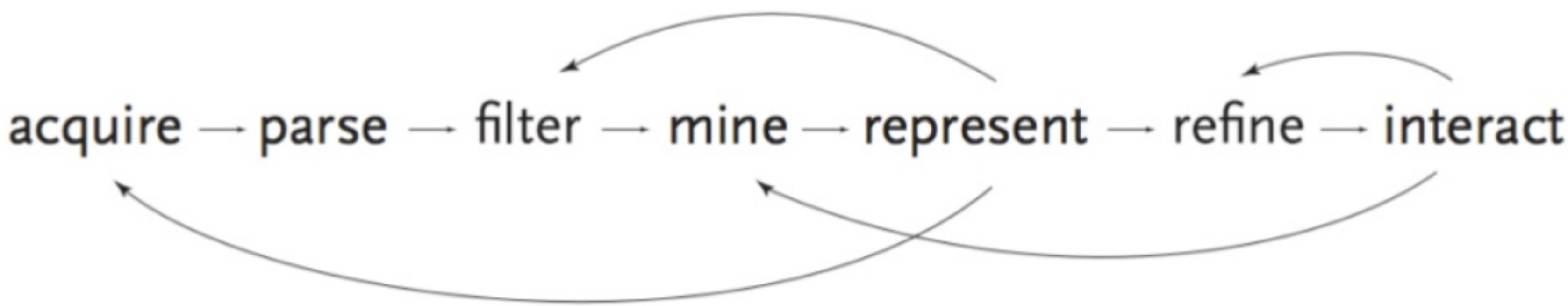
Visualisation pipeline:

Data modelling | Data selection | Visual mappings | Scene parameters (view transformations)

User interface must allow **visual thinking**
– exploit the human system

Too much data to just absorb
– UI must allow the user to **explore the dataset**

WHAT ARE THE INTERACTIONS NEEDED?



Ben Fry,
Computational Information Design

VISUALISATION APPROACH

(Shneiderman and Plaisant, 2010)

Introduction (cont.)

- Sometimes called *visual data mining*, it uses the enormous *visual bandwidth* and the remarkable *human perceptual system* to enable users to make discoveries, take decisions, or propose explanations about patterns, groups of items, or individual items.
- Visual-information-seeking mantra:
  - Overview first, zoom and filter, then details on demand.
  - Overview first, zoom and filter, then details on demand.
  - Overview first, zoom and filter, then details on demand.
  - Overview first, zoom and filter, then details on demand.
  - Overview first, zoom and filter, then details on demand.

BASIC 7 TASKS ALL VISUALISATION UIs SHOULD HAVE (?)*

1. **Overview task** - users can gain an overview of the entire collection
2. **Zoom task** - users can zoom in on items of interest
3. **Filter task** - users can filter out uninteresting items
4. **Details-on-demand task** - users can select an item or group to get details
5. **Relate task** - users can relate items or groups within the collection
6. **History task** - users can keep a history of actions to support undo, replay, and progressive refinement
7. **Extract task** - users can allow extraction of sub-collections and of the query parameters

*(Shneiderman and Plaisant, 2010)

VISUALISATION REQUIRES A MODEL OF INTERACTION

Data and View Specification	**Visualize** data by choosing visual encodings.
	Filter out data to focus on relevant items.
	Sort items to expose patterns.
	Derive values or models from source data.
View Manipulation	**Select** items to highlight, filter, or manipulate them.
	Navigate to examine high-level patterns and low-level detail.
	Coordinate views for linked, multidimensional exploration.
	Organize multiple windows and workspaces.
Process and Provenance	**Record** analysis histories for revisitation, review, and sharing.
	Annotate patterns to document findings.
	Share views and annotations to enable collaboration.
	Guide users through analysis tasks or stories.

Image: Heer and Shneiderman (2012)
http://dl.acm.org.ezp.lib.unimelb.edu.au/citation.cfm?id=2146416

HANG ON…

Should we start thinking about designing a UI before considering map purpose, the user and their goals?

VISUALISATION REQUIRES A MODEL OF INTERACTION

A ‘**cookie cutter**’ approach to visualization is easy

However, specialized applications, such as interactive map interfaces, have particular interaction needs

Thinking about the *purpose* of each UI is critical

VISUALISATION REQUIRES A MODEL OF INTERACTION (Fry, 2009)

Too much information

Data collection

Thinking about the data

Data never stays the same

What is the actual purpose?

TOWARDS VISUALISATION

"Confusing widgets, complex dialog boxes, hidden operations, incomprehensible displays, or slow response times can limit the range and depth of topics considered and may curtail thorough deliberation and introduce errors."

(Heer and Shneiderman, 2012)

USER CENTRED DESIGN TERMINOLOGY

User experience, Usability

USER CENTRED DESIGN (UCD)

User-centred design [is] a philosophy based on the needs and interests of the user, with an emphasis on making products usable and understandable.

(Norman, 2002)

- Human centred (HC) design can be considered similar (but beware)

More information:
https://www.youtube.com/watch?v=Wl2LkzIkacM
www.springer.com/cda/content/document/cda_downloaddocument/9781447151333-c2.pdf

USER EXPERIENCE (UX)

- UX is central to interaction design
  - How users feel (pleasure and satisfaction)

(Preece et al., 2015)

- "**User experience** is a consequence of the presentation, functionality, system performance, interactive behaviour, and assistive capabilities of an interactive system, both hardware and software. It is also a consequence of the user's prior experiences, attitudes, skills, habits and personality"

(ISO, 2010)

USER EXPERIENCE (UX)

Example: Design of a physical mobile phone

a) Weight is moderate, case is smooth and easily fits within the hand

b) Weight is heavy, case is angular and is awkward to hold

iPhone, Samsung, Xiaomi, ZTE…

How might we consider UX for interactive maps?

UNDERSTANDING DESIGN GOALS

1. User experience goals
2. Usability goals

USER EXPERIENCE

“Person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service” (ISO, 2010)

Desirable

- Satisfying
- Enjoyable
- Pleasurable
- Fun
- Appealing
- Exciting

Undesirable

- Boring
- Frustrating
- Annoying
- Unpleasant
- Gimmicky
- Patronising

(Rogers et al., 2015)

USER EXPERIENCE GOALS

Turn them into questions to define goals, many examples:

- Appealing
- Frustrated

(Rogers et al., 2015)

USABILITY

“Extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use” (ISO, 1998)

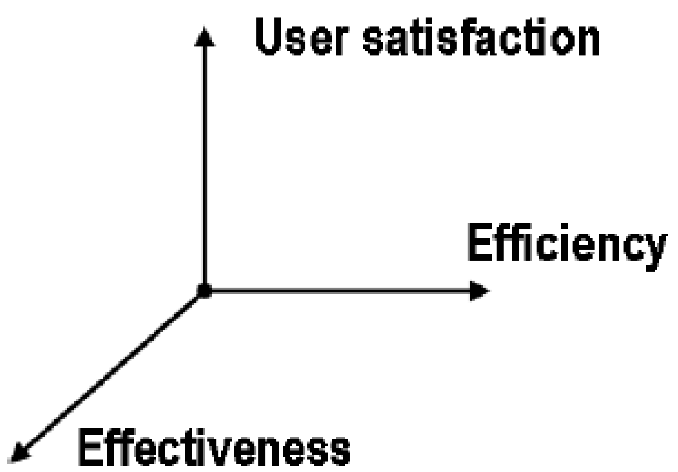


Image: Kulyk et al. (2006)

*There are alternative definitions for usability. This subject uses the ISO 9241-11 (1998) definition used in Information Visualisation (Kulyk et al., 2006)

USABILITY GOALS

Again, turn these into questions to find the goals, e.g.:

- **Effectiveness**
  Is the interactive map capable of allowing users to find the location they want?

- **Efficiency**
  Once users learn to use the interactive map, can they sustain a high level of productivity?

- **Satisfaction**
  Does the interactive map provide an appropriate set of functions? Do these allow the user to carry out their task in the way they want to do it?

Derived from Rogers et al. (2015)

User experience goals are different from usability goals!

FORMAL DESIGN METHODOLOGY

Why and How?

Once the need for developing an **interactive map** has been identified, and the decision has been made to use human-centred development, four linked human-centred design activities are required

(ISO, 2010)

FORMAL DESIGN PROCESS

ISO 9241-210:2010

- Ergonomics of human-system interaction
  Part 210: Human-centred design for interactive systems

Download from: https://www-saiglobal-com.ezp.lib.unimelb.edu.au/online/autologin.asp

Design activities

0. Identify purpose (e.g., map user needs)
1. Understand context of use
2. Specify user requirements
3. Produce designs
4. Evaluate designs

ITERATIVE DESIGN PROCESS

Can be incorporated with development processes, e.g., waterfall, rapid (RAD) or AGILE

ITERATIVE DESIGN PROCESS

"The most appropriate design for ar interactive system cannot typically be achieved without iteration"

Section 4.5, ISO9241-210:2010

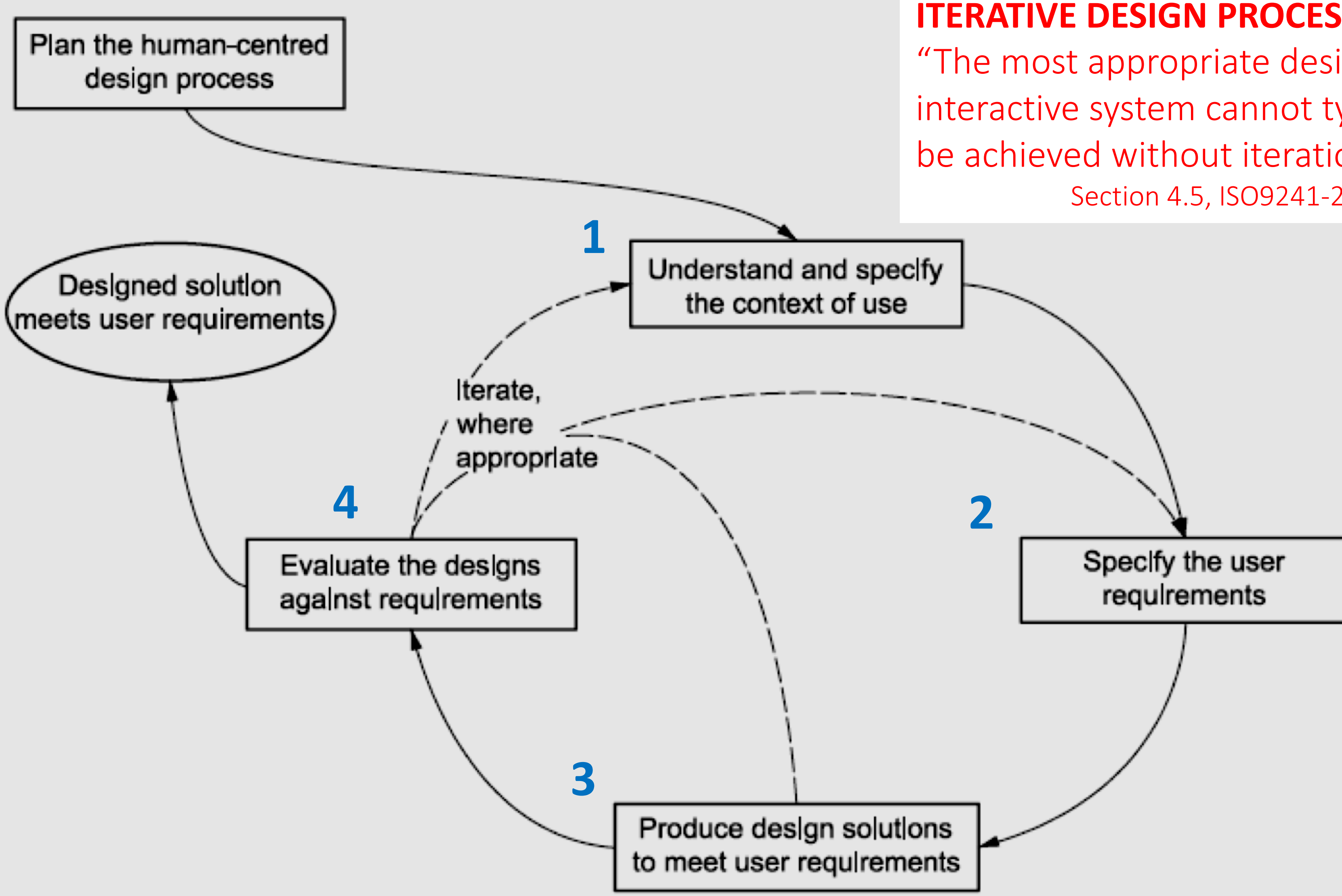


Figure 1 — Interdependence of human-centred design activities

Image: ISO 9241-210:2010

WHY USE ITERATION FOR INTERACTIVE SYSTEMS?

- There are often a number of **different user** groups and stakeholders
- The **context of use** can be highly diverse and can vary from user group to user group and between different tasks
- At the beginning of a project, the **requirements** are unlikely to be exhaustive. Some requirements only emerge later.
- User **requirements** can be diverse and potentially contradictory to each other and to those of other stakeholders
- Initial **design solutions** rarely satisfy all user needs
- It is difficult to ensure that all parts of the system are considered in an **integrated** manner

(ISO, 2010)

0. IDENTIFY PURPOSE

- Identify purpose for product (e.g., map or geovisualisation)
  - What is the current problem/motivation/needs?

- Determine users (audience)
  - A specific audience, e.g., experts/specialists?
  - A broad audience, e.g., novices?

- Determine a suitable sample size drawn from the user population
  - Consenting users are called participants in the study

Example in geovisualisation: http://openaccess.city.ac.uk/411/

1. UNDERSTAND CONTEXT OF USE

(Lloyd and Dykes, 2011)

Contextual Inquiry (CI) can be used to research the application area

Data collection methods:

- Interviews
- Observations
- Questionnaires
- Examining documents
    - Internal (e.g., analysis processes)
    - External (academic articles in domains)
- ....

Images: Creative Commons

More information: https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/contextual-design

1. UNDERSTAND CONTEXT OF USE

(Lloyd and Dykes, 2011)

Context Analysis (CA) techniques to analyse data and its meaning to an individual user group, e.g. relationships and communication method

- Word frequencies
- Examining keywords
- Card sorting
- …

Images: Creative Commons

More information:
http://repository.upenn.edu/cgi/viewcontent.cgi?article=1232&context=asc_papers

Example: Designing interactive maps for an internet provider

- Observations of corporate use of interactive maps via intranet
- Identify technical context and processes
  - e.g., sales team (address lookup)

Provision of fibre optic internet services

Images: Pitney Bowes, GNAF premium

(ISO, 2010)

1. UNDERSTAND CONTEXT OF USE

After investigation the following must be fully described

a) **Users and other stakeholder groups**
   - Identification of different groups

b) **Characteristics of the users or groups of users**
   - Identify relevant characteristics of the users
     e.g., knowledge, skill, experience, education, training, etc.
   - Identify accessibility requirements for inclusive design*

*Inclusive design and accessibility: http://www.w3.org/WAI/intro/usable
More information: http://dfat.gov.au/about-us/publications/Documents/accessibility-design-guide.pdf

(ISO, 2010)

1. UNDERSTAND CONTEXT OF USE

c) Goals and tasks of the users
- Separate goals of users from others, e.g., system
- Frequency, duration and activities to be carried out in parallel
- Identify potential risks

d) Environment(s) of the system
- Technical environment, e.g., software, hardware,
- Other physical, social, cultural

2. SPECIFY USER REQUIREMENTS

User requirements provide the basis for design and the evaluation of solutions to meet user needs

Requirements exist whether you discover them or not, and whether you write them down or not

(Robinson and Robinson, 2012)

Depending on scope, user requirements can be defined at varying levels

2. SPECIFY USER REQUIREMENTS (ISO, 2010)

The formal specification of user requirements includes

a) **The intended context of use**
    See previous

b) **Requirements derived from user needs and the context of use**
    e.g., requirement to use map outdoors

c) **Requirements arising from ergonomics and user interface guidelines**
    e.g. accessibility requirements

(ISO, 2010)

2. SPECIFY USER REQUIREMENTS

d) Usability requirements including measurable performance and satisfaction criteria

e.g., an objective might be 95 % of the users can successfully locate an address

e) Requirements derived from organizational requirements that directly affect the user

e.g., a call centre system might require that customer inquiries can be answered within a specific time frame

(Lloyd and Dykes, 2011)

Example: Geovisualisation tool development

Lloyd and Dykes (2011) use three main methods to elicit requirements:

1. Lecture
2. Template
3. Scenario

(Lloyd and Dykes, 2011)

1. Lecture

Following understanding the context of use, a lecture was conducted to describe common visualisation techniques and tools to participants

Visualisation techniques: use of marks (e.g., primitives, visual variables)
Tools: what are common to perform task (e.g., zoom)

After two weeks, the following were used to capture user requirements:

- Recall
- Card sorting
- Scenario

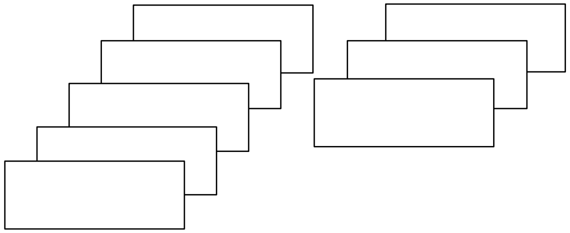
(Lloyd and Dykes, 2011)

Recall

- Individual/group interviews were used to gauge participant interest in techniques and tools presented in the lecture

Card sorting

- To see how users (novice and experts) think about the techniques and tools presented, together with their possible interactions
- Results can be analysed (e.g., clustering) and used to focus design



More information: https://www.usability.gov/how-to-and-tools/methods/card-sorting.html

(Lloyd and Dykes, 2011)

Sketching

- An example application is presented (e.g., crime analysis)
- Participants asked to sketch a process using the techniques and tools from the lecture
- Analyses
  - Count the number of ideas in the different sketches: Visualisation techniques, e.g., star plot/glyph

Sketching example: http://dl.acm.org.ezp.lib.unimelb.edu.au/citation.cfm?id=1671019

(Lloyd and Dykes, 2011)

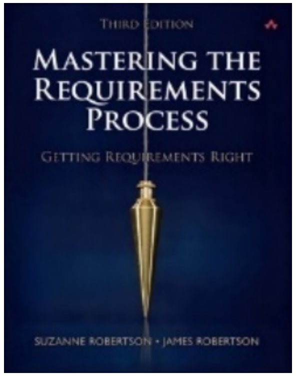
2. Template

- Discussions using a formal template, e.g., description, rationale

- Broad focus to discover requirements
  - Understand the work as it is currently performed
  - Strip away the technology to get an idea of its real purpose

- Describe use cases (UML) and specify requirements in template

Volere template: Robertson and Robertson (2012)
http://proquestcombo.safaribooksonline.com.ezp.lib.unimelb.edu.au/9780132942850



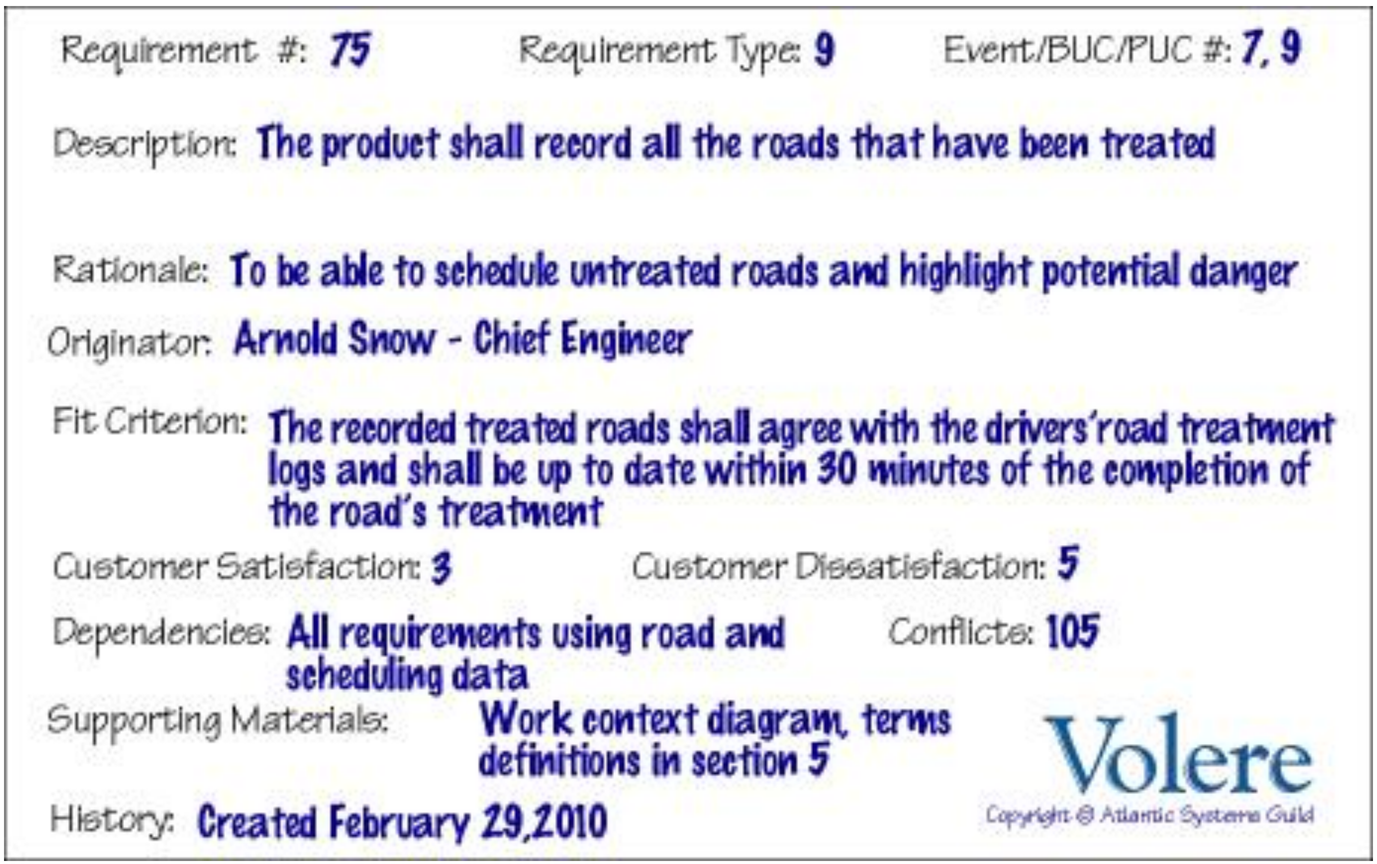
(Lloyd and Dykes, 2011)

3. Scenario

- “Stories about people and their activities… [that] support reasoning about situations of use” (Carroll, 2002)
- A discovery tool to determine interactions for functional requirements
- Scenarios are often designed following previous tasks after establishing context and early requirements
    - Crime analysis
- **Example interactions:** aggregate, filtering, compare, zoom
- **Example tools:** map, table, histogram

CLEARLY SPECIFY REQUIREMENTS

- Volere example



Requirement #: 75 Requirement Type: 9 Event/BUC/PUC #: 7, 9

Description: The product shall record all the roads that have been treated

Rationale: To be able to schedule untreated roads and highlight potential danger

Originator: Arnold Snow - Chief Engineer

Fit Criterion: The recorded treated roads shall agree with the drivers'road treatment logs and shall be up to date within 30 minutes of the completion of the road's treatment

Customer Satisfaction: 3 Customer Dissatisfaction: 5

Dependencies: All requirements using road and scheduling data Conflicts: 105

Supporting Materials: Work context diagram, terms definitions in section 5

History: Created February 29,2010

Volere

Copyright © Atlantic Systems Guild

Image: http://www.volere.co.uk/template.htm

(Lloyd and Dykes, 2011)

RESOLVING TRADE-OFFS

During requirements capture, differences may emerge between user requirements

- Typically between participants or groups

Potential conflicts may include:

- Interaction requirements, e.g., accuracy vs. speed
- Design feedback, i.e., what the user interface should look like

These must always be resolved.

(ISO, 2010)

3. PRODUCE DESIGNS

Early designs

Follows (1) Context of use and (2) Requirement stages

“Designing for the user experience is a process of innovation that takes account of user satisfaction (including emotional and aesthetic aspects), as well as effectiveness and efficiency. The following principles should be taken into account when designing” (page 14)

a) suitability for the task
b) self-descriptiveness
c) conformity with user expectations
d) suitability for learning
e) controllability
f) error tolerance
g) suitability for individualization

Do these look familiar?

3. PRODUCE DESIGNS

(ISO, 2010)

Formalising the interactions

Designing the interaction involves deciding how users will accomplish tasks ***with*** the system rather than describing what the system looks like

e.g., **dialogues** describing interactions user-system

3. PRODUCE DESIGNS

(ISO, 2010)

Designing the interactions

- Making high-level decisions (e.g. initial design concept)
- Identifying tasks and sub-tasks
- Allocating tasks and sub-tasks to the user and to the system
- Identifying the interaction objects required for the completion of the tasks
- Identifying and selecting appropriate dialogue techniques
- Designing the sequence and timing (dynamics) of the interaction
- Designing the information architecture of the user interface of an interactive system to allow efficient access to interaction objects

3. PRODUCE DESIGNS

(ISO, 2010)

Designing the user interface

- Display type
- Input devices
- Dialogue principles
- Windows, Icons, Menus, Pointers (if applicable)
- Presentation of information - mapped areas, linked data graphics
  - Graphic primitives
  - Visual variables
- User guidance
- Accessibility

3. PRODUCE DESIGNS

Early designs

Typically use a sketch based approach (e.g., wireframe) to communicate the general layout and areas where information is to be visualised

Once completed, designs are presented to the participants for review and analysis, and may undergo reiteration (or be discarded)

Example wireframe prototype (foreground), containing spatial (map), temporal (glyphs) an crime attribute (tree map) data

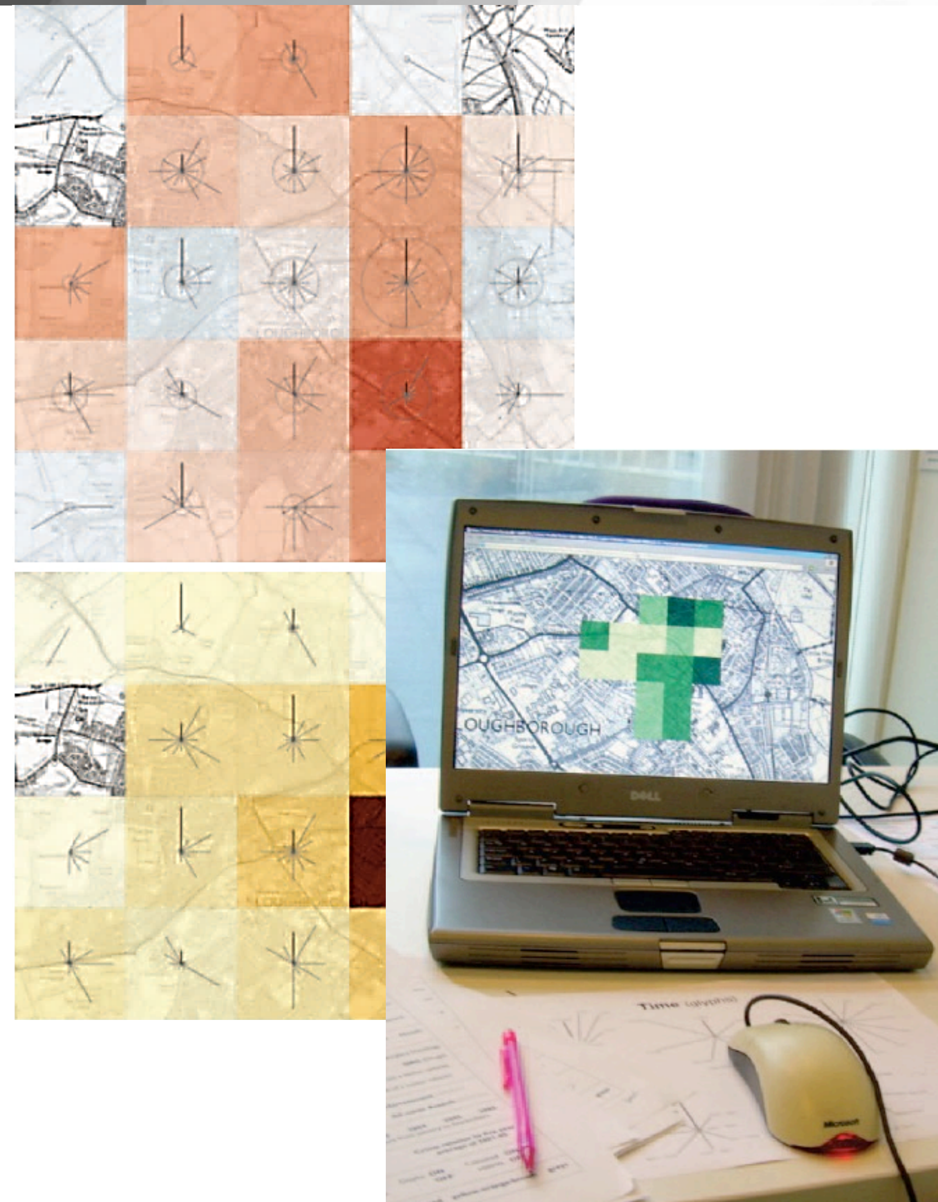
Image: Lloyd and Dykes (2011)

3. PRODUCE DESIGNS

Later designs

Focus on making the design solutions more concrete
(e.g., making functional prototypes)

Once completed, designs are <u>further</u> presented to the participants for review and may undergo reiteration



Images: Lloyd and Dykes (2011)

4. EVALUATE DESIGN SOLUTIONS

(ISO, 2010)

Formally test the design solution with participants

Provide feedback on strengths and weaknesses of the design solution from the user's perspective (to improve the design)

Collect new information about user needs

4. EVALUATE DESIGN SOLUTIONS

Four critical points where user failures can occur

- Users can form an inadequate goal
- Might not find the correct interface object because of an incomprehensible label or icon
- May not know how to specify or execute a desired action
- May receive inappropriate or misleading feedback

Reiterate

THE BIG PICTURE

	HC Approaches	Data Collection	Data Analysis	Summary Process Findings
Context of Use	Contextual inquiry (CI)	Interviews; Observation; Studying docs;	Transcription; Word frequency; Keyword in context (KWIC)	1. Word frequency & KWIC are useful & efficient analysis tools 2. Specialists' internal documents & broader academic writing on the domain provide insights & context.
		Card sorting: domain tasks	Classifying (card sort)	
Requirements	Template (Volere)	Questionnaire conducted orally	Transcription; Deductive coding	1. Transcription with deductive coding is highly labour intensive. A trained note-taker recording & coding during data collection is an alternative, although prior coding schemes are difficult to achieve. 2. A scenario of specialists' context provides 'common ground' - information that enables geovis experts to suggest relevant methods. 3. Geovis experts express their ideas differently. Awareness of personal styles might be important when experts meet domain specialists (or other geovis experts). 4. Sketching & counting instances of tools & interactions can elicit information to supplement card sorting & summative interview. 5. Sketching can establish relative acceptability & comprehension of geovis methods (which may in turn contribute to learning).
	Scenario used by geovis experts	Interview & think aloud; Summative questioning		
	Lecture for communicating geovis to specialists	Card sorting: geovis methods; Sketching; Recall interviews	Counts of geovis methods in card sort & in sketching	
Design Early Prototypes	Early design	Documenting design process	Reflection (autoethnography)	1. Autoethnographic inspired approach to reflection in the geovis design process is useful. 2. See *transcription* above. 3. Specialists interact effectively with modified wireframe prototypes, which elicit a rich body of information, creativity & understanding.
	Wireframe prototype	Think aloud; Summative questioning; Observation	Transcription & deductive coding; Counts, & representative comments, coded by approval, ideas, limitations, opinions & queries; Counts of tools, interactions & data; Summative questioning & observation for effective additional evidence	
Design Later Prototypes	Paper prototype with user testing & active intervention protocol; Digital prototype with user testing & active intervention protocol; Digital prototype with free exploration protocol	Think aloud; Summative questioning; Observation;	Transcription & deductive coding; Counts, & rep. comments, coded by instances of exploratory activity, hypothesis forming, insight/ideation, expectation confirmed/confounded & suggestions for improvement; Summative questioning & observation for effective additional evidence	1. See *transcription* above. The later prototyping required transcription of 150,000 words, taking several months. 2. Both paper & digital prototypes engage specialists successfully, elicit exploratory activity, hypothesis forming, confirm/confound expectations & establish possible improvement, with both protocols. 3. A paper prototype with multiple representations of real data relies on the prior existence of a digital process, if not a digital prototype. 4. A free exploration protocol yields results with fewer resources & less researcher intermediation that a user testing protocol. It may also address some of the power/partnership issues, stimulate interest & help with trust & team-building. See *requirements* above.

Table: Lloyd and Dykes (2011)

LINK TO EXAMPLE

Lloyd, D and Dykes, J. (2011) Human-Centered Approaches in Geovisualization Design: Investigating Multiple Methods Through a Long-Term Case Study. *IEEE Transactions on Visualization and Computer Graphics*, 17(12), 2498-2507

Access: http://ieeexplore.ieee.org.ezp.lib.unimelb.edu.au/document/6065017/