Hochschule Kempten
University of Applied Sciences

drive livinglab

Vehicle Technology SS 23

FT30 – Advanced Driver Assistance Systems

Agenda

Nr.	Datum	Inhalt
1	23.04.	Introduction Advance Driver Assistance Systems and Automated Driving
2	07.05	ADAS/AD for Longitudinal Guidance
3	14.05.	ADAS/AD for Lateral Guidance
4	28.05.	ADAS/AD for Automated Parking
5	**14.04.**	**User Experience with ADAS**
6	**18.06**	**Track Day**
7	TBD	Exam Questions

Introduction

User Experience is concerned with **„all aspects of the user‘s experience when interacting with the product, service, environment or facility“** (ISO 9241-210)

→ Holistic view on the subjectively witnessed product quality
→ Also incorporates the user‘s emotional connection to the task

https://www.slideshare.net/domain7/ux-vs-usability

Interactive System

A combination of hardware, software and services that **users** interact with in order to achieve specific **goals**.

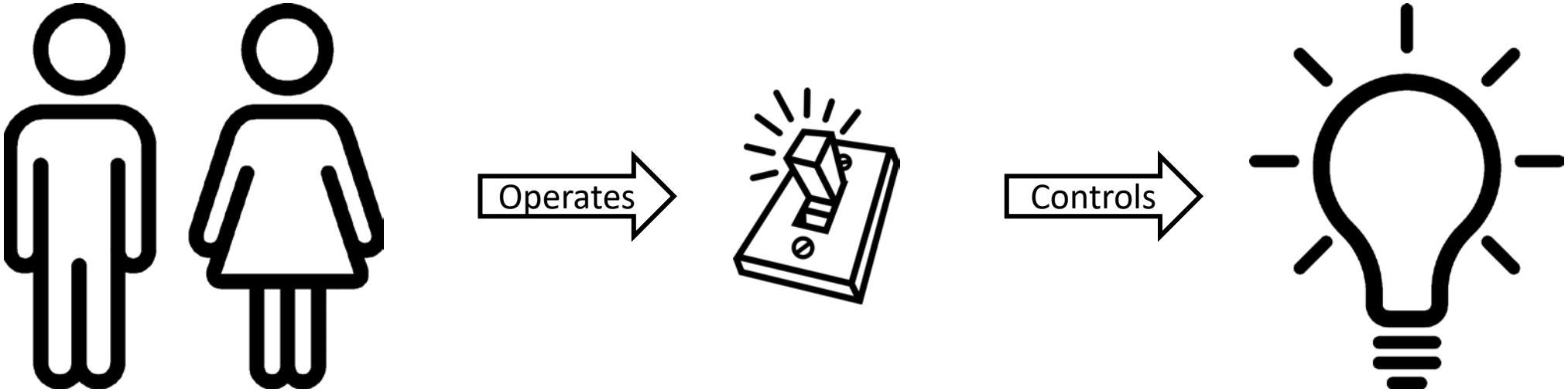
Notes:
1. This includes, where appropriate, packaging, user documentation, online help, support and training.

2. Even systems that do not accept input from **users** are covered by this definition, for example destination boards in an airport or signs in a train station.

https://www.zastavki.com/

What is an HMI?

An HMI (= Human Machine Interface) is a component of certain device, refers to a dashboard that allows users to communicate with machines, computer programs or systems. The interface consists of hardware and software that allow user inputs to be translated as signals for machines that, in turn, provide the required result to the user.



HUMAN
(User)

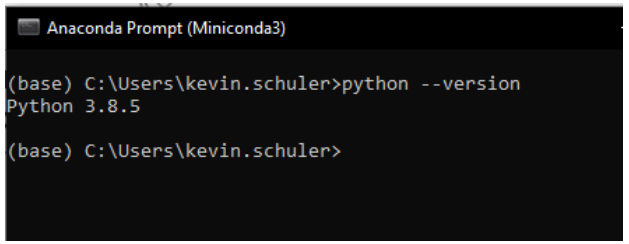
INTERFACE

MACHINE

What is an HMI?

Examples:

1. **CUI** (Character User Interface): Text-oriented operation by means of commands.



2. **GUI** (Graphical User Interface): User interface divided into areas with graphical icons for selecting programs and functions

https://www.conceptdraw.com/How-To-Guide/picture/Windows8Startscreen.png

What is an HMI?

3. **VUI** (Voice User Interface): Speech recognition controls the system. Output is also by voice/acoustic

https://www.psypost.org/

4. **NUI** (Natural User Interface): Further development of GUI & VUI combined with gesture recognition for the most natural interaction possible.

© BMW

5. **BCI** (Brain Computer interface): Control via brainwaves or nerve impulses

https://media.springernature.com/

What is human-centred design?

Human-centred design is an approach **to design** that aims to make **interactive systems more usable** by **focusing** on the **use of the interactive system** and applying usability knowledge and methods.

What is Usability? (Gebrauchstauglichkeit)

Usability: DIN ISO 9241-11
“Usability is the extent to which an **interactive system** is **effective, efficient** and **satisfying** to use in a specified **context of use**.”

Effectiveness & Efficiency

Effectiveness
The accuracy and completeness with which users achieve specified goals.

Efficiency
The resources used in relation to the results achieved.

Example:
You have a company and want to develop and build a car in 5 years.
Finishing the project and building the car in 5 years would be **effective and efficient**.

Finishing the car in 10 years would be **effective**, but not efficient.

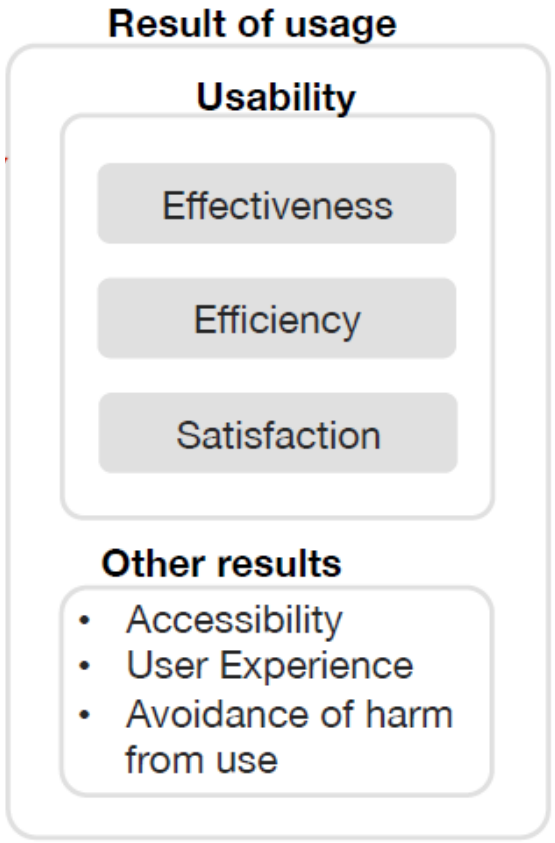
Finishing early in 2 years, but instead of the car you built a bicycle, would be **efficient** but not effective.

Effectiveness, Efficiency and Satisfaction together make up the Usability.

Concept of Usability

Notes:
1. Usability depends on users, goals and tasks, and other aspects of the **context of use**.

2. Technical defects may lead to **usability problems** if they prevent **users** from solving their **tasks effectively** or **efficiently**.

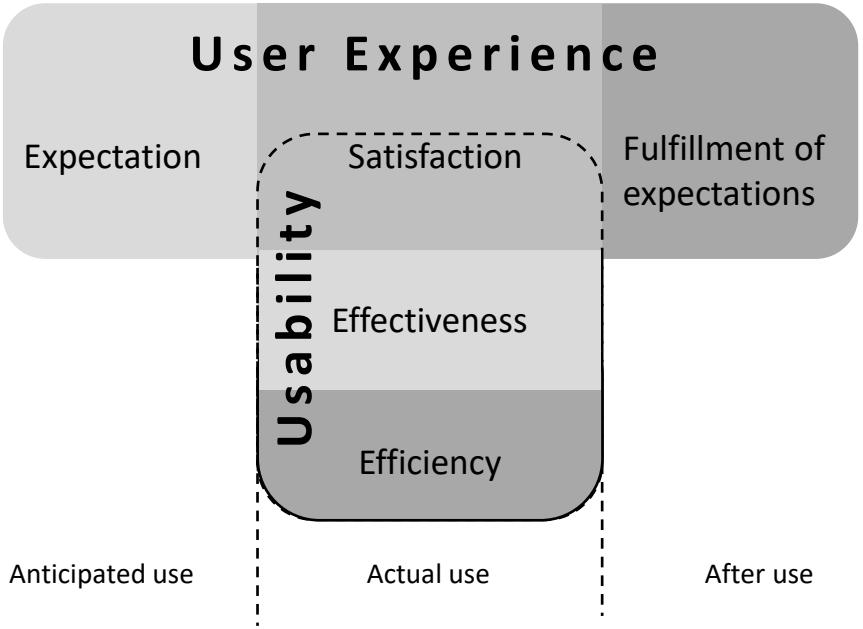


What is User Experience (UX)?

User Experience:
A **user's** perceptions and responses that result from the use and/or anticipated use of an **interactive system**.

Notes:

1. **User's** perceptions and responses include the **user's** emotions, beliefs, preferences, comfort, behaviours, and accomplishments that occur **before, during** and **after** use.

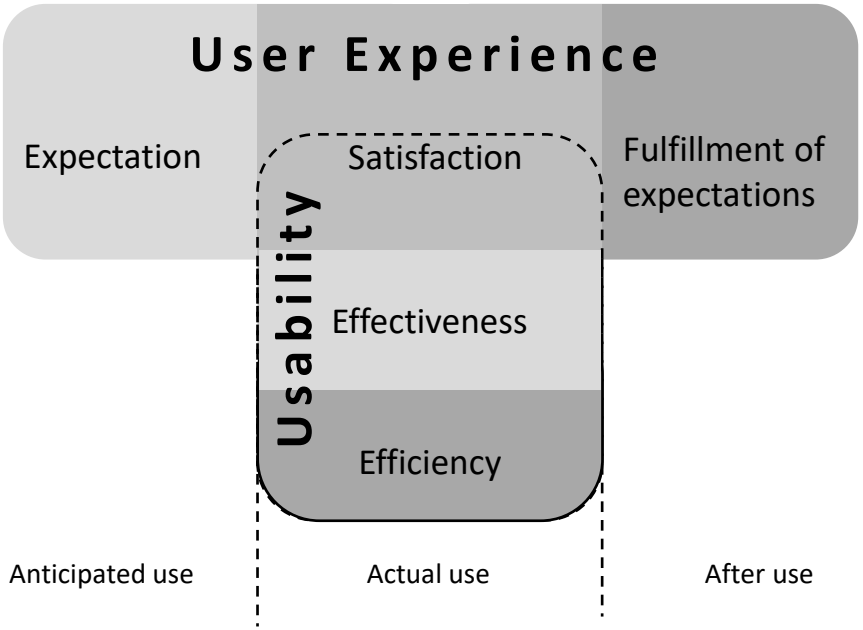


What is User Experience (UX)?

2. User experience is a consequence of brand image, presentation, functionality, system performance, interactive behaviour, and assistive capabilities of the **interactive system**.
It also results from the **user's** internal and physical state resulting from prior experiences, attitudes, skills, abilities and personality; and from the **context of use**.

3. **Usability** criteria can be used to evaluate aspects of user experience.

4. **Usability** is mainly about the interaction with the **interactive system**. User experience also considers what happens before and after the interaction through to final use and recollections of use.



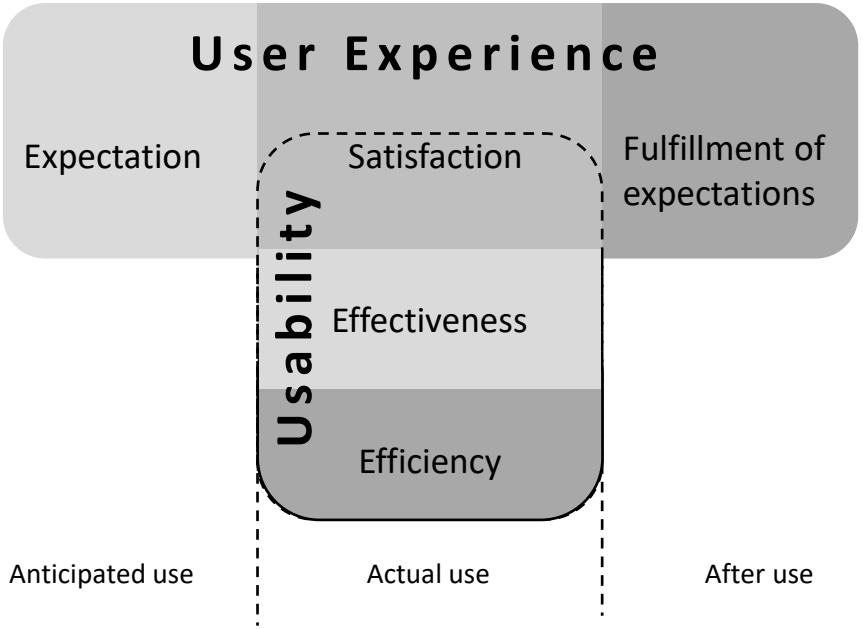
What is User Experience (UX)?

5. User experience is mainly about **satisfaction** and fulfilment of expectations.

6. User experience is often referred to as UX.

7. The following figure shows the relationship between user experience and **usability**.

Usability is **effectiveness**, **efficiency** and **satisfaction** during actual use,
while user experience is the **satisfaction** or dissatisfaction **during** anticipated use, **actual** use and **after** use.



What is the difference between Usability and UX?

Example
When using the parking assistant in a parking lot to park your car:
1. **Usability problems** encountered during activation affect both the user experience and **usability** (e.g., not managing to activate the assistant properly).

2. The quality of the parking maneuver affects only the user experience. It does not affect **usability** of the parking assistant.

3. Being made fun of because your car is parked badly affects the user experience of subsequent uses of the parking assistant. It does not affect the usability of the system.

Further Terms: (Automotive) User Interface

All components of an **interactive system** (software or hardware) that provide information and controls for the **user**, to allow them to accomplish specific **tasks** with the **interactive system.**

Head Down Display (HDD/ Head Unit), Head Up Display (HUD), Infotainment Display,…

The driver´s (user´s) attention **is not to be diverted** away from the road.
Car ≠ Smartphone on wheels

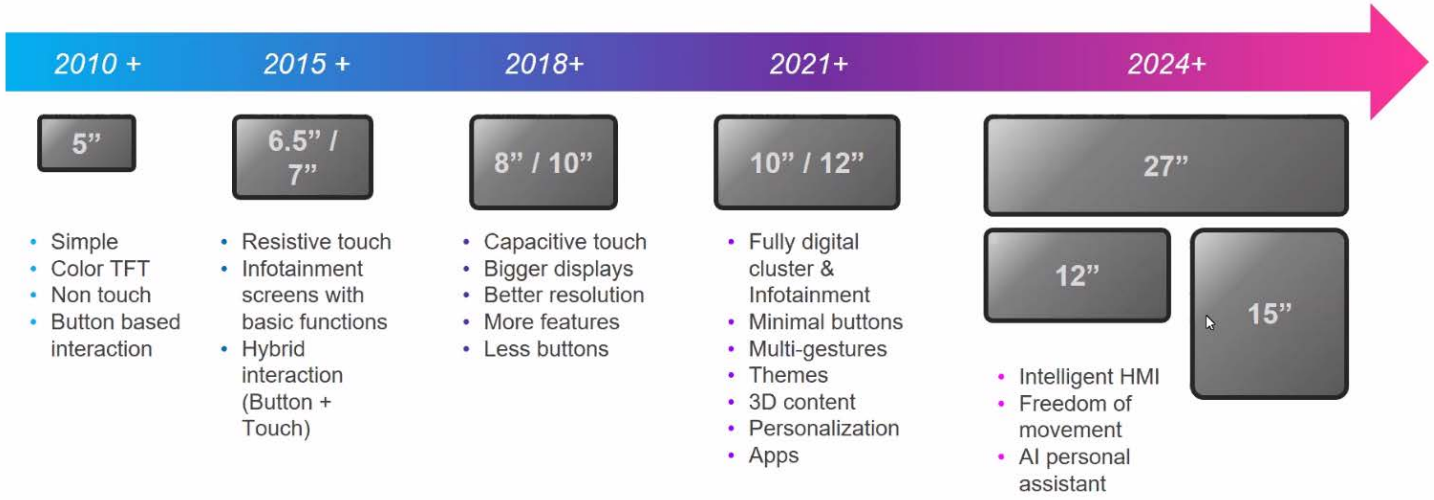
Competitors to the OEM:
Google/ Apple/ Microsoft/ Amazon design own dashboard experience (Google Maps, Android Automotive OS, Apple CarPlay, Alexa Auto)

https://www.ego-cms.com/post/automotive-user-interfaces-the-past-the-present-and-the-future

Quelle: alexaAuto

Display Evolution in Automotive UI

OEM´s differentiating with more& larger displays



Quelle: Visteon

Further Terms: ISO 9241

A family of standards covering **human-centred design**.

ISO 9241 includes standards related to

a. Software ergonomics;

b. The human-centered design process;

c. Displays and display related hardware;

d. Physical input devices;

e. Workplace ergonomics;

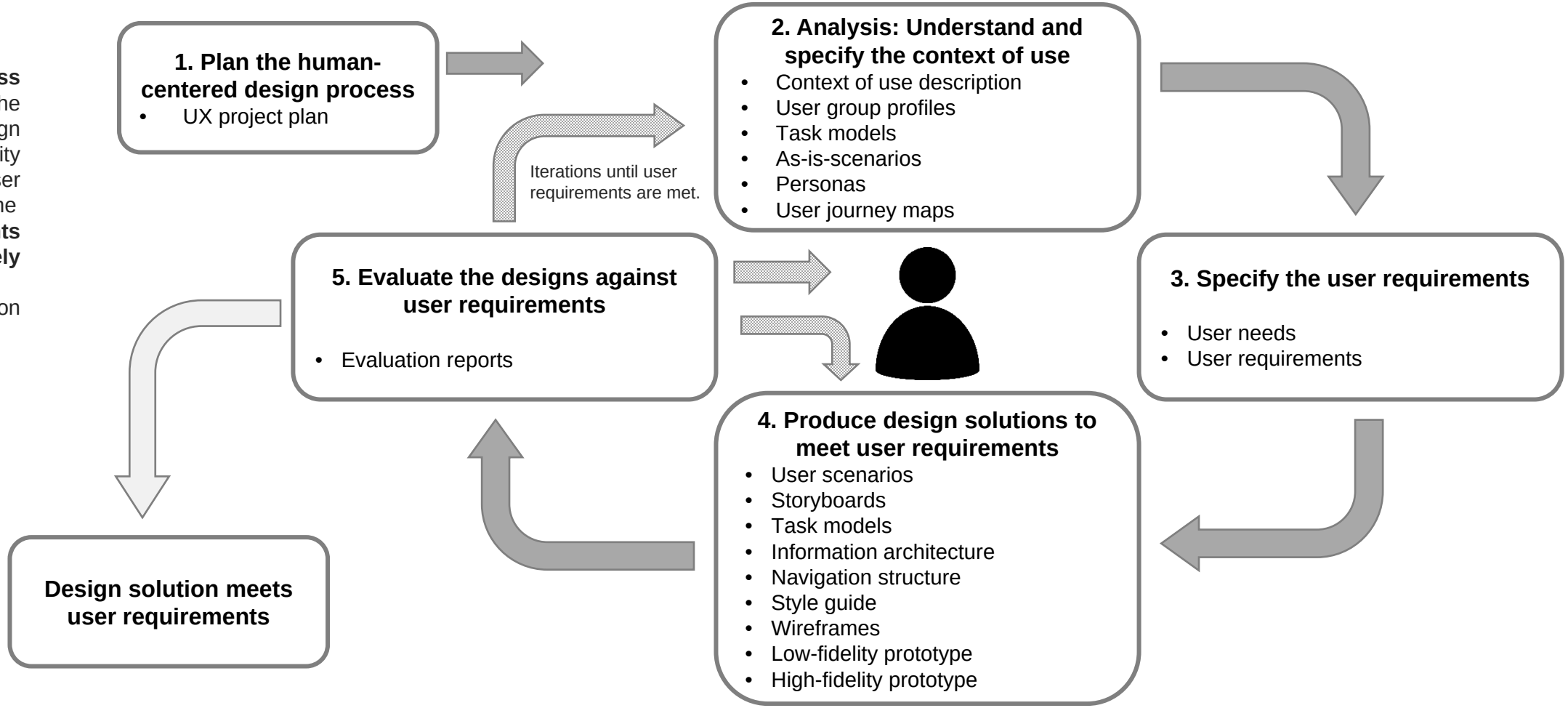
f. Environment ergonomics;

g. Control centres.

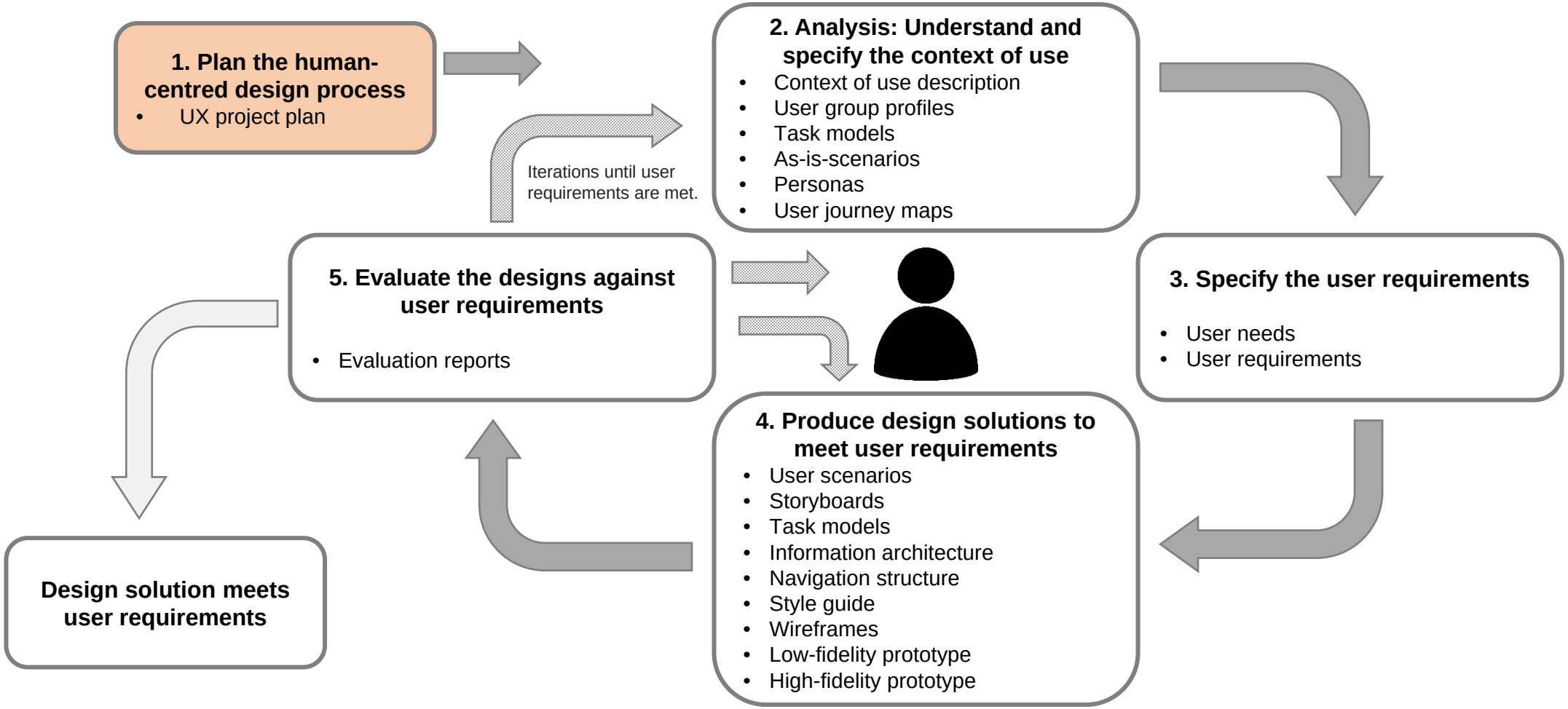
https://i1.wp.com/nottenergy.com/wp-content/uploads/2018/06/ISO-Logo.png?ssl=1

The human-centered design process, ISO 9241-210

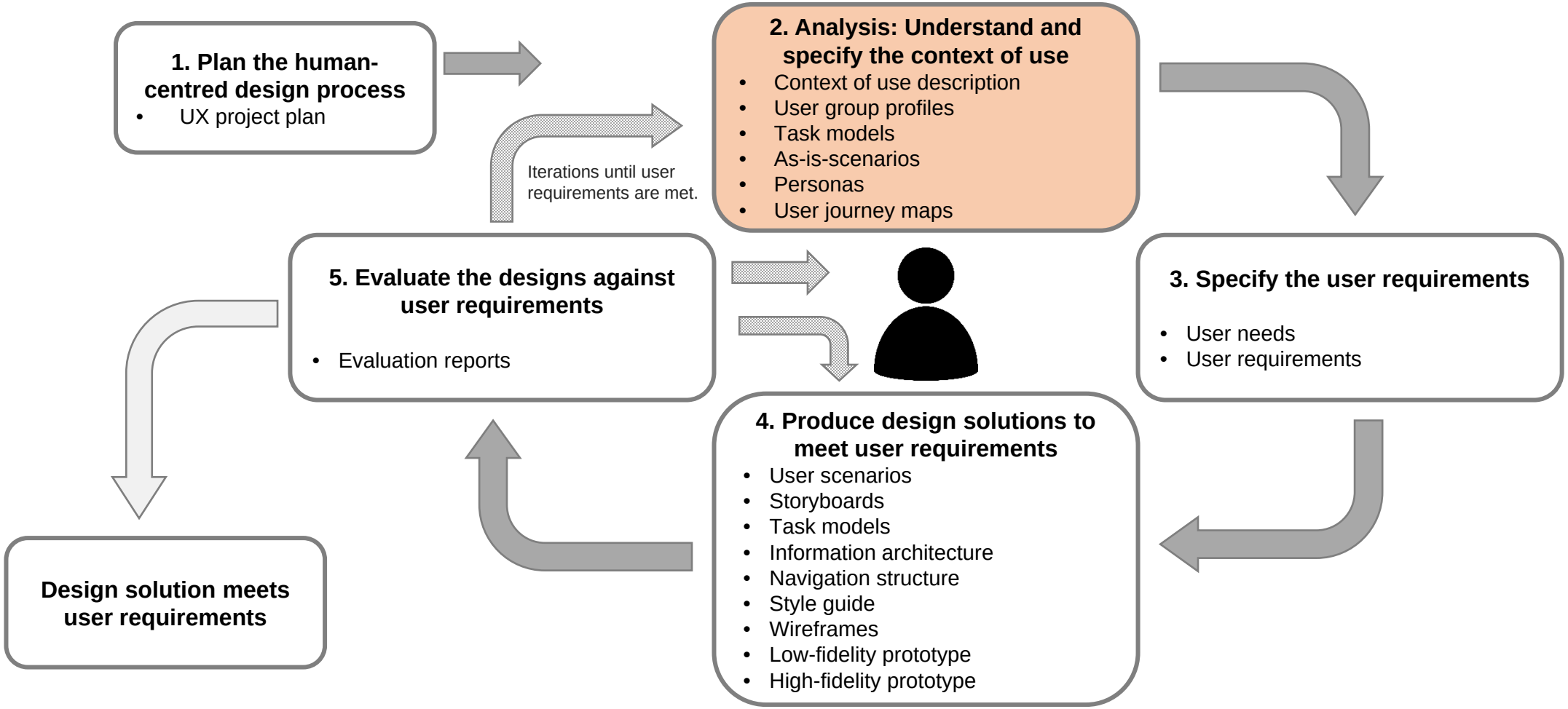
Repetitive.
An **iterative process** repeats steps in the human-centred design process until a usability evaluation of the user interface shows that the **user requirements have been adequately met**.
Process based on **customer feedback**.



1. Plan the human-centred design process



2. Analysis: Understand and specify the context of use

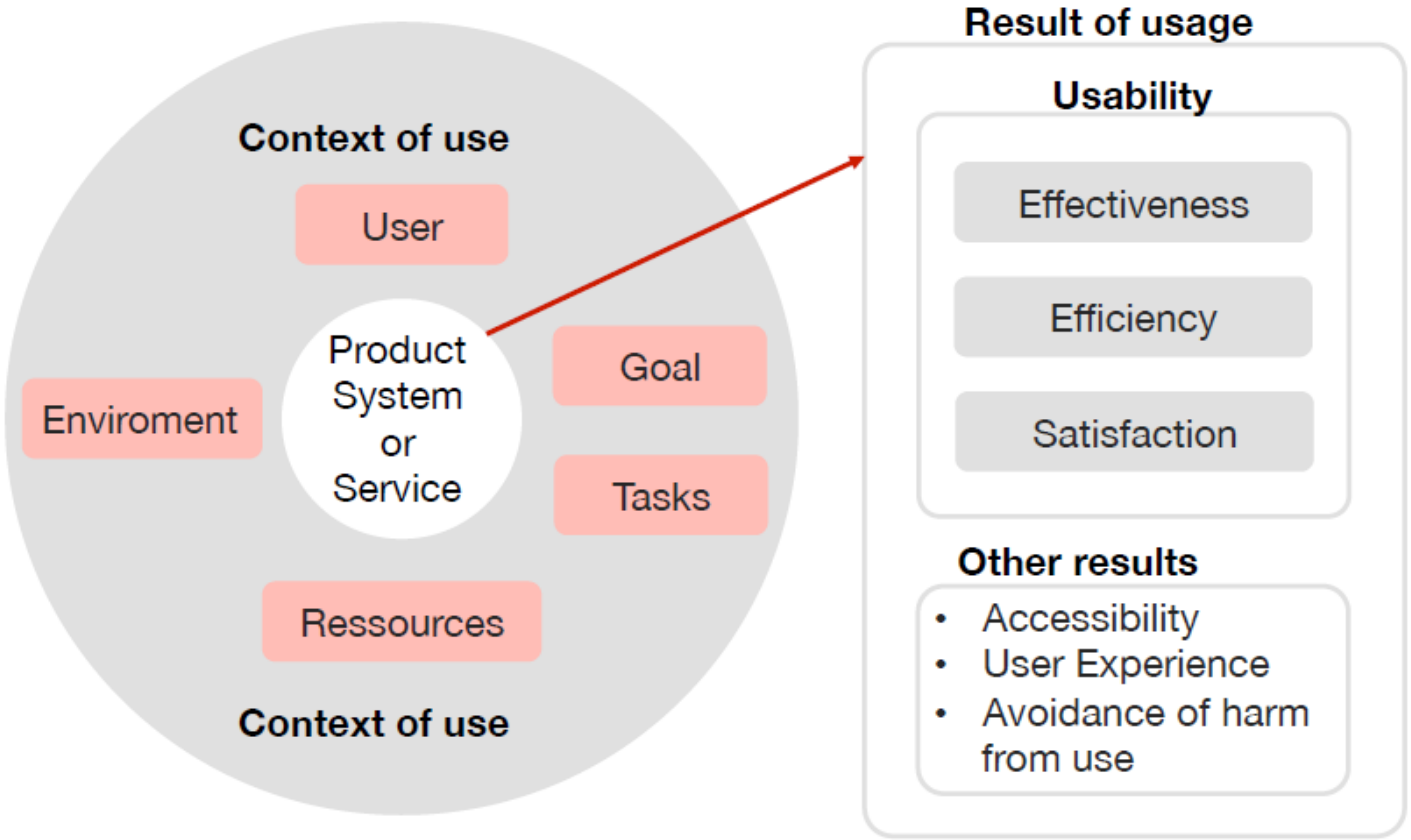


Context of use

A combination of **users**, **goals**, **tasks**, **resources**, and **environments**.

Notes:
1. The context of use is determined by **interviewing users** or by **observing** them carry out tasks.

2. The results from **focus groups**, **observation** and **contextual interviews** are described in the **context of use description**.



Context of use: Example

Example of context of use, users, goals and tasks, environments and resources:

	Example 1	**Example 2**
Interactive System	Messaging App	Parking Assistant
Users	Husband	Driver
Goal	Tell wife he will be late from work.	Park the car.
Task	Send message	Activate the parking assistant.
Social Environment	Marriage	-
Physical Environment	Work	Parking Lot
Resource	Phone	Car

User

A person who interacts with an **interactive system**, or who uses the output of the system.

User group

A collection of **users** with the same or similar personal characteristics and contexts of use related to the **interactive system** (retirees, college students,…)

User group profile

A generalized description of a user group.

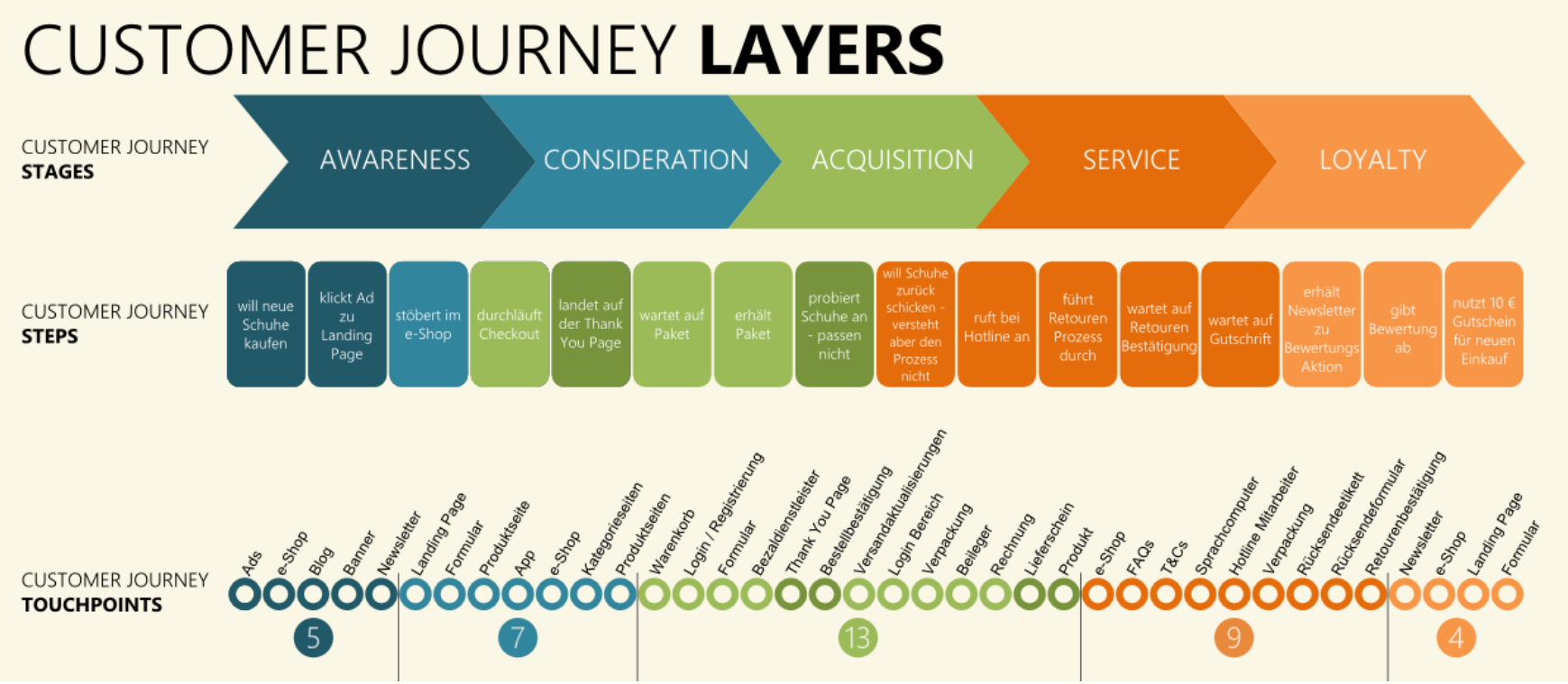
Persona

A description of a **fictitious but realistic user** and what they intend to do when using an **interactive system**.

http://designr.com.br/wp-content/uploads/2018/04/Persona-para-UX-Design-945x628.jpg

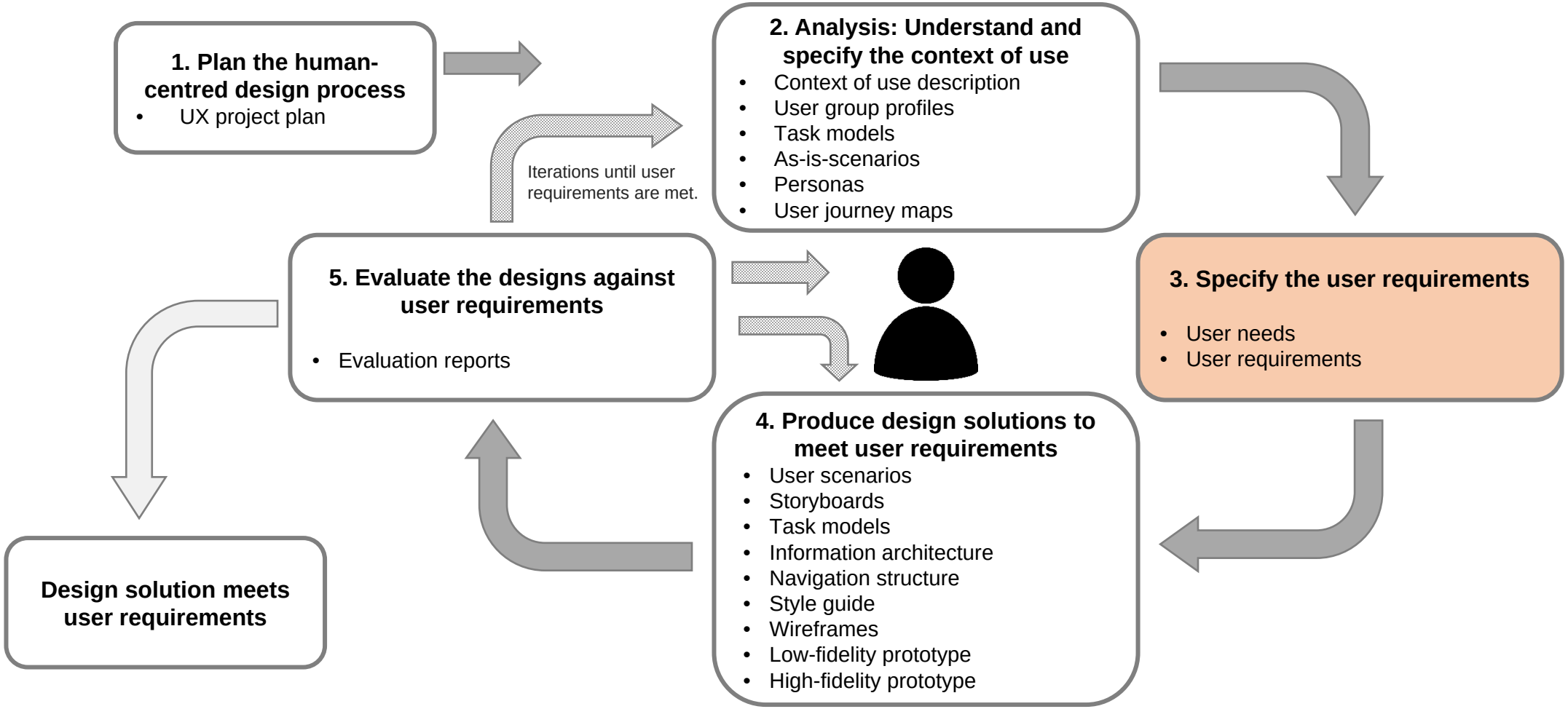
User/customer journey map

A graphical or tabular description of **all encounters users have with the interactive system** covering all touchpoints that influence the user experience, making the overall user experience tangible for others.

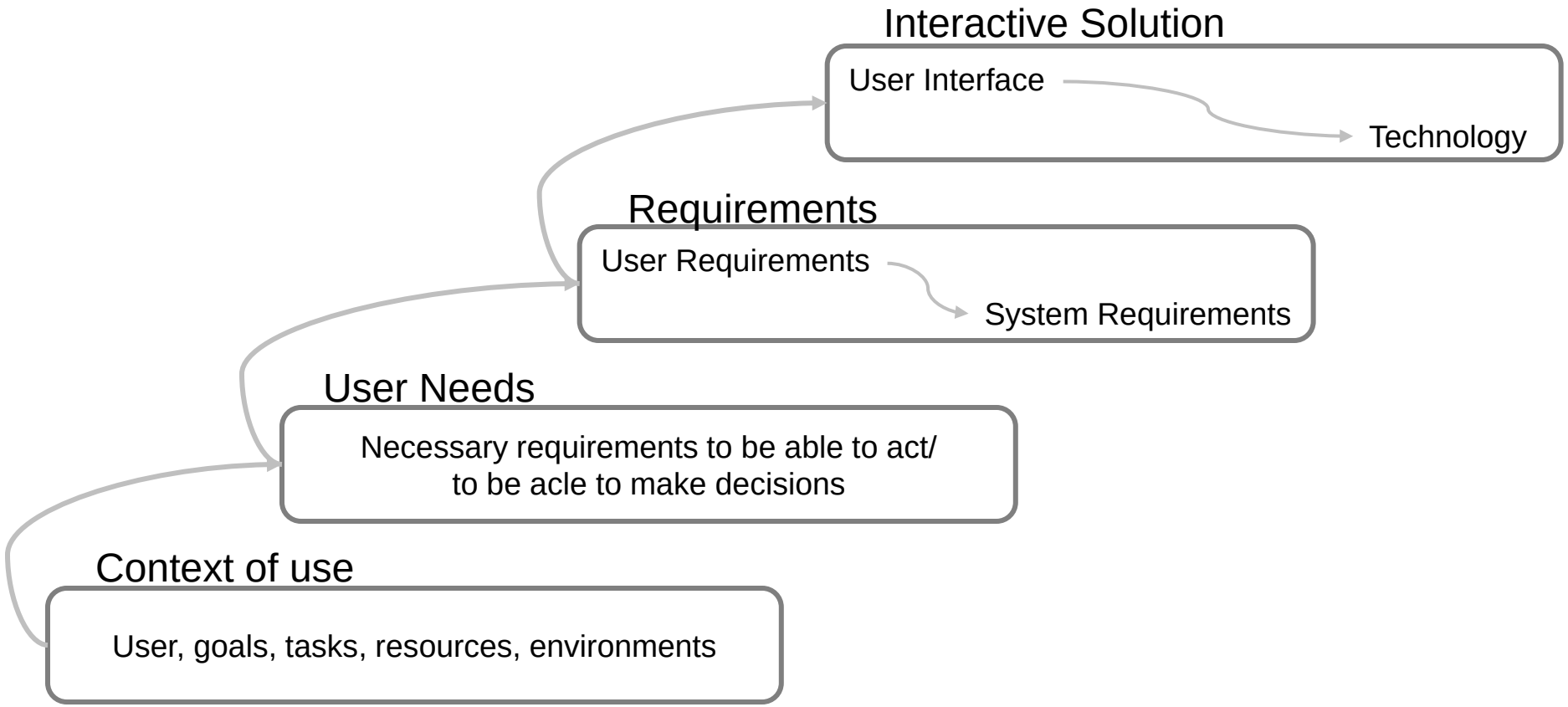


http://www.omkantine.de/wp-content/uploads/2016/04/5_Customer_Journey_Duration.png

3. Specify the user requirements



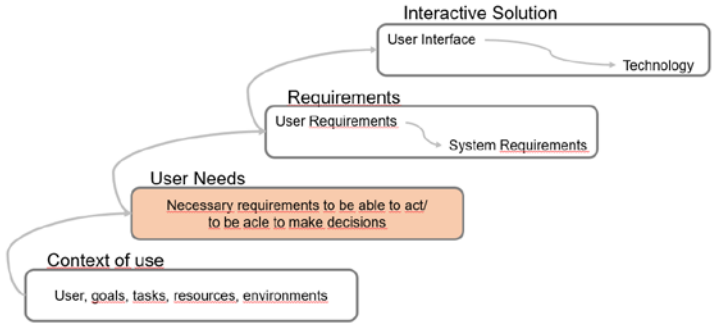
Working model usability engineering



Working model usability engineering: User needs

1. User needs often represent **gaps** (or discrepancies) between **what is** and **what should be**.

2. User needs are transformed into **user requirements**. **User requirements** are then prioritized for implementation, taking the **context of use**, user priorities, trade-offs with other **requirements** and constraints into consideration.

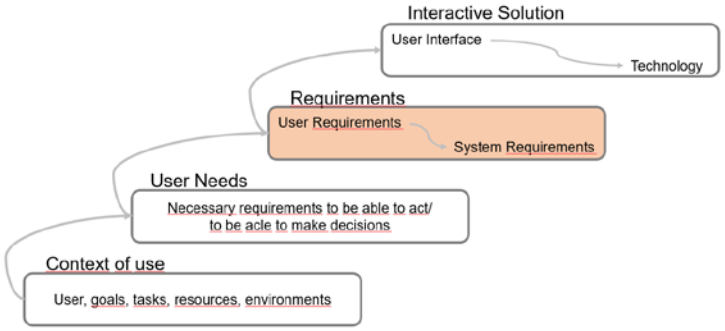


Examples of user needs:

1. During a drive on the highway (**context of use**), a driver (**user**) needs to know if the ACC is active and set to the right speed (prerequisite) in order to comply with road regulations (**goal**).

2. As part of monitoring the cash flow (**context of use**), an account manager (**user**) needs to know the number of invoices received and their amounts (prerequisite), in order to complete the daily accounting log (**goal**).

Working model usability engineering: User requirements



A **requirement** for use that provides the basis for design and **evaluation** of an **interactive system** to meet identified **user needs**.

Notes:

1. User requirements are derived from **user needs**.

2. A user requirement can be a **qualitative user requirement** or a **quantitative user requirement**.

3. Both **qualitative** and **quantitative user requirements** provide a basis for the design of the **interactive system** and can be verified by evaluating the **interactive system**. While **qualitative user requirements** address the way in which the **interactive system** is used to arrive at a user **goal**, **quantitative user requirements** set measurable **goals** for **usability** and **user experience**.

Relationship between user need & user requirement

Examples of relationships between **user need** and **user requirement:**

1. **User need**: Users who frequently rent cars from a car rental company need to know what options they chose for previous reservations so they can apply them to future reservations.

Corresponding **user requirements**:
a. Users must be able to select the types of cars they chose in previous reservations;

b. Users must be able to select the payment methods they used for previous reservations.

Relationship between user need & user requirement

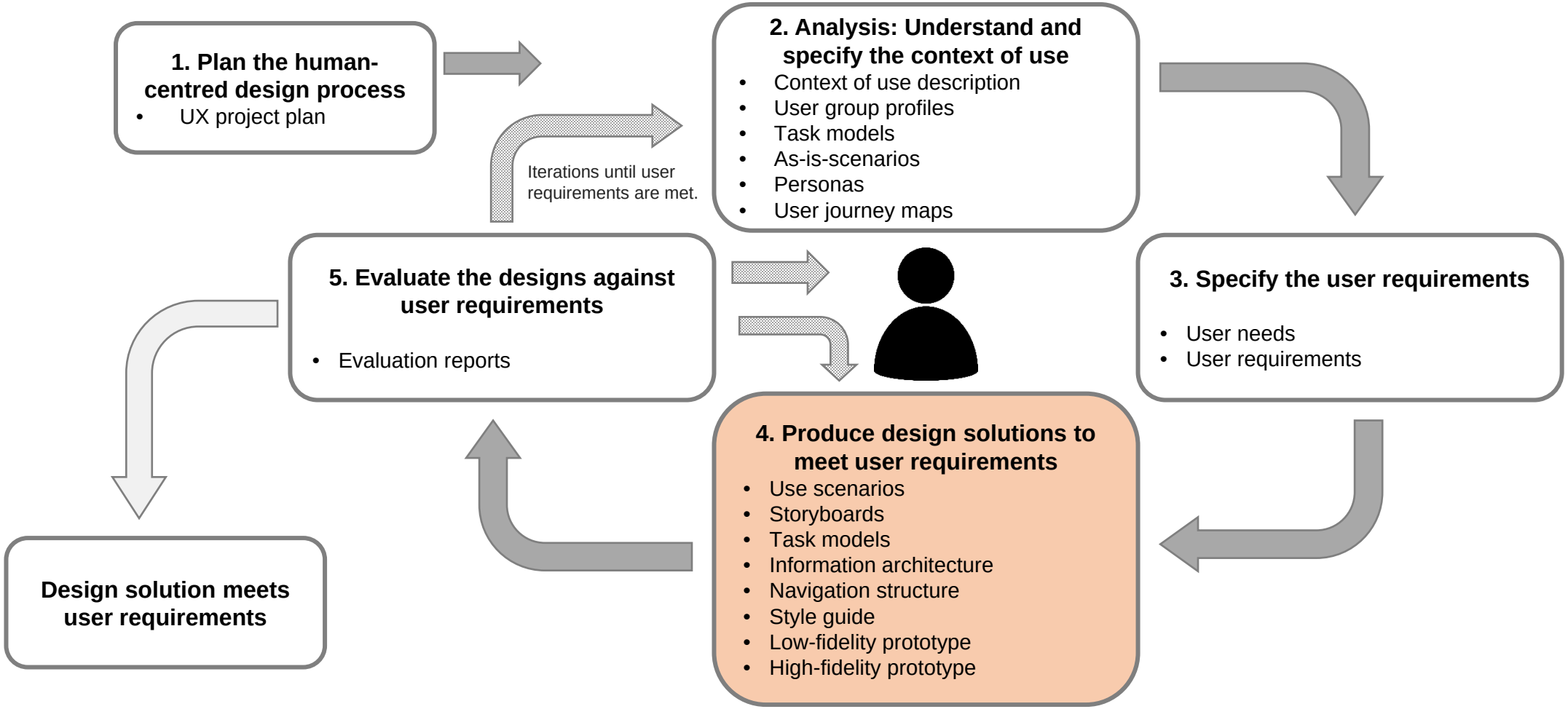
Examples of relationships between **user need** and **user requirement**:

2. User need: Drivers need to always know speed limits to drive safely on public roads and not get in trouble with the police.

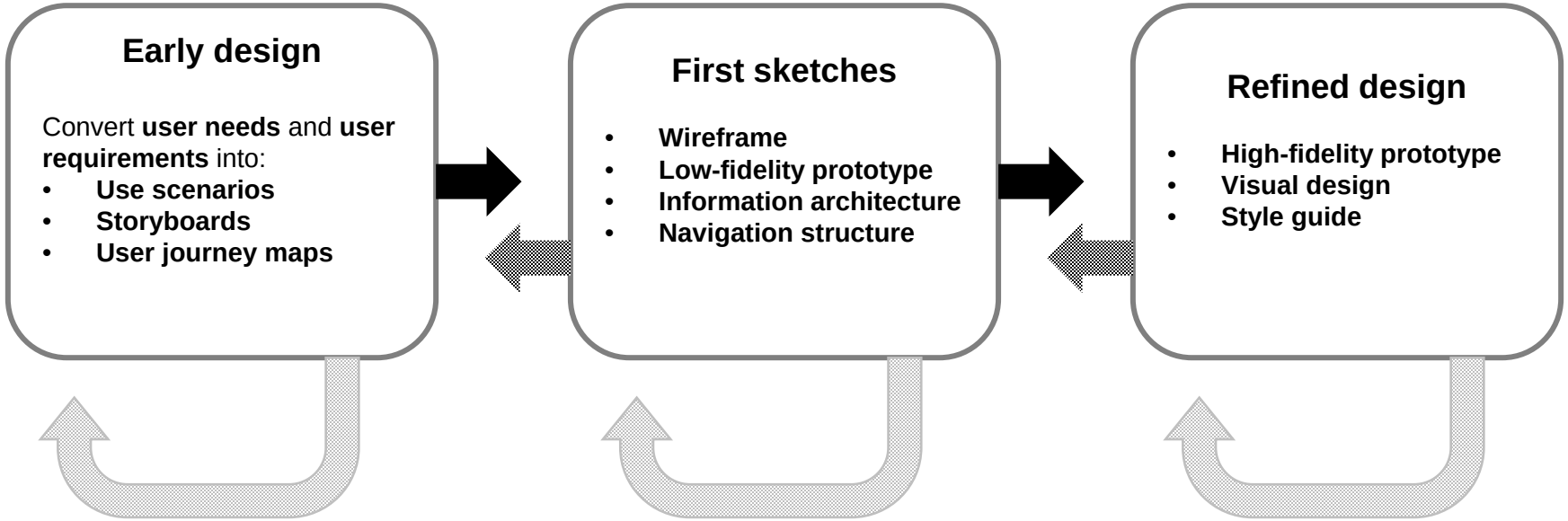
Corresponding **user requirements**:
a. Drivers must be able to see current speed limits in the instrument cluster or head up display at any time.

b. If ACC is available and active, users must be able to accept the new speed limits with a simple action or by default

4. Produce design solutions to meet user requirements

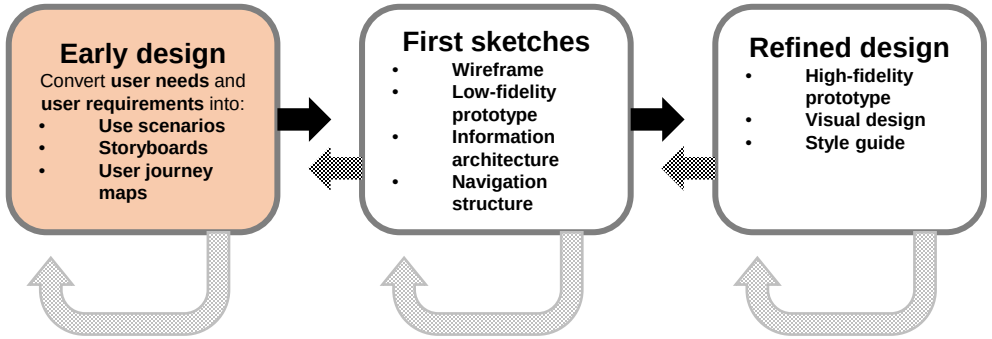


Design Solutions: Iterative Design



Design Solutions: Use Scenario

A narrative text description that describes an intended usage situation with the **interactive system** under development.



Example of a use scenario:
1. “Before leaving for the airport, John Miller checks the availability at the airport car park with his new application. If enough parking spaces are available, he reserves one with his new application and then calmly drives to the airport. He knows that since the application has been launched there is a separate entry for cars with reservations.”

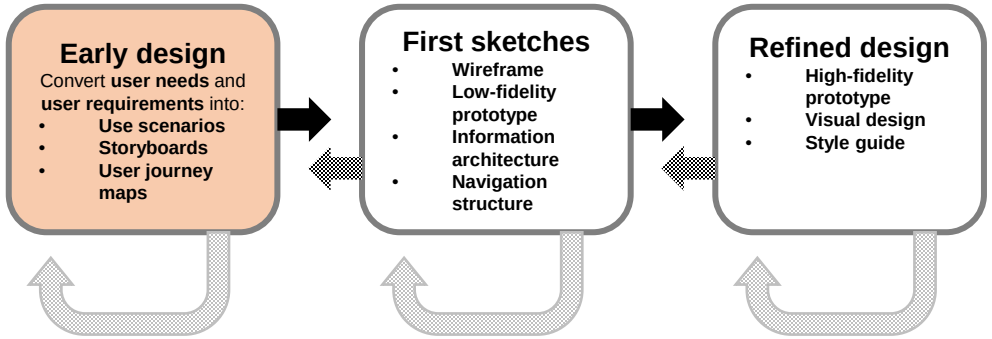
2. The following text is a bad example because it is too specific: “John Miller looks at the ‘Overview of available parking spaces’ screen and selects one by clicking the ‘Select’ button. He then clicks the ‘Reserve’-button and reserves the parking space.”

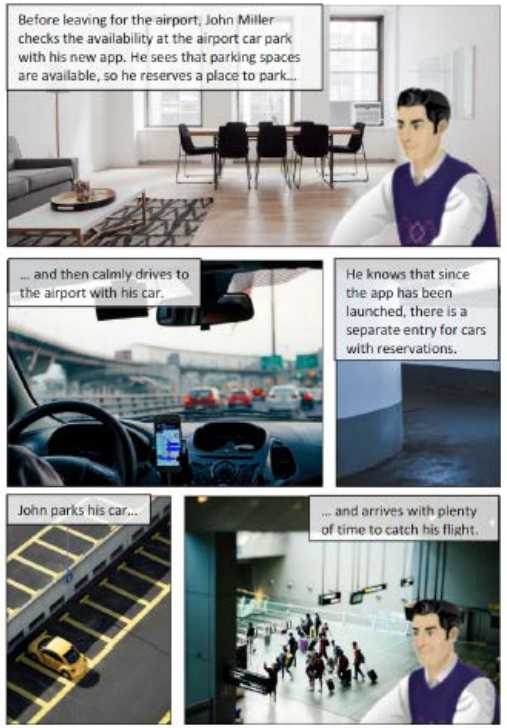
Design Solutions: Storyboard

A sequence of visual frames illustrating the interplay between a **user** and an envisioned **interactive system**.

Notes:

1. The purpose of a storyboard is similar to the purpose of a **use scenario**.
2. A storyboard is a comic book style representation of a **use scenario**.
3. Storyboards can also be used to illustrate a current **user experience**.

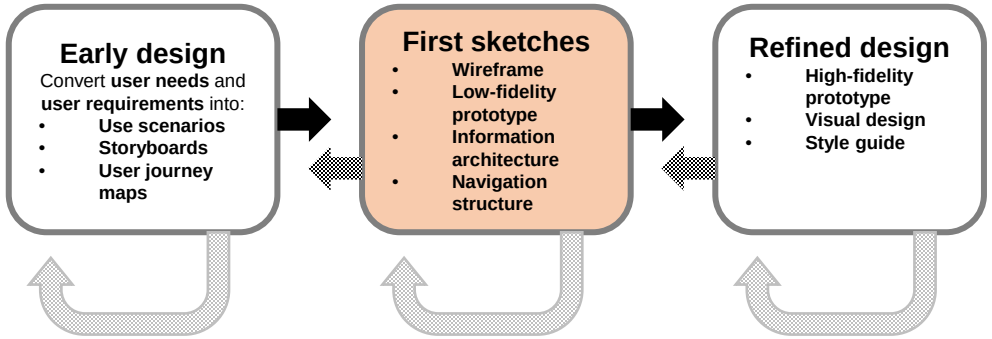


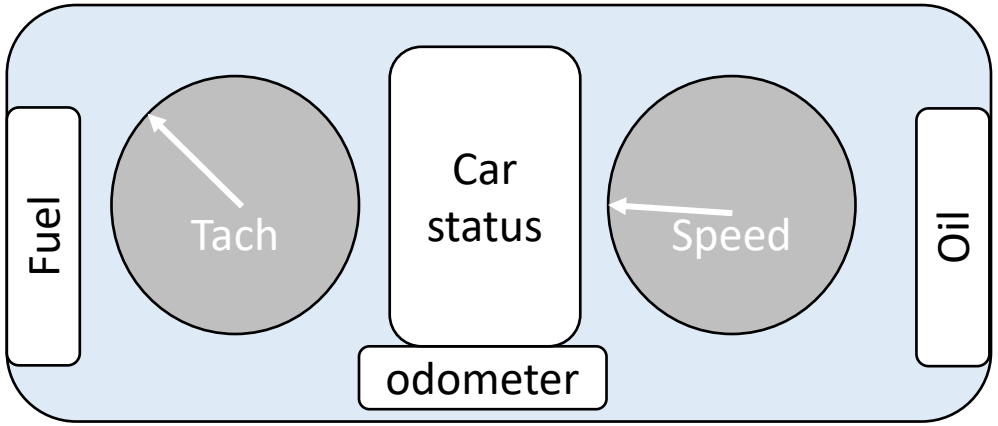


Design Solutions: Wireframe

A screen or page in a **low-fidelity prototype** for a graphical **user interface** comprised of lines, rectangular boxes and text that represent the intended interaction design.

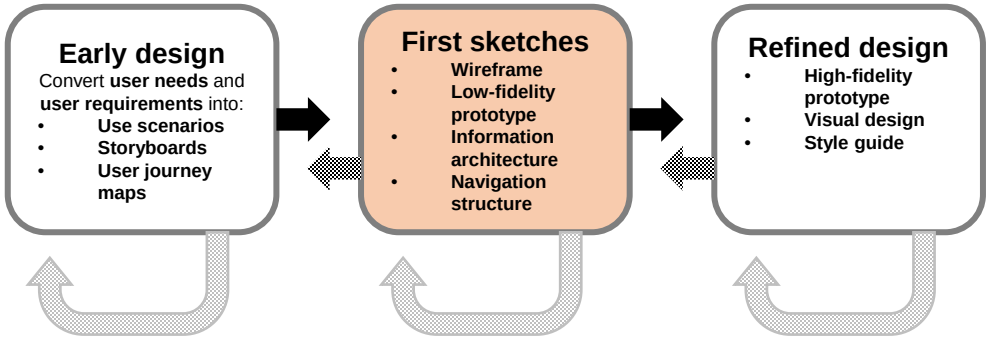
Note:
Wireframes typically do not address visual design and precise layout.





Example: Wireframe for a car's Instrument Cluster

Design Solutions: Information architecture

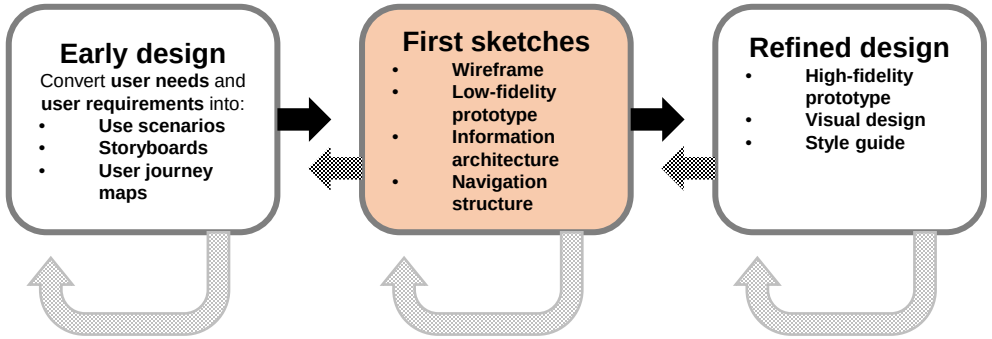


The naming and structuring of the information that must be accessible to the **user**.

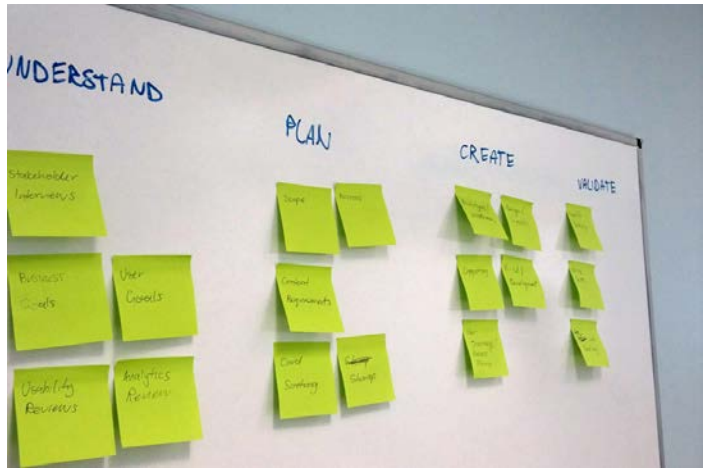
Note:
Examples of UX-related deliverables in the information architecture:
a. Data model from the user perspective; content and content hierarchy;
b. The words used in the **user interface**, for navigation and content;
c. Navigation structure, for example menu structure and site map.

Design Solutions:

Navigation structure / Card Sorting



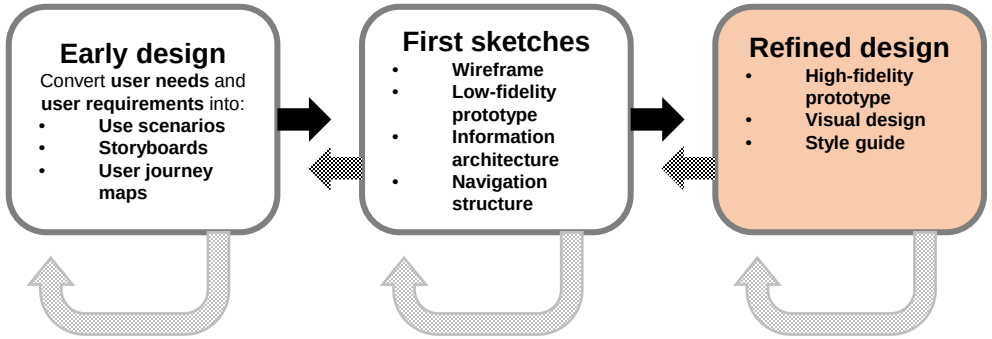
A method for structuring information –
such as menus in a **navigation structure –** that involves writing key concepts onto different cards and asking **users** to sort these cards into groups.



Notes:
There are two methods of card sorting – open and closed:
a. During open card sorting, **users** are asked to sort the cards into groups that they feel represent distinct domains of information.
b. With closed card sorting, the group names are pre-defined, usually by a prior round of open card sorting, and **users** are asked to populate those groups with the cards.

Design Solutions: Lo-Fi-> Hi-Fi Prototype

A representation of all or part of an **interactive system** that, although limited in some way, can be used for analysis, design and **usability evaluation**.



Notes:
The key purposes of a prototype are
a. To facilitate early **evaluation** of the **effectiveness** and **efficiency** of an **interactive system** at a time when it is still reasonably cheap to make fundamental changes to **information architecture** and design.
b. To increase the interest of prospective **users** in the new **interactive system** based on a concrete example. **Users** often find it easier to criticize something than to answer the **open question** “What do you want?”.
c. To show **stakeholders** and colleagues a concrete example of what it is that you are planning.
d. To serve as a specification for the implementation of the **interactive system**. This particularly applies to **high-fidelity prototypes**.

Principles in dialogue design, ISO 9241-110

1. Suitability for the task (Aufgabenangemessenheit)
The property of an **interactive system** to support the **user** in the completion of the **task** – that is, to base the functionality and the dialogue on the **task** characteristics (rather than the technology chosen to perform the **task**).

a. The **dialogue** should present the **user** with information related to the successful completion of the **task**.
b. The **dialogue** should avoid presenting the **user** with information not needed for the successful completion of relevant **tasks**.

2. Self-descriptiveness (Selbstbeschreibungsfähigkeit)
The property of a **dialogue** to, at any time, make it obvious to the **users** which dialogue they are in, where they are within the **dialogue**, which actions can be taken, and how they can be performed.

3. Conformity with user expectations (Erwartungskonformität)
Correspondence to predictable contextual needs of the user and to commonly accepted conventions.

Principles in dialogue design, ISO 9241-110

4. Suitability for learning (Lernförderlichkeit)
A dialogue is suitable for learning when it supports and guides the **user** in learning to use the **interactive system**.

5. Controllability (Steuerbarkeit)
The ability of a **user** to initiate and control the direction and pace of the interaction until the point at which the **goal** has been met.

6. Error tolerance (Fehlertoleranz)
The property of a **dialogue** to achieve the intended result with either no, or minimal, corrective action by the **user** despite evident errors in input.

7. Suitability for individualisation (Individualisierbarkeit)
The property of a dialogue that allows **users** to modify interactions and the presentation of information to suit their individual capabilities and needs.

Principles in dialogue design, ISO 9241-110

TikTok´s **UX/UI** is **designed against ISO 9241**

Elimination of choice

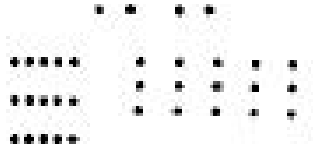
1. Linear content: One video at a time, instead of an array of videos
2. Algorithm-based feed without alternatives

- ~~**Dialogue**~~ **-> Monologue**
- High **user engagement**, over **1.6 billion users** worldwide

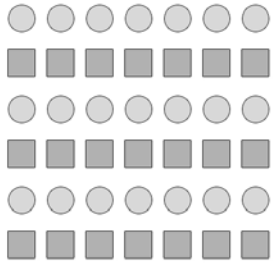
(Bloomberg, April 2022)

Principles in Layout design

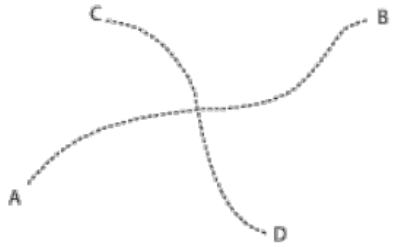
1. Law of Proximity (Nähe)
In the perceptual field, those objects are perceived as **belonging together that have the smallest distance to each other**.



2. Law of Similarity (Ähnlichkeit)
Elements that **resemble each other** to the point of sameness are perceived as **belonging together**.

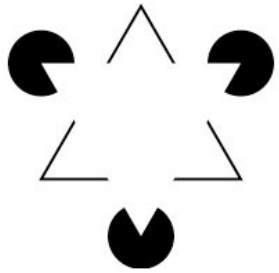


3. Law of Good Continuity (gute Fortsetzung)
Intersecting contours are interpreted as **belonging together** if they appear **as little bent or kinked** as possible.



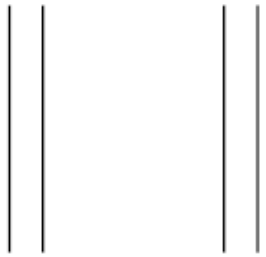
Principles in Layout design

4. Law of Closedness (Geschlossenheit)
When a clear shape emerges, **objects that are partially obscured are perceived as closed**. It also creates a spatial depth.



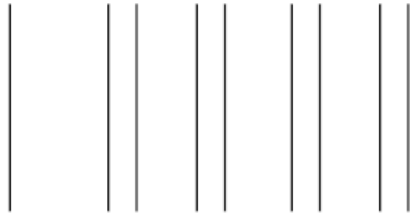
5. Law of Symmetry (Symmetrie)
Symmetrical shapes are interpreted as figures, whereas the asymmetrical components are perceived **as a background**.

6. Law of Same Width (Ebenbreite)
Stripes of the same width are perceived **as the boundary** of a figure (see Law of Proximity).



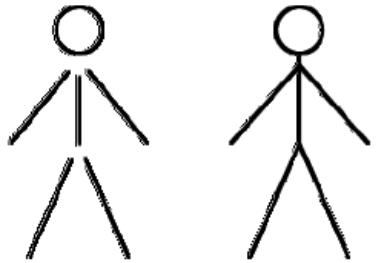
Principles in Layout design

7. Law of Fitting without Remainder (Aufgehen ohne Rest)
Individual elements are perceived in such a way that they are completely "accommodated" and thus **form a whole**.



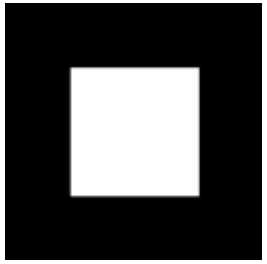
8. Law of Good Continuity (gute Fortsetzung)
Individual elements **arranged along familiar shapes** (e.g., a line or a circle) are more likely to be **perceived as coherent** than others.

9. Law of Good Gestalt (gute Gestalt)
Each figure is interpreted as a structure that is **as simple** (orderly, balanced, coherent) **as possible.** The perception has an inherent tendency to "good shapes".



Principles in Layout design

10. Law of figure-ground Relationship (Figur-Grund Beziehung)
The following aspects are used to differentiate between figure and (background) ground: Closedness, demarcation, texture, color, articulation, contrast, brightness, spatiality.



11. Law of Common Fate (gemeinsames Schicksal)
Elements that change or move uniformly are perceived as units.

12. Law of Past Experience (Erfahrung)
Initially unknown structures are perceived as familiar shapes with meaning (e.g., letters, words) thanks to individual experience.

https://explorable.com/gestalt-laws-form-continuation-common-fate

Voice Assistant – XPeng7

https://www.youtube.com/watch?v=_nqOseVjxl0

Voice Assistant – Alexa

https://www.youtube.com/watch?v=0ckHk3dOk-s

UX in Cars: Outlook

UI/UX facing high levels of automation

Room for personalization

Transfer user profiles car-to-car (Vehicle fleets, Car Sharing)

Hyper-digital consistency: Smartphone, car, smart watch, computer all use same, personalized layout

Anticipate customers wants

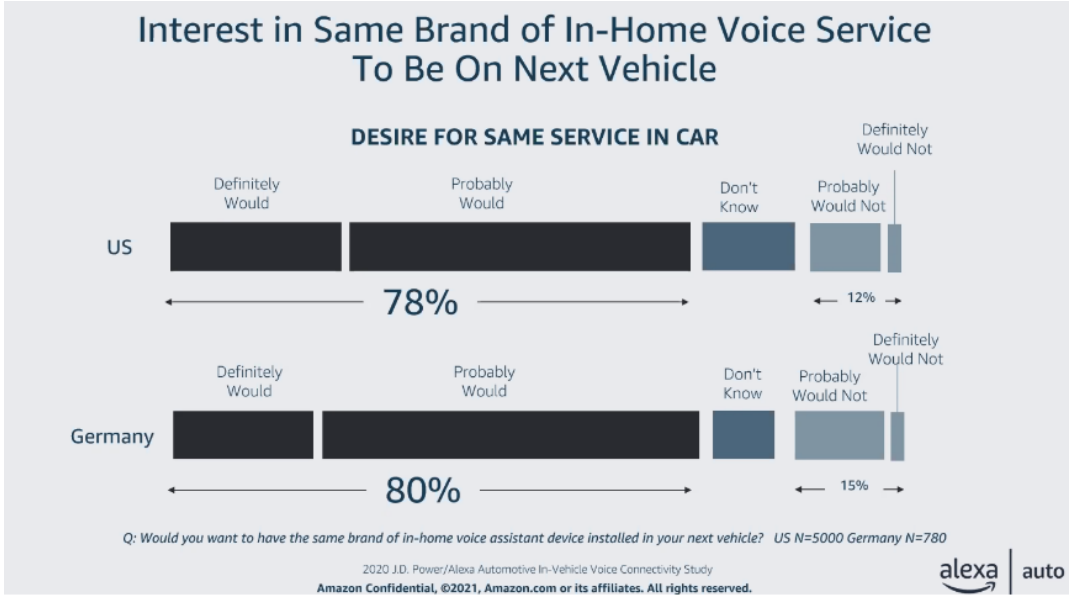
Originally “dumb” functions will have access to **millions of lines of code**: garage door opener, lights, scent, seating position

Occupant monitoring: Emotion detection for **adapted recommendations**

Commute:

To work - Amp you up.

After work - “Entertainment equivalent of a glass of scotch.”

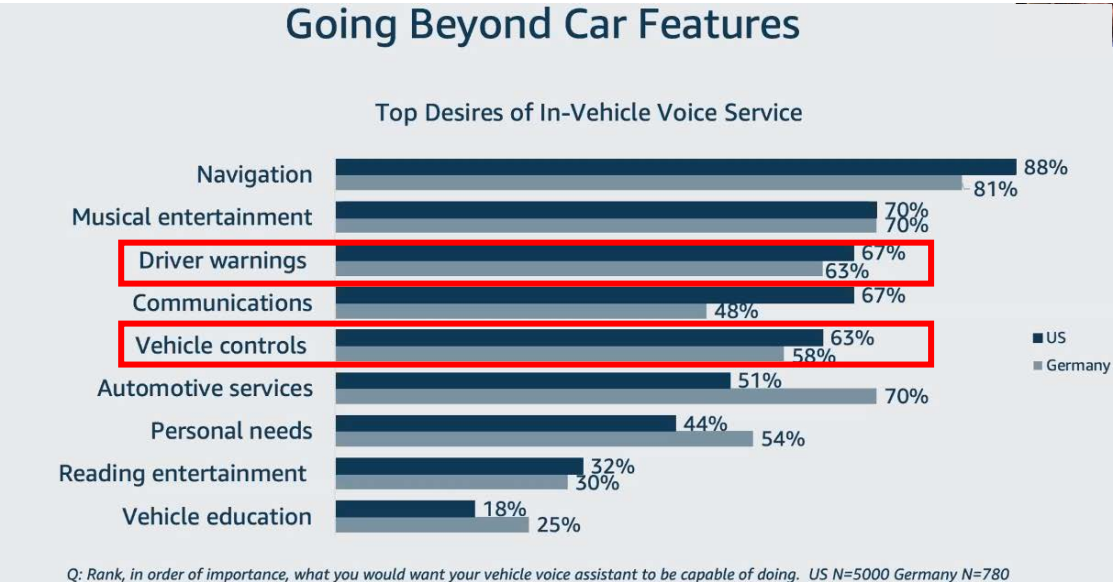


Quelle: alexaAuto

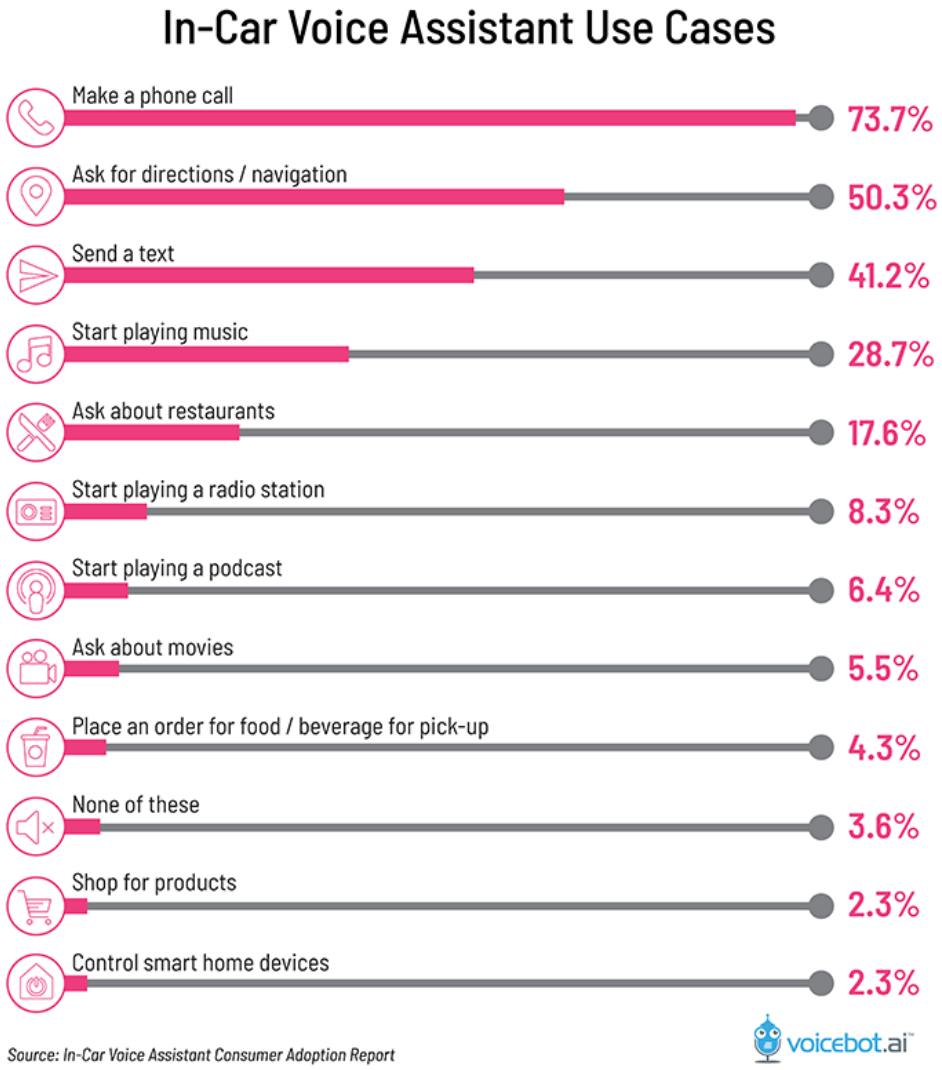
drive livinglab

Kempten University of Applied Sciences

Voice Assistant – Current State



https://research.voicebot.ai/in-car-voice-assistant-consumer-adoption-report-2020/



Voice Assistant – Current State

But…

https://research.voicebot.ai/in-car-voice-assistant-consumer-adoption-report-2020/

And also…

Infotainment is most problematic category: Almost one-fourth of all problems cited by new-vehicle owners relate to infotainment. Top complaints include built-in voice recognition; Android Auto/Apple CarPlay connectivity; touchscreens; built-in navigation systems; and Bluetooth® connectivity.

J.D. Power 2020 Initial Quality Study

Exterior UI

Signal a pedestrian it is safe to pass in front of the car.

Signal for cars behind them that they are braking for a pedestrian.

https://www.mercedes-benz.com/de/innovation/autonomous/forschungsfahrzeug-f-015-luxury-in-motion/

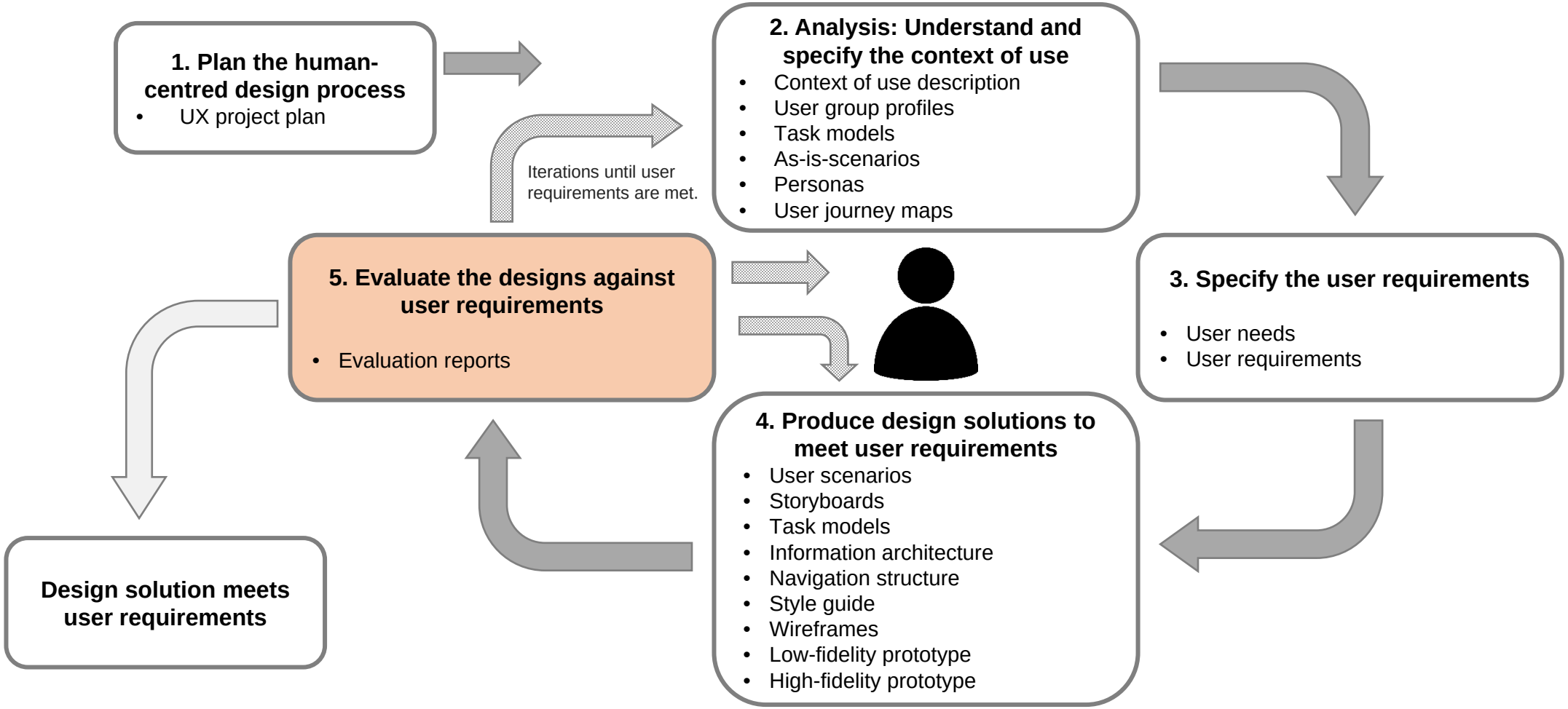
Exterior UI

Show text for other road users

Project crosswalks for pedestrians.

https://www.mercedes-benz.com/de/innovation/autonomous/forschungsfahrzeug-f-015-luxury-in-motion/

5. Evaluate the designs against user requirements



Main activities in a usability test

Terms

Usability evaluation

A process through which information about the **usability** of an **interactive system** is gathered in order to improve the **interactive system** (known as formative usability evaluation) or to assess the merit or worth of an **interactive system** (known as summative usability evaluation).

Usability test

A usability evaluation that involves representative **users** performing specific **tasks** with the **interactive system** to enable identification and analysis of **usability problems**, or the measurement of **effectiveness**, **efficiency**, and user **satisfaction**.

Reminder (slide 21): **Effectiveness, Efficiency and Satisfaction together make up the Usability.**

Usability test task

A description of a **task** that a **moderator** asks a **usability test participant** to carry out during a **usability test**.

Examples of usability test tasks for a vehicle with level 2 assistance:
1. Activate the ACC on the highway and set your desired cruising speed.
2. Reduce the speed with ACC controls by 5/10/17 km/h.
3. Adjust the following distance to the leading vehicle to the smallest possible gap.
4. Deactivate the ACC.

Examples of invalid usability test tasks:
1. Tell me what you think of the instrument cluster (opinion).
2. Navigate through the Head Unit for 5 minutes and tell me what you think (hazy, opinion).
3. Does the car have enough power? (does not address usability).

Procedure for conducting a usability test

1. Preparation: Write a **test plan** and select **tasks.**
2. Recruiting: select and invite candidates that have the appropriate characteristics **(user group)** to participate in the **usability test**.
3. Briefing: inform the **test participant** about the purpose of the test.
4. Pre-session interview: Questions about the **participants**' background and previous experience with the **interactive system**.
5. Task Solving: **Participants** undergo the test procedure.
6. Post-session interview: Questions about the participants' **user experience** and general impression of the **interactive system**.
7. Reporting: write a report with the findings and a recommendation for further steps.

Usability evaluation metrics according to ISO/IEC 9126-4

The ISO/IEC 9126-4 recommends that usability metrics should include:

Effectiveness
The accuracy and completeness with which users achieve specified goals.

$$\textbf{Effectiveness} = \frac{\text{Number of tasks completed successfully}}{\text{Total number of tasks undertaken}}$$

Efficiency
The resources expended in relation to the accuracy and completeness with which users achieve goals.

$$\textbf{Efficiency} = \frac{\sum_{j=1}^{R}\sum_{i=1}^{N}\frac{n_{ij}}{t_{ij}}}{NR}$$

N = The total number of tasks (goals)
R = The number of users
n_{ij} = The result of task i by user j; if the user successfully complete the task, then Nij = 1, if not, then Nij = 0
t_{ij} = The time spent by user j to complete task i. If the task is not successfully completed, then time is measured until the moment the user quit the task.

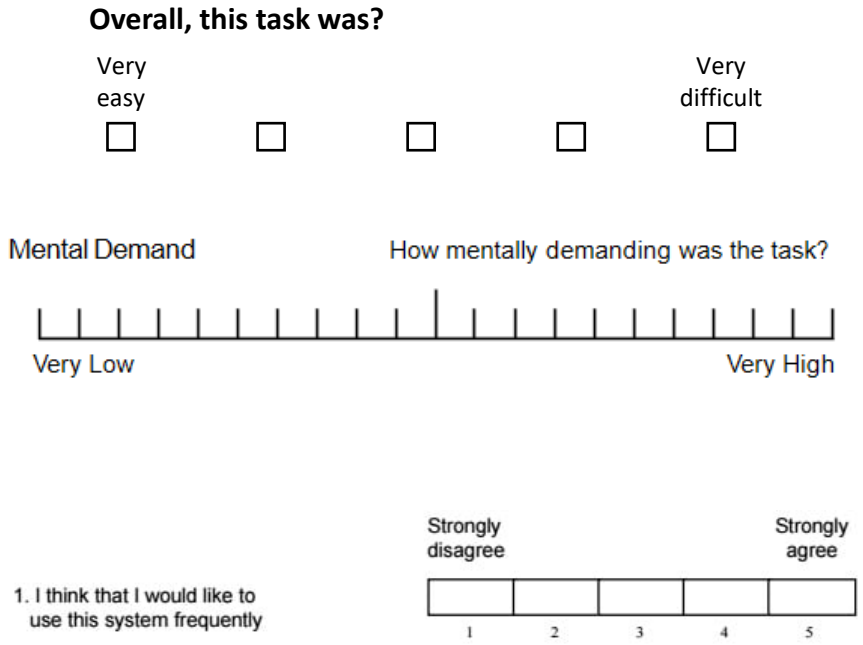
https://usabilitygeek.com/usability-metrics-a-guide-to-quantify-system-usability/

Usability evaluation metrics according to ISO/IEC 9126-4

Satisfaction
The comfort and acceptance of use.

Task Level Satisfaction
Questionnaires to be filled in immediately after the task:
ASQ: After Scenario Questionnaire
NASA-TLX: NASA's task load index is a measure of mental effort
SEQ: Single Ease Question

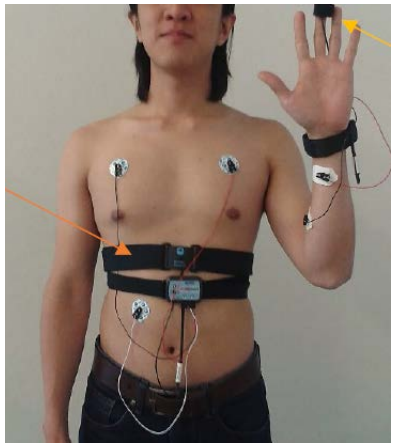
Test Level Satisfaction
Questionnaires to be filled in at the end of the test session:
SUS: System Usability Scale
SUPR-Q: Standardized User Experience Percentile Rank Questionnaire



https://usabilitygeek.com/usability-metrics-a-guide-to-quantify-system-usability/

Objective evaluation methods

While questionnaires only yield subjective (biased) data, there is ways to capture objective (unbiased) data during a **usability test** with the help of measurement setups**.**



Physiologial Metrics

Biosignals like heart rate, sweat gland activity and muscle activity indicate stress that the participant experienced while solving a task.

Eye Tracking

Metrics derived from eye movement can help evaluate an HMI, e.g., by showing where participants look first or longest and how often the focus switches between points of action.

https://www.ergoneers.com/

Head Tracking

Head movement can show if a display arrangement complies with ergonomic standards.

Usability test: Parking Assistant Example

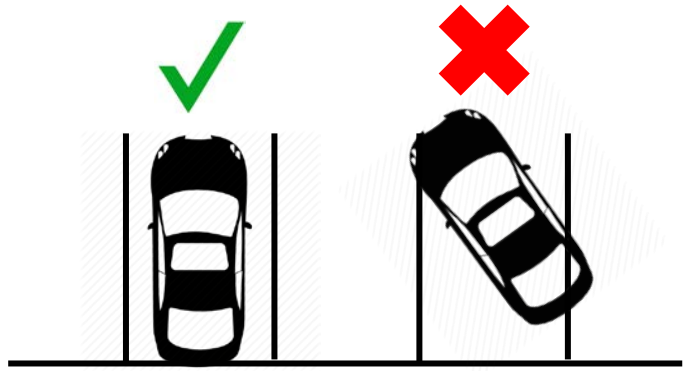
User Group
Students

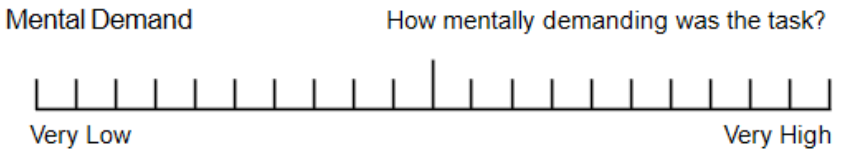
Task
Use the automated Parking Assistant to park the vehicle.

Measure of Effectiveness
Car is parked within markings yes/no.

Measure of Efficiency
Time until automated parking maneuver is completed.

Measure of Satisfaction
Questionnaire (e.g., NASA-TLX), Post-Task Interview

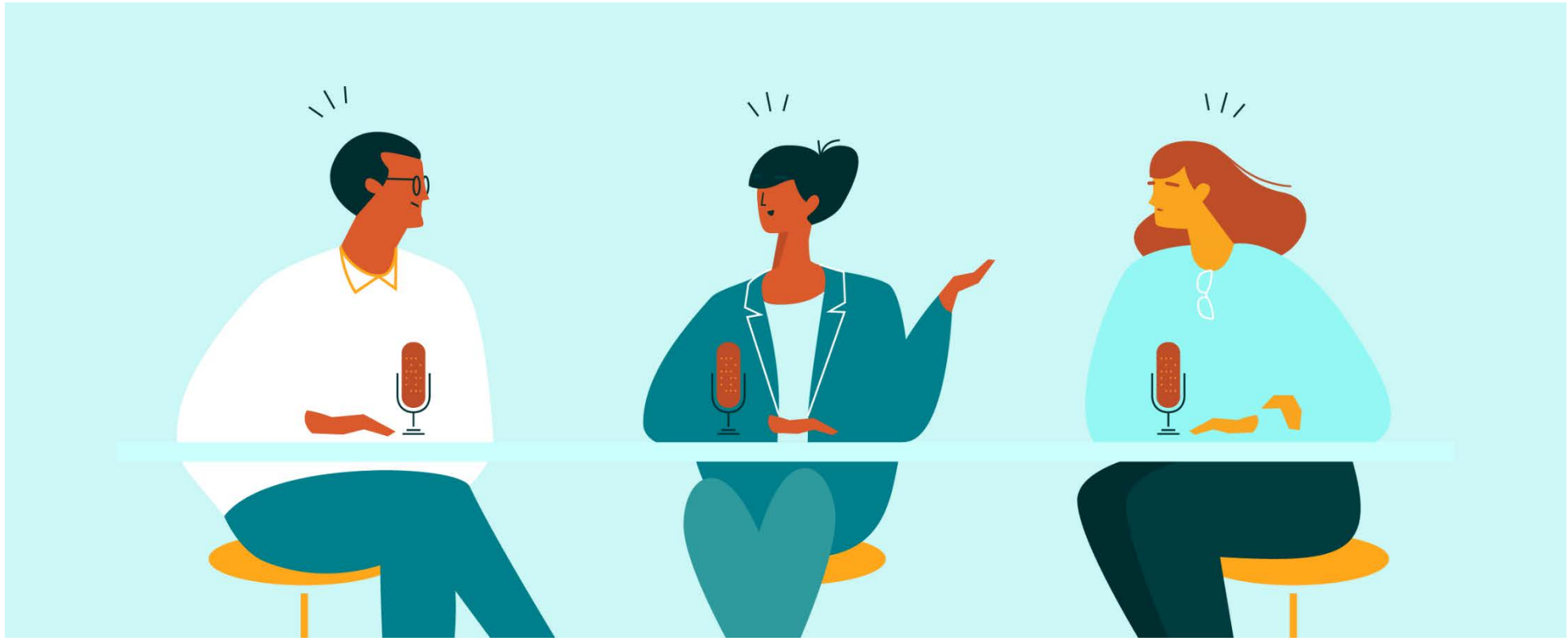




Workshop: Online Usability Test/HMI Evaluation (60-90 min)

https://www.screensstudio.com/

Workshop: Results Presentation & Discussion



https://blogmedia.evbstatic.com/wp-content/uploads/wpmulti/sites/3/2018/01/03211704/panel.png

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