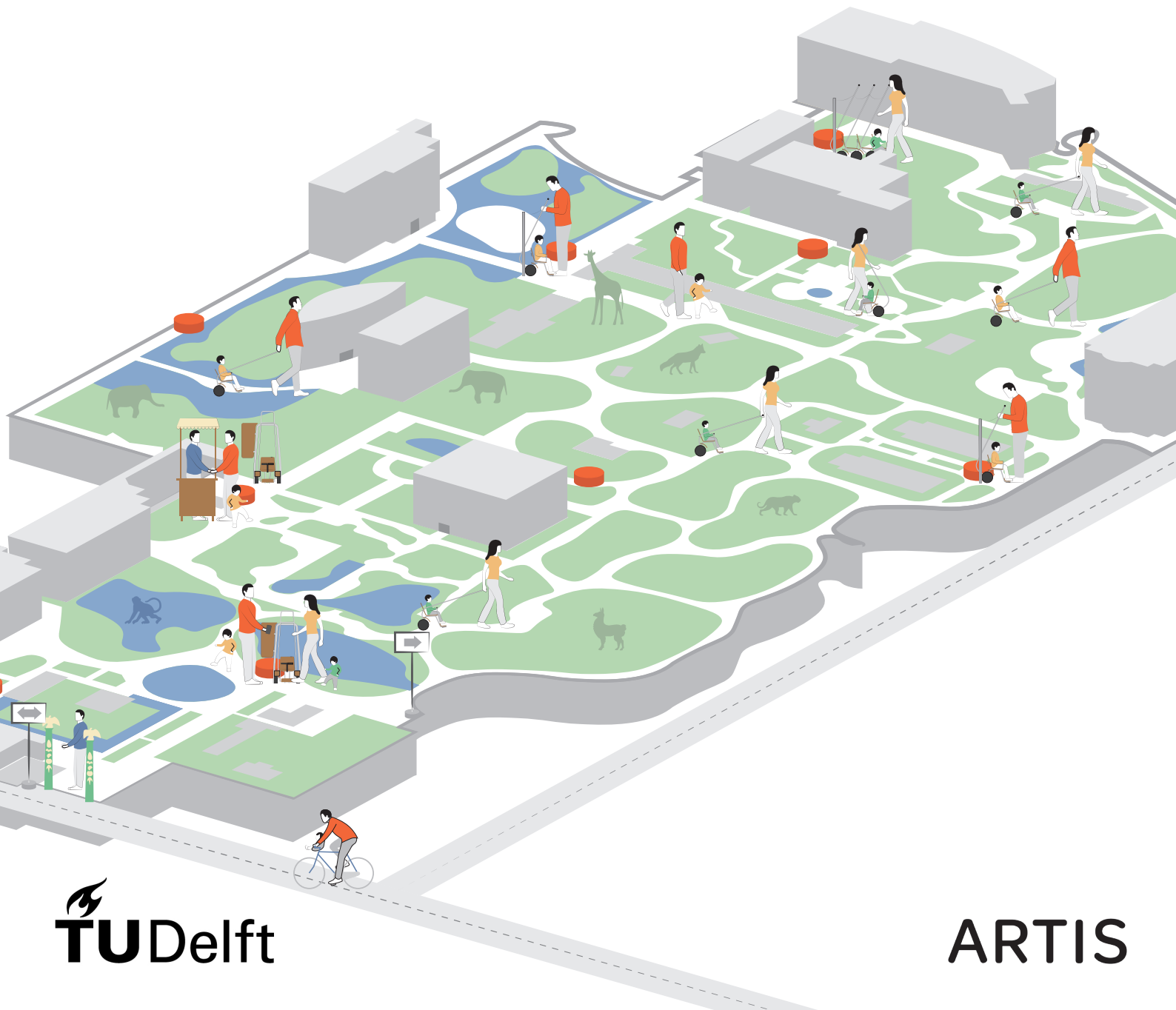


Accessible last-mile mobility support for children in Artis

a product-service proposal

Lotte Hoeksma
Master thesis
Integrated Product Design

Delft, August 2020



Accessible last-mile mobility transport for children in Artis
a product-service proposal

Delft, 20th of august, 2020

Master Thesis

Msc Integrated Product Design
Faculty of Industrial Design Engineering

Author

Lotte Jantje Hoeksma

Supervisory team

Chair | Prof. ir. Jos Oberdorf
Mentor | ir. Caroline Kroon
Company mentor | Frits Hogen Esch

Delft University of Technology

Faculty of Industrial Design Engineering
Landbergstraat 5
2628 CE Delft
The netherlands

ARTIS

Plantage Kerklaan 38-40
1018 CZ Amsterdam
The Netherlands

Preface

Dear Reader,

With this final thesis, I conclude my graduation project and thereby my studies at the TU Delft. Eight years of studying and adventures led me to this final graduation project in Artis. A place where I used to come often as a child and have now had the opportunity to experience from a different point of view.

First and foremost, I would like to thank Artis for the unique atmosphere and my colleagues for sharing their knowledge. I now know, it takes much more than animals to run a zoo. In particular, I would like to thank Frits Hogen Esch, for giving me the confidence and opportunity to start messing with one of Artis much-valued icons, the children's carts. Your enthusiasm throughout the project was contagious.

I would also like to thank Artis' visitors for sharing their experiences, participating in interviews and user tests resulting in valuable insights throughout the project.

In particular, I want to thank my graduation committee Jos Oberdorf and Caroline Kroon for their guidance and showing me that designing is a team effort. Jos, thank you for 'shooting from the hip' which challenged me to bring my work to a higher level each time. Caroline, thank you for the personal way of coaching and the pep talks when I needed them.

Next, I would like to thank Indy for her creative thoughts and time during two days of intensive brainstorming. I want to thank Daan for his help with 3D-printing and rendering. Jan, thank you for helping me bending and soldering, it made the cart come to life.

I would like to thank my friends and family who supported me throughout my studies. I especially want to thank my brother, Stijn, for making remote studying feel close, Ivo for his positive mindset and my parents for the endless support which got me to the finish line.

Finally, thank you reader for taking interest in my thesis and enjoy the read!





Executive summary

As the oldest zoo of the Netherlands, Artis aims to provide her visitors with a carefree experience. **Artis offers mobility support by means of freely available carts to ease the visit of young children and their caregivers. The identified shortage of children carts influences the visitor experience negatively.** Increasing the number of carts is not considered an option because of the lack of space in the park and high costs per cart. Furthermore, the cart retains an iconic status within the park, which makes Artis hesitant to change.

This research aimed to **redefine the mobility support service for children and caregivers in Artis.** The goal was to design a product-service combination that fulfils both the needs of the visitor, Artis staff and management.

Wide-ranging research including interviews, observations and desk research brought together the views of the internal stakeholders and visitors. Synthesis of data points and insights showed that **there is not only a shortage of carts and a lack of space, but that the current service does not meet the expectations of the visitor.** The service was thought to be unpredictable, inaccessible and unavailable and the cart was considered unsafe, not suitable for all relevant ages, and had many physical shortcomings. Also, the service blueprint showed that the service challenges the organization by high demand for maintenance, unpredictable daily servicing and unwanted involvement of the front office. Concluding, **both the service and cart needed to be redesigned to tackle the identified problems.**

Key challenges and design criteria were formulated to guide the design process; the service-product combination should provide suitable and safe mobility support for caregivers and children aged 1 up to and including 3 years of age which can be picked up, left and parked any time. A self-service is sought that is predictable and accessible. The service should provide sufficient capacity, require minimal (daily) maintenance, fit the park vision and should use minimal space in the park.

An intensive design process followed and resulted in a product-service proposal. The proposed service provides readily available and predictable mobility support that fits children and their caregivers with different age-dependent needs. A large number of inviting and safe, one person pull-carts is offered which can be picked up and left at any of the ten compact stations throughout the park, thus stimulating intermittent use. It is a non-supervised self-service using tokens. The cart is made of simply bent powder-coated steel tubes and weather-resistant wood, making the cart durable, relatively easy to produce and maintain. The carts nest in stations allowing for minimal use of space, they are unobtrusive and can be scaled up easily.

The proposal was evaluated with visitors and main internal stakeholders. Visitors saw value in the possibility to take and leave a cart at the different stations and the availability of information made it accessible. Furthermore, the cart was considered safe. The Artis staff considered the **concept valuable in the short term and long term and concluded that implementation of (parts of) the concept would improve the visitor experience.** Review of the newly designed product-service concept leads to the conclusion that the proposal is an improvement on the current service.

Time restrictions limited further development of the concept. Before the cart is production-ready, **several parts need further development and testing with 1:1 scale prototypes.** Meanwhile, elements of the proposed service can already be integrated to improve the current service. Interactions with new service touchpoints can then be **validated in the park.** When the new service is launched, practice must show if the stations are located in the right place and if the number of the proposed carts and stations suffices to stimulate the sharing of carts.

Content

Preface	5
Executive summary	7
1. Introduction	11
1.1 Introducing the project	12
2. Analysis	15
2.1 Artis	16
2.2 Mobility support in Artis	20
2.3 Role of internal stakeholders	27
2.4 Visitor research in park	30
2.5 Designing for children	34
2.6 Mobility support in other zoo's	36
3. Synthesis	39
3.1 Service blueprint	41
3.2 Main pain points of the current service	44
3.3 Conclusion research and Challenges	45
3.4 Design criteria	48
4. Summary design process	51
4.1 Service design	52
4.1 Cart design	56
5. Product-service proposal	61
5.1 Accessible last-mile mobility support for children in Artis	62
6. Concept elaboration	69
6.1 Service and corresponding touch points	70
6.2 Design of the station	74
6.3 Elaboration on the design of the cart and its main parts	76
6.4 Costs and maintenance	80
7. Evaluation	83
7.1 Scale models	84
7.2 Design evaluation	85
7.3 Visitor evaluation	88
7.4 Stakeholder evaluation	90
8. Conclusion	93
8.1 General conclusion	95
8.2 Tackeled challenges	96
8.3 Recommendations	98
8.4 Reflection	101
8.5 Literature	102



CHAPTER 1

Introduction

SECTION 1.1

Introducing the project

Project aim

Imagine going to Artis with your two-year-old child. After stalling your bike, you pass the entrance and the monkey rock and take a cart. It is time to explore Artis.

Artis aims to provide her visitors with a carefree experience offering several services and facilities. To ease the visit of young children and their caregivers specifically Artis offers mobility support by means of freely available carts.

Artis is confronted with several problems involving their mobility support service. An internal study (Factpack Horeca en overige faciliteiten, 2019), noted a shortage in the number of carts and advised to increase its number to meet current and future demands.

However, increasing the number of carts is no easy matter because of space limitations inside the park, possible costs and strong feelings about the authenticity of the cart.

The project aimed at redefining mobility for children and their caregivers in Artis. The goal of the project was to design a product-service combination that fulfils the mobility needs of the children aged one up to and including three years of age and their caregivers visiting the zoo. The aim was to find a solution that can be implemented in the short term and will last for the future.

Approach

The project started with an Analysis phase to get a broader perspective on the context, the user and the service as a whole. The views of the internal stakeholders and the behaviour of visiting caregivers and their children were investigated. Competitive services were compared and knowledge about designing for children was acquired. Insights were obtained from interviews, observations and desktop research. This led to a thorough understanding of the

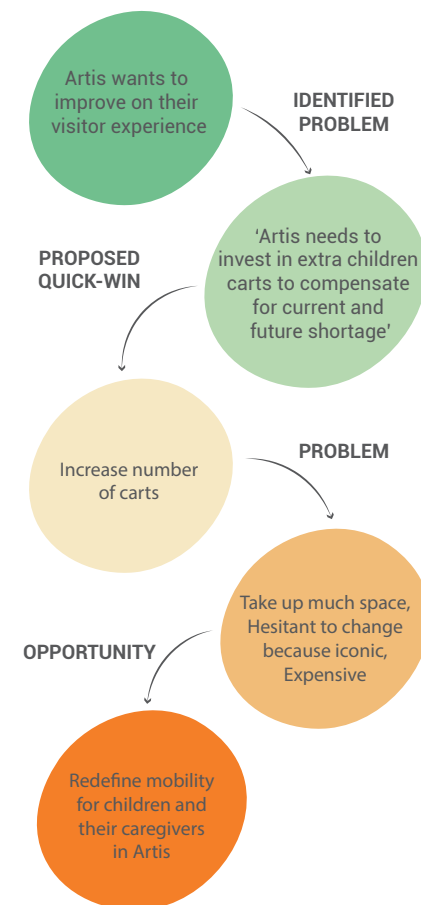


Figure 1.1: Visual of initial project brief

journey of visitors with children using mobility support in Artis described in chapter 2.

In the next phase described in chapter 3, named synthesis, data points and insights from the research were brought together and mapped in a service blueprint. Pain points in the visitor scenario and internal organization were identified. Conclusions and main problems were translated into eight key challenges for the service and cart. An extensive list of design criteria followed from the key challenges and insights.

Chapter 4 describes the design process and how the challenges were translated into a service concept with a specially tailored cart.

Three possible service directions followed from clustering ideas, post-its and sketches. The most valuable direction was chosen after evaluation with stakeholders. Thereafter, the cart was designed. Brainstorms, CAD models, sketches and mock-ups supported several iterations which resulted in the final design of the cart and service concept.

The heart of the report, Chapter 5, presents the designed product-service concept aiming to provide accessible and flexible mobility support, it clarifies the main characteristic and summarizes the main benefits of the concept relative to the present service. Details on the service, the involvement of internal stakeholders, and description of all touchpoints are given in chapter 6. Chapter 6 also elaborates on the design of the station and cart, materials used, production, maintenance and costs.

The concept proposal was evaluated with internal stakeholders in Artis as well as with visitors by discussing the challenges, storyboards and several physical scale models. The design of the cart was evaluated and points for improvement were identified. Chapter 7 presents the evaluation.

The report concludes with a reflection on how the concept tackles the challenges in chapter 8. Short-term and long-term recommendations are presented in the last section of the report. Appendices are presented in a separate document.

Note: This approach has been described mostly linear, for clarity reasons. The actual process was much more iterative, continuously switching between design, analysis and synthesis throughout the project.

Reading guide

The report describes the analysis, synthesis, design process, concept proposal both compactly and elaborately and ends with conclusions and recommendations. Those who want to quickly scan the report should read paragraphs marked with a blue line (like this one) and chapter 5, the concept proposal, the focal point of the report. Readers interested in the details of the design and how it came about can read chapters 3, 4 and 6. Chapter 8 reflects on how the proposal meets the challenges and what should be done to continue the project, this is worth reading for those who want to develop the concept further.

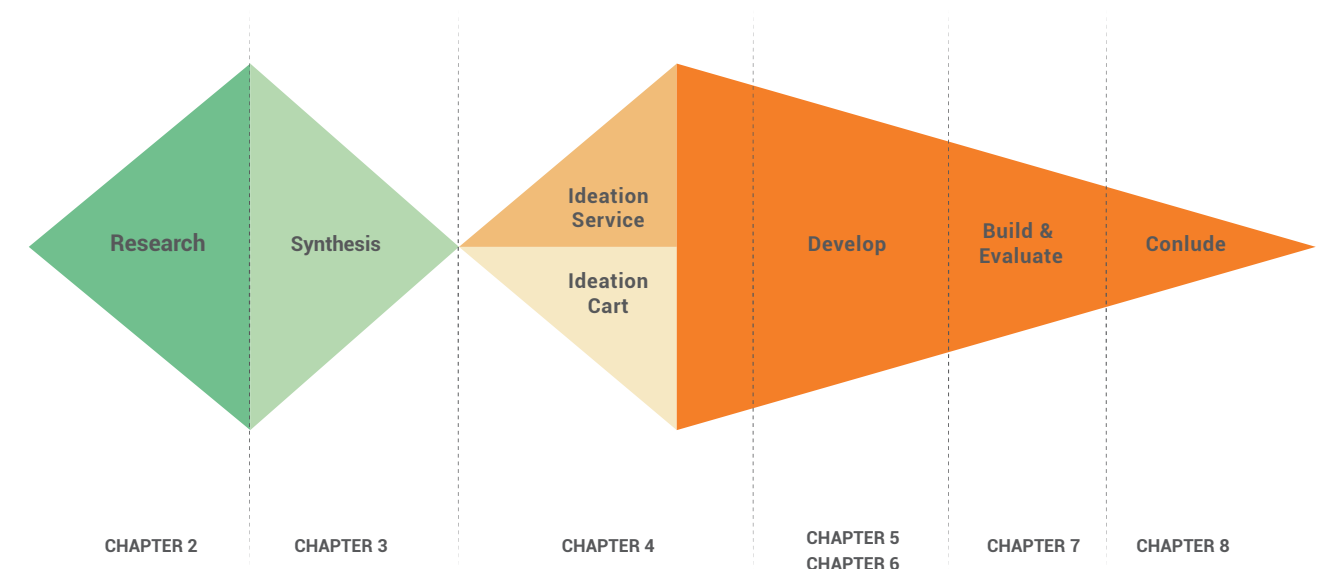


Figure 1.2: Visualization of the project approach in relation to the report chapters



CHAPTER 2

Analysis

SECTION 2.1

Artis

This chapter shortly describes Artis and its visitors, the park structure, how visitors move through the zoo and the role of facilities.

2.1.1 The zoo

As the oldest zoo of the Netherlands, Artis is situated in the centre of Amsterdam. Artis is not only a zoo, it is a museum and botanical garden where culture, education, nature and heritage come together and complement each other. The zoo's mission and vision are based on the concept of Natura Artis Magistra: Nature is the teacher of art and science. Its primary goal is to provide nature- and environmental education, to her visitors.

Artis is shifting her focus from zoo towards eco-garden, to show the relationship between all facets of the ecosystem. In the future, there will be more space and fewer animals. Having a positive impact on the environment is Artis's mission in terms of sustainability for 2030. Artis encourages the live experience of the zoo, at the same time it has to keep track of technological trends that may change visitor's preferences and needs.

2.1.2 Visitors

The park attracted 1.4 million visitors in 2018 and expects to receive two million visitors in 2030. Visitors are categorized in school visitors (9%), day visitors (58%) and members (33%) (Artis Financieel jaarverslag, 2019). Based on the age distribution of Artis members, the percentage of children aged one up to and including three is 6%. It is assumed that this percentage holds for all visitors. (Datasheet, Age distribution Artis members 2018). The number of visitors a day varies enormously, between 700 and 12000 mostly following a seasonal trend. It is highest in summer and lowest in winter. The time spent in the park varies between 1.5 and 4.5 hours.

2.1.3 The park

The park is relatively small (14 hectares) and

has a complex path structure with small and bigger lawns. Approximately 10 kilometres of path meanders through the park. Lawns enclose islands each with its own identity, determined by the animals, plants and architecture. There are both walk through and walk by enclosures that are be roofed or unroofed. The park and its main elements are visualized in Figure 2.2 on page 18. The butterfly pavilion, sea lions and aquarium are difficult to access with strollers due to split levels in these buildings. Alternative routes are indicated with signs.

Artis is moving and changing. Animal enclosures and buildings are constantly being renovated and renewed. Preliminary plans are made for the rearrangement of the entrance area, the addition of an extra entrance at the back of the park and new walkthrough enclosures. All changes affect the flow of visitors through the park.

About fifty per cent of the visitors first walk along the outer elephant path, thereafter their route is undefinable. The routes in the middle of the park are less used when entering the park but more often used when visitors are leaving. Roughly half of the visitors go around the park clockwise. Most popular enclosures are the Lions, Elephants, Giraffes, the Flamingo Bridge, and the Spider monkey bridge, indicated in dark grey in Figure 2.2 on page 18; Enclosures less visited are indicated with light grey. Day visitors visit the majority of the park, and areas around the sea lions and penguins are in high demand (Artis Analytics Report, 2020).

2.1.4 Role of facilities and services

Artis offers multiple facilities and services to her visitors; water taps, restaurants, wheelchairs etc. They strongly affect the visitor experience and satisfaction. Several facilities are specifically aimed at children and or their caregivers, one of them being the children's carts; facilitating caregivers and their children to move easily through the park.

Lack of capacity

A recent external study revealed a lack of capacity for several facilities, including children's carts. For every facility a so-called 'shortage tipping point' was determined, indicating when the capacity is insufficient for the number of visitors in the park.

The tipping point for a shortage of carts, currently there are 60 available, is estimated to be around 3000 visitors (Figure 2.1). The capacity of carts (60 carts) suffices on 44% of the days, and is thus insufficient on 56% of the days, corresponding with almost all weekends and holidays. Artis has to scale up facilities, including the children carts to meet current and future needs of the visitor.

Vision on facilities

Artis maintains clear guidelines for its facilities. The facilities aim to unburden the visitors and to make these available when needed and free of charge. To illustrate, when someone needs a wheelchair it is readily available.

The facilities enable people to go and look wherever and whenever they want to go. Less is more, the facilities should be simple, shatterproof, inclusive and should facilitate sustainability. For that reason, there is no emphasis on making Artis a children's paradise. When considering new facilities, operational costs, flexibility, ease of maintenance and the possibility of scaling up and down are of great importance. (Park vision, internal document)

All facilities blend in the environment, radiate unity and uniformity aiming to have one recognizable style, colour and shape. Facilities are unobtrusive to pay tribute to the animals and heritage, a more elaborate analysis of the facilities can be read in appendix D. Artis does not use thematization throughout the zoo, but one could argue the overarching theme for the facilities is 'Authentic city park'. For example, the litters could also fit in the Vondelpark in Amsterdam as well as the lanterns.



Figure 2.1: Visitor composition (Top) Shortage tipping point for number of visitors sorted from low to high (Bottom)



Figure 2.2: Map Artis

SECTION 2.2

Mobility support in Artis

This paragraph describes the current service and its main elements. A reversed function analysis by means of observation and an analysis of the carts and other physical touch points were performed to get a clear description of its functions.

Visitors are in need of a stroller or other modes of transportation when their child is not able to walk during the whole visit to Artis. Providing a child with a mobility option keeps the supervisor from carrying their child and increases their range to visit the whole park.

2.2.1 Service lay out

There are 60 carts available, suitable for one child aged 2 up to and including 5 years of age. Carts are stored and locked at one of four locations in the park. Figure 2.3 depicts the basic user scenario.

Artis uses a self-service system, visitors can take a cart at any of the stations by inserting a two-euro coin in the coin lock connected to the cart, unlocking the cart from the station. No face-to-face contact with an Artis employee is needed. The cart can be taken along and used and can be

returned at one of the carousels in the park. By locking the cart to the station, the two-euro coin is returned. At the end of the day, ideally all carts are locked to a station making sure no carts are lying around in the park. The service is free of charge. A cart can be taken by any visitor dependent on availability, and they cannot be reserved.

Insights

- The universal coin lock enables self-service for the visitor at every station. Enabling Artis to have multiple unmanned stations where carts can be taken and returned.
- The two-euro coin functions as a deposit stimulating the visitor to return the cart to a station after use.
- The carts can be used dependent on availability, it is uncertain for the visitor if there is one available.

2.2.2 Stations Locations in the park

There are four collection and take out points for the carts in Artis, also visible on the take out map. One point with three carousels offering space for in total 48 carts is situated at the end of the Papegaaienlaan, the main walking route from the entrance (Figure 2.4 (1)).

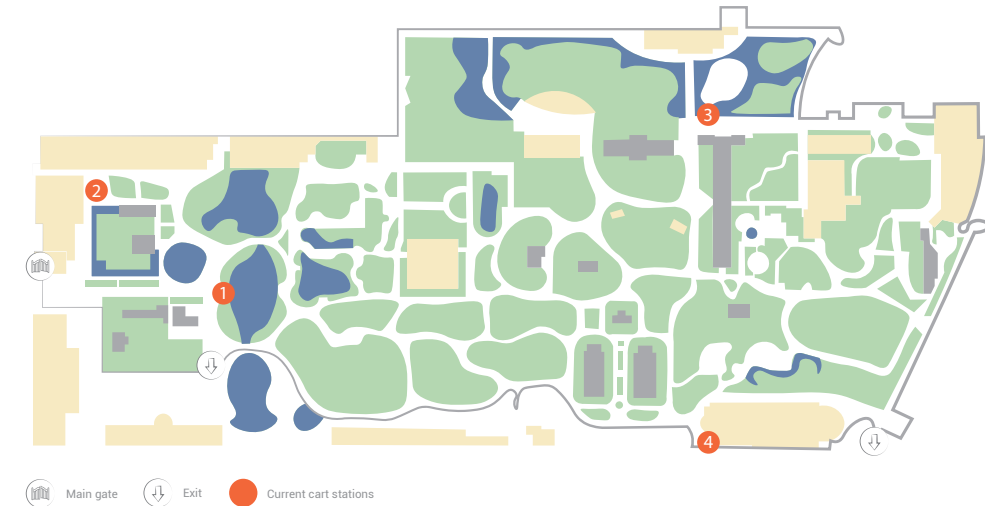


Figure 2.4: Current locations stations with carts in the park

Another pick-up point with one carousel is situated in front of the ape-bird house, the carousel was recently moved from the Gibbon enclosure because of renovation of the enclosure. Two hundred meters from the Two Cheeta's restaurant, fifteen attachment chains are integrated in the fence (3). This station is fairly in the middle of the park.

Finally, next to the aquarium (4), there is space for 8 carts. Because the aquarium is inaccessible for carts and the back exit is nearby this station has potential. However, it is hardly visible when approached from the aquarium and not visible at all from the exit. Only visitors that know the station use it, or the ones bumping into it accidentally.

Insights

- Location of the carousels at the Papegaaienlaan and monkey-bird house are close to the entrance covering the two main walking routes, the one at the Papegaaienlaan is mainly used.
- Stations should be visible and recognizable.
- Stations close to inaccessible enclosures or close to the entrance and exit are great offering natural locations
- Multiple stations enable the visitor to leave and take a cart at any of the stations.



Figure 2.3: Visualisation user scenario mobility support in Artis

Stations' main functions

The carousel enables permanent storage of the carts which are locked when not in use. Since all carousels have a universal connection system, all carts can be attached to any of the chains. Each station has a limited amount of attachment chains, when full, no carts can be returned. All stations are outside and visible for all visitors.

The coin lock is attached to the cart on the end of the pull bar, this is connected to one of the chains enabling the cart to be stored in neutral position taking up a lot of space. There are two types of stations, carousels and bars. The chains on the straight bars have different lengths to make

sure the carts do not get in each other's way. The circular shape of the carousel determines the circular shape of all carts together when stored. The carousel makes the carts visible and accessible for the visitors in a playful way.

Children can get in a cart before unlocking. This allows the caregiver to lift in the child first and then unlock the cart. However, the pull bars of the carts interfere with each other forcing the visitor to first disentangle the carts before being able to take one. Because of the separate chains, multiple visitors can take and return a cart at the same time.

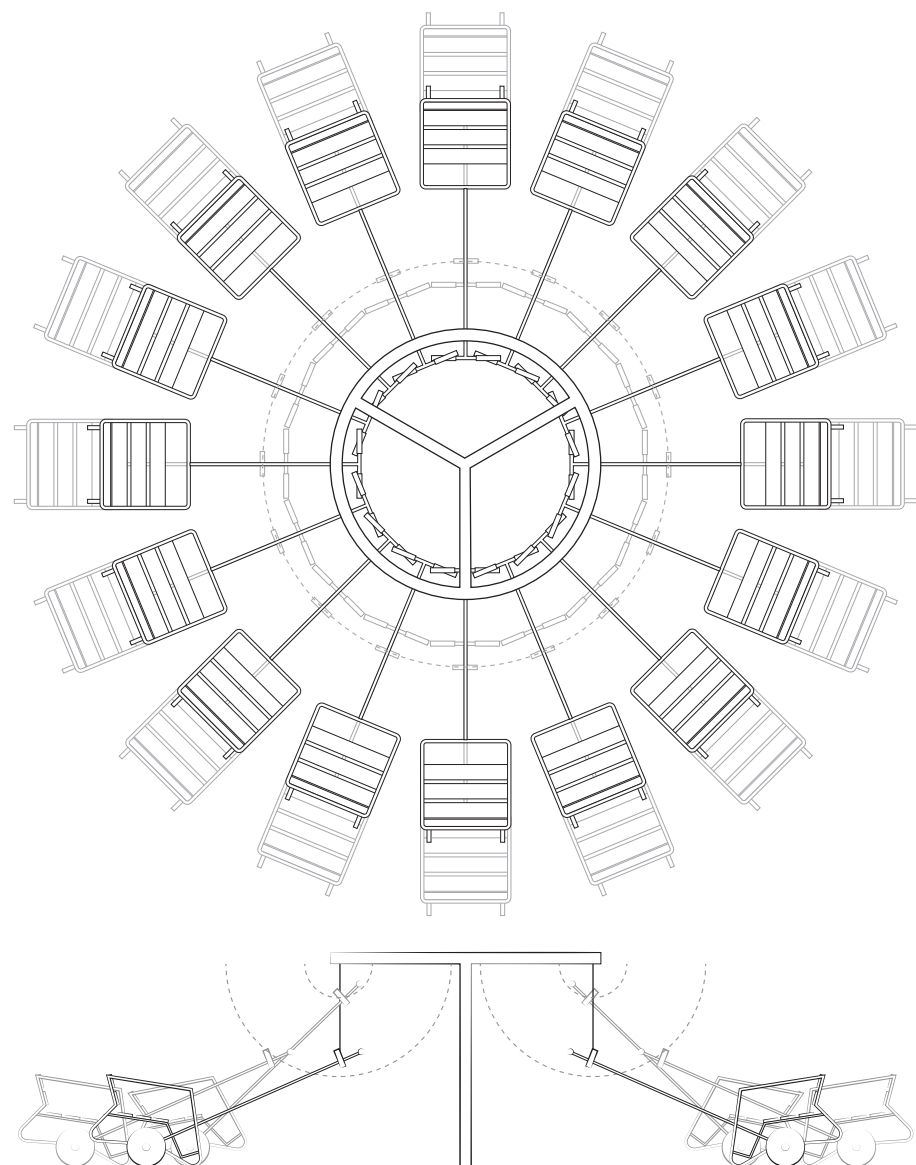


Figure 2.5: Top and side view of carousel with carts

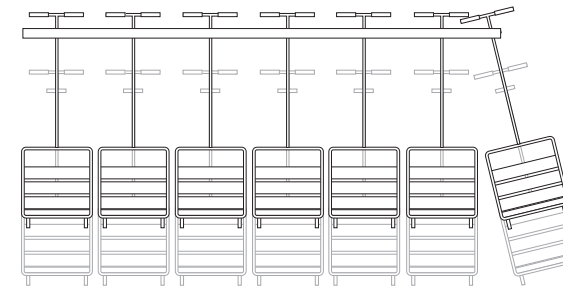


Figure 2.7: Top view of station bar type

Insights

- A cart in neutral position takes up a lot of space in the park, either stationed or parked temporarily during a visit.
- The carousels can only host a fixed number of carts hindering accessibility when a visitor wants to return her cart and no space is left.

Space occupation

The round carousels together with the carts occupy maximal 16 m² (4x4 m²). Space occupation is determined by the number of carts connected to the carousel and how far they are pushed inwards to the middle. The height of the carousel is 95 cm, the circle has a diameter of 120 cm. The bar stations vary in length but are all 95 cm high.

Space occupation is largely influenced by the orientation of the carts. If a new cart or station should be designed, a station in which the carts can be nested would decrease the total space occupation.

2.2.3 Carts History of the carts

The precise history of the carts is unknown. Personal correspondence with multiple Artis employees and looking through the Artis archives resulted in the following story. According to several employees working in Artis for over 40 years, the children carts were first introduced in the mid-seventies and have remained unchanged since then. Ten years ago 10 carts were built to add to the collection. Before the children carts, there was a so called 'boemeltje' in Artis. This excursion train was used from 1963 onwards and was seen as important educational feature in the park. During the summer season, the train took visitors on tour through the park where the driver explained all about Artis. The train turned out to be more meaningful entertainment for visitors than the previous way of transport by elephant or camel.

The carts have a lot of nostalgic value. Multiple generations of visitors have used them and employees are attached to them. Therefore, Artis is hesitant to change the carts.

Function analyses

The main function of the cart is to enable caregivers to transport their children through Artis. Carts can take different positions as visualized in Figure 2.8. In neutral standing position, the wheels and front part of the frame touch the ground resulting in four contact points (1)



Figure 2.6: Mobility support in Artis before 1975

ensuring stability. When the pull bar is released (possible accidentally) the front part of the frame functions as brake blocks. Also ensuring that the cart cannot move when not initiated by the caregiver lifting up the pull bar.

When the pull bar is lifted by the caregiver, only the wheels touch the ground, enabling the cart to be driven (2). The seating angle is determined by the lift height of the handle bar. The cart cannot tip over backwards due to the triangular shape on the back of the frame functioning as a stop (3).

All elements of the cart are depicted in Figure 2.9. The top of the frame functions as a restriction bar (11), making sure the child cannot fall to the front or sides when seated. The child needs to climb over when getting in. The wooden seat and back rest (9 & 10) are made from pinewood because it does not splinter. A footrest (5) is integrated in the metal frame, separating the legs from the wheelbase and ground. The pull bar (3) functions as lever for pulling the cart and as a steering wheel, it is connected to the wheel axis and also forces the legs of the child to both sides of the cart. The horizontal bar (4) in the front of the frame keeps the pull bar in place and ensures that the child cannot slip from the cart to the front. The pull bar is connected to the wheel axis with pins, it is locked to the frame with a 'lock' at the horizontal bar. The pull bar can be detached from the cart for maintenance.

Two rubber handles (2) on both sides of the pull bar enable the caregiver to walk on both sides of the handle bar or hold the cart with two hands. Sitting in cart the child can look around, without any visual obstruction. However, the seating is positioned rather low, preventing children from seeing some animals in their enclosure.

The carts are attached to the carousels with a coin lock (1). All carts have the same lock, the visitor can attach and unlock at any station. A sticker on the coin lock indicates that only a two-euro coins can be inserted.

Insights from analyses

- When choosing materials, child safety and wear should be taken into account.
- The ground contact points at the front make sure the cart cannot drive when not pulled by a caregiver and function as a break. Both functions are valuable to take into account if a new cart should be designed.
- Ground contact points wear fast due to on and off contact and impact with the ground.
- When driving, the restriction bar makes sure the child cannot fall out, but also enables the child to hold on tight when standing up. The restriction bar hinders getting in and out easily.
- There is no clear entrance direction due to the restriction bar enclosing the whole seat.
- The footrest invites to stand on but makes sure feet cannot touch the ground when driving.
- If a new cart should be designed, it should not be able to tip over to any side when climbing in, out or when seated.

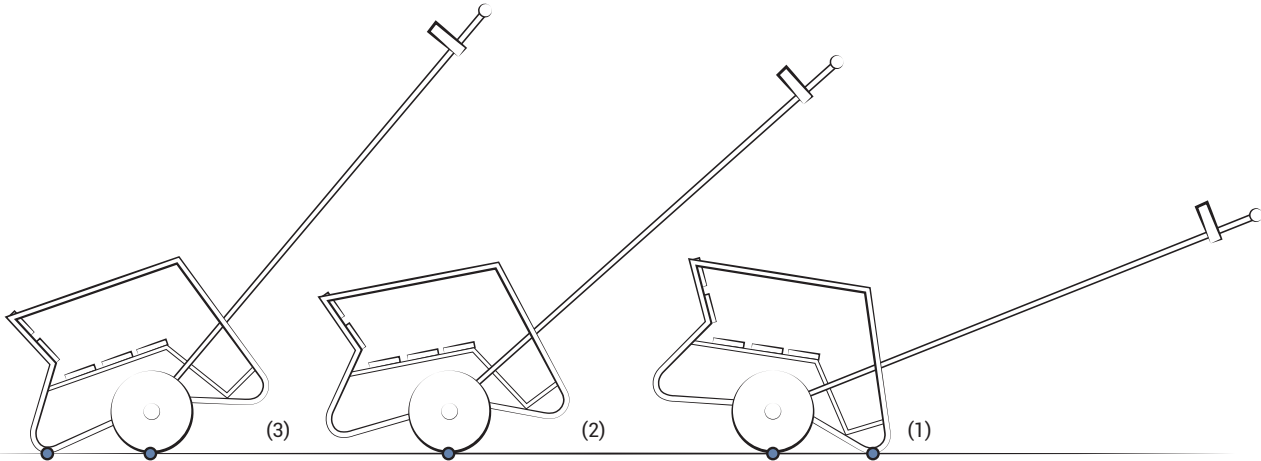


Figure 2.8: Different positions of the cart, side view

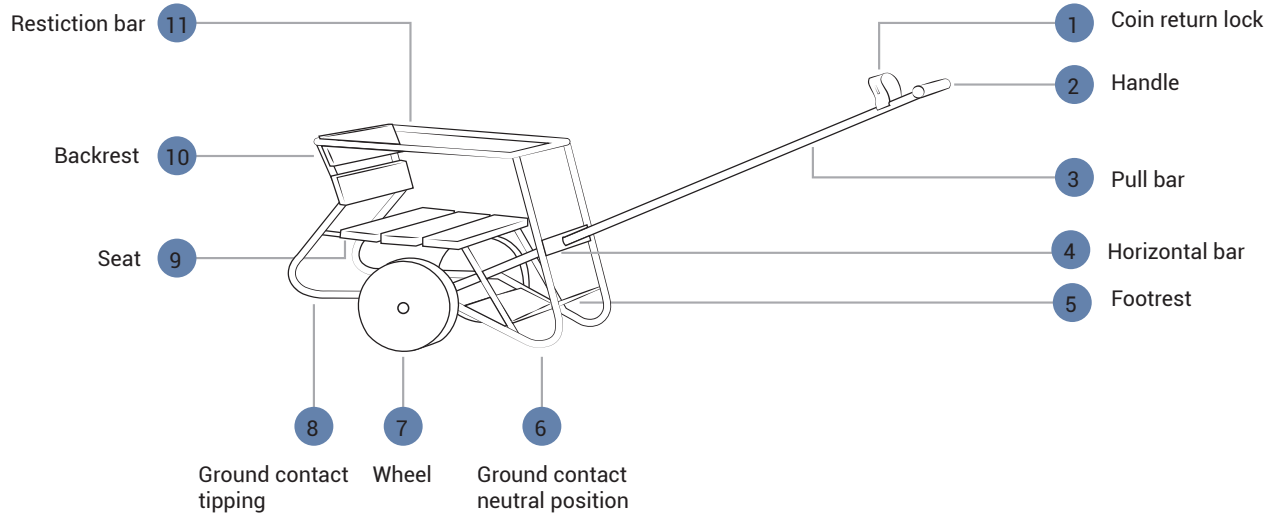


Figure 2.9: Identified elements of current cart design

Colors and aesthetics

The frame has the original steel color. The seats come in three different colors; blue, yellow and red. On the back of the backrest, the Artis logo is painted in white together with the carts number. Visitors can recognize their cart by color and the number. The color of the carts makes them inviting for children. Furthermore, the number and color is used by the maintenance department to identify and report carts that need maintenance.

In sum: color has a double function, for aesthetics, and identification of the cart for both the visitor and Artis. The number could also be of help when counting the carts.

Measurements and space occupation

Measurements were taken by hand, Figure 1.27 shows the measurements of the current cart. When in neutral position, the cart is 130 cm long and around 40 cm wide. The wheels are below the

center of gravity of the child enabling easy lifting for the caregiver. Whether in neutral position or in use, the cart takes up a lot of space.

2.2.4 Physical touch points

Apart from the carts and stations there are several physical elements in the park which visitors can encounter, called touch points. Touch points were identified by walking through Artis with a cart and looking for hints on how to use the service.

Routing signs in Artis point direction to animals and facilities, but do not indicate exactly where they are. Directions to cart stations are indicated on the signs by the icon shown in Figure 2.11.

Information sign on carousel on top of the carousel explains the deposit system, and tells the visitor that the carts may be returned at one of the other stations. It is not mentioned where those stations are.

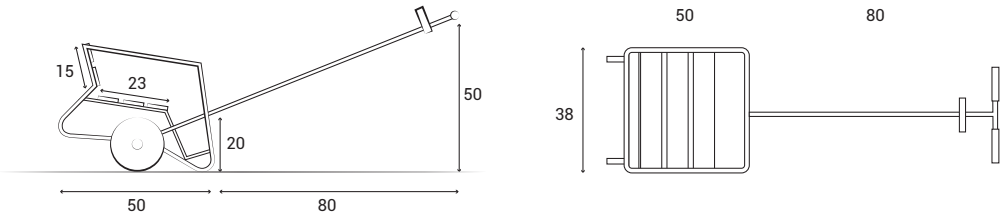


Figure 2.10: Measurements current cart

Alternative routes for enclosures that have a special wheelchair route are indicated with signs on the wall. These routes can also be used by visitors using a stroller or cart. To enter the butterfly pavilion, sea lions, mandrills and little pandas with a wheelchair or stroller, visitors need to use the lift downstairs at the enclosure of sea lions.

The various locations of the cart stations are indicated on the **Park map** which can be bought at the ticket office or the shop. Stations are indicated with the same icon as used for the road signs. The carousels are not visible on the Artis map that can be downloaded Artis' website.

The availability of mobility support is briefly mentioned at Artis' **website**. Only the main carousels at the end of the Papegaaienlaan are mentioned. The website says: *'There are carts suitable for children between two and five available at the end of the Papegaaienlaan. These can be used with a deposit of 2 Euro.'*

The **visitor regulations** about the use of mobility support for small children can only be found when downloaded from the website. They say: *'It is prohibited to: To move around by means of rolling stock such as bicycles, pushbikes, skateboards and/or skates. This does not include wheelchairs, strollers and bikes/scooters for children up to the age of three, as well as cars in the car park.'*

At the entrance the **gate information sign** shows the general visitor rules of the park and indicates the maximal height of scooters and bikes that can be taken inside the park. There are no rules given for the use of carts.

2.2.5 Wear and tear

The carts and carousels are not sheltered being always in the open unprotected surviving all Dutch weather types. The fact that the carts are attached to the carousels prevents them from flying around during a storm. Rainfall and moist invites mildew to the seats, that need to be replaced once in a while.

On a busy day all carts are in use. The cart can easily go for 10 km on a day, on different surfaces, constantly stopping and interacting with different users. As a result, current carts show adjustments, to increase the lifespan such as the metal plates welded to the frame because the frame was worn out.

- If a new cart should be designed, wear due to high intensity use and outdoor factors should be designed for.
- The materials and construction should last long and the cart should be able to drive over each kind of terrain.



Figure 2.11: Physical touch points

SECTION 2.3

Role of internal stakeholders

In order to describe the role, values and capability of internal stakeholders with respect to the service, stakeholders were investigated and interviewed. This chapter presents the results of the interviews together with the insights.

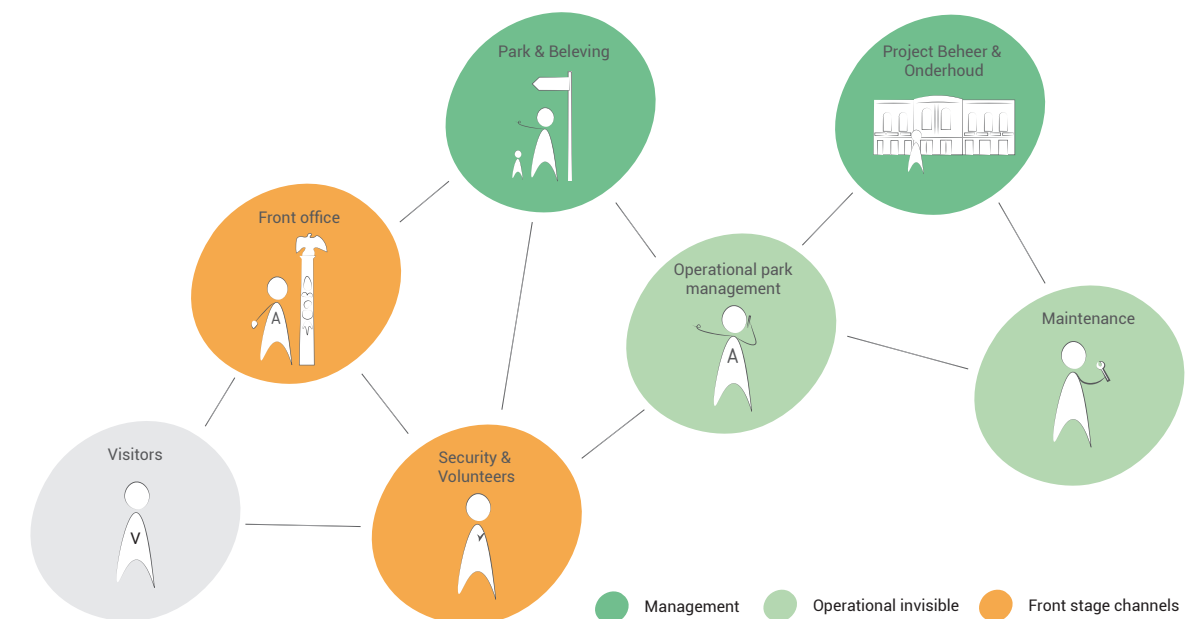


Figure 2.12: Relation between stakeholder groups

2.3.1 Internal stakeholders

Stakeholders are divided into three groups; 'Management', 'Operational invisible' and 'Front stage channels'. Their interrelationship and level of influence on the service is described in the next paragraphs. The methods used for interviewing and identifying stakeholders is described in appendix appendix E.

Management

Park management controls all departments and is responsible for adhering to the park vision. They are invisible for the visitor and direct the operational invisible and front stage channel stakeholders.

Operational invisible

Operational stakeholders are invisible for the visitor. They make sure all conditions for the service to operate are met.

Front stage channels

The front stage channels are in contact with the visitor and form the face to face touch points within the service.

The results and insights from the interviews are described on the next pages per stakeholder.



Department Park Beheer & Onderhoud

Project Management and Maintenance ensures that the park infrastructure is well maintained, including enclosures, paths, plants etc. Interviews revealed some major concerns with the service. The carts and carousels are thought to take up too much space and are considered to obstruct developmental plans for the park. The service has low priority. Possible new locations for stations are not taken into account when making new development plans for Artis. (To illustrate: the future plans for the outside Gibbon enclosure jeopardize the carousels. A new location for the children's carts at the entrance are not yet considered.) Furthermore, the high costs (900 euro per cart) restrain Artis from investing in new carts.

Insights from Park Beheer & Onderhoud

- When designing a new service or cart, space limitations are an important concern.
- High costs of the carts restrain Artis from investing in extra carts.
- The physical parts of the service should be easily adaptable to changes in park layout and visitor flow.



Department Park & Beleving

The main goal of the Park & Beleving department is to provide the visitor with the best experience possible. They make sure that everything that can interrupt or improve the perfect visit is taken care of. This includes accessibility and the facilities in the park. The carts are considered part of the facilities that Artis offers. And are considered as a non-obligatory service. However, they see the carts as one of the icons forming the identity of the park.

Interviews revealed: Park & Beleving considers the current service model fully in line with the vision, the carts are free to use. Furthermore, because of the self-service system waiting time is limited. In their view visitors should be able to explore the park in their own way. The park should stimulate children to move. An important concern is that the park should not become an amusement park for children. They fear that the Artis will be dominated

by carts. A wish expressed during the interviews was to extend the user group of the service so younger children can also use them. They share the concern about the space taken by the carts and carousels as well as the limited capacity considering the increasing number of visitors in the future.

Insights from Park & Beleving

- When designing a new service or cart it is desirable to maintain mobility service for free
- New solutions should follow the park aesthetics and facility vision to fit into the park as a total entity.
- Solutions should stimulate all visitors to explore their own individual route.
- The possibility to extend the usability of the service to younger children should be considered. Reevaluating the target group could result in a more fitting service.



Department of maintenance

Maintenance of the carts is done in house at the workshops. Both the social workshop and black smith are responsible for the maintenance of the carts. Interviews revealed that maintenance of the carts take a lot of time and is therefore costly. The amount spend is approximately 8400 euros a year, i.e. 140 euro per cart excl material costs. This seems to be unknown to the management. Yearly maintenance consists of; painting or replacing seats, replacing wheels and checking the frame.

Artis is able to do all maintenance of the current cart in house. Maintenance is increased by misuse of the carts by schoolchildren and the intensive conditions since they are always outside. Several changes have been made to the cart to prolong its lifetime since 1975 such as welding parts to the frame, install bearings for wheels and replacing the wheel axis for 20 mm ones.

Insights from the department of maintenance

- When redesigning the service or cart, inhouse maintenance capabilities should be taken into account
- When redesigning the service, maintenance costs should be limited and known to include in

the business case.

- The department of maintenance can be consulted about issues of misuse and 'huffer proofness'



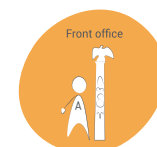
Operational park management

Operational park management is responsible for the daily servicing of the carts, takes care of the

carts and stations and signals when carts are damaged. The interview revealed high demand of maintenance resulting in a reduced number of carts available for visitors; a mismatch between the number of available carts and the number of visitors. Daily servicing entails finding and locking unattached carts at the end of the day. Because the system is self-organizing, ideally no daily servicing is needed. Since not all carts are locked at the end of the day, checking if all carts are attached is needed daily, carts lying around need to be resituated.

Insights from operational park-management

- The need of daily servicing of the present system is minimal. When designing a new service or cart the new system should preferably have this quality and minimized.
- The number of carts available for the visitor is less than the number of carts in the system. By planning the number of carts, the need of maintenance should be taken into account.



Front office

The front office has face to face contact with the visitors. It involves the ticket booth, gate control,

service desk and shop. Interviews revealed that the shop keepers are troubled by spending time on the service. They provide many visitors with a two-euro coin to unlock the carts. The service desk receives many questions about the service. Questions are: Is there any service available? Where can I find the carts? Can I return my cart

at the end of the park? Can I get a two-euro coin? They receive positive comments about the fact that the service is free of charge. However, they also receive negative comments about the lack of safety of the carts. Gate control checks the tickets when entering and ensures that the visitor regulations are met. They also receive a lot of questions about the use of the service.

Insights from the Front office

- The unlocking system by means of the two euro coins needs reconsideration. The Artis shop is unintentionally involved in the service.
- The current service raises a lot of question for the visitor. A new system should be self-explaining as much as possible. Possibly an explanation about the service should be readily available before and during the visit. Thereby reducing the stress on the front office.



Security & Volunteers

Security guards the park. The interview revealed that the guards ensure each morning that the carts are used by the rightful visitors, caregivers and their children. The guard is concerned about the misuse of the carts by schoolchildren and use of the carts as a luggage carrier.

Volunteers are stationed at every walk-through enclosure to guide visitors and keep an eye on them. Interviews revealed that they need to address visitors using the carts for the wrong purpose.

Insights from Security & Volunteers

- If possible, the service should discourage misuse and inappropriate use by schoolchildren and other visitors. Involvement of security and volunteers will then be minimized.

SECTION 2.4

Visitor research in park

In order to get a complete overview of the visitor journey in Artis of visitors using mobility support, visitor research was done during low season and the spring holiday of school children. Interviews (both in depth and short), observations, immersion and a small questionnaire result in insights and conclusions.

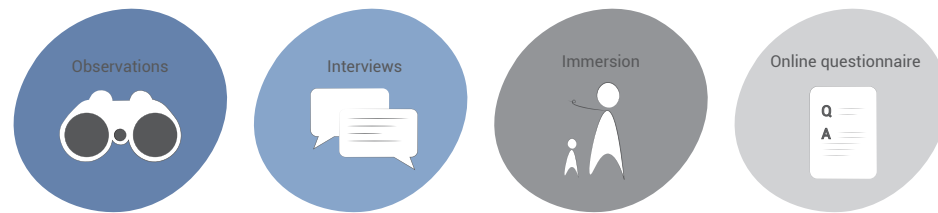


Figure 2.13: Visual overview of parallel research

Appendix appendix E describes the methods used, the results per research are described below resulting in insights.

2.4.1 Observations

A total of 49 caregiver child combinations were observed. The majority of these combinations (90%) showed interest in carts. The majority of combinations contained either one child (72%) or two children (23%). In one case no child was observed. Approximately 20% of those showing interest in the cart also carried another kind of child transport, including buggies, scooters and balance bikes.

Interest in the cart originated in approximately 50% of cases from the child and in the other 50% from the caregiver. A child interested in a cart may run to the carousel and start whining for a cart. In other cases it walks to the cart and seems confident that the caregiver will get one for him or her. In 25% of the cases the colour of cart was discussed before unlocking. Often a child showed a preference for a cart with a specific colour.

The moment caregiver and child have decided to take a cart they have to detach the cart by means of a two-euro coin. Observations showed that a little more than one in five caregivers (22%) did not possess a two-euro coin to disconnect a cart and precisely 25% of the caregivers encountered problems with the lock. Of those eventually leaving with a cart 80% took one cart and 20% took two carts.

Interaction with carousel: at the carousels, caregivers kept the cart when it was wet. Children interact with the carts by touching, pointing, trying to move the cart or climbing in. Children walked underneath empty carousels playing with the chains. Visitors not having the right coin for the cart do not take one or go to the coffee station to get one, they are sent to the shop to get a coin and return afterwards to get a cart. Schoolchildren try to sit in the carts at the carousels.

Interaction with cart: Observations showed children getting in and out of the cart during the visit. They climbed out or in by themselves or were assisted by their caregiver. When climbing

out, feet got stuck in the cart, sometimes a shoe was lost when getting out. Caregivers pulled the cart when the child was walking. At animal enclosures children got out of the cart most of the time. At enclosures where the animal is visible from the cart, the cart was positioned by the caregiver to make the animals visible for the child. Observations also showed caregivers sitting in the carts pulled by the child! The carts were sometimes used for two children at the time, sitting on each other's lap or one child inside the cart and the other sitting on the pull bar. Observations showed caregivers pushing the cart instead of pulling. Children too big for the cart sat in it with their legs over the metal frame.

Carts were left unattended in front of inside animal enclosures. During lunch time, carts were stalled inside the restaurant or taken to the table. Strollers were taken to the table too and were then used as bag or coat carrier. Carts and strollers were found gathered in front of the playground during the day.

The number of carts at the beginning and end of the day fluctuated per station. Carts were left unlocked when there was no space left to lock them. There were always carts available at the beginning of the day at the Papegaaienlaan.

Insights from observational research

- When designing a new service or cart, it should be attractive and fun for children.
- The composition of the public offers the opportunity for a cart with two positions.
- Children aged two and three should be able to get in and out without trouble. At the same time the mobility support should be suitable for children aged one.
- Inside and walk through enclosures form obstacles.
- Carts are often disposed of or left for short periods of time when visitors do not need mobility support.
- It should deal with the fact that carts temporarily left by the visitor can form gathering points
- Unlocking system by means of the two-euro coins needs reconsideration.



Schoolchildren testing out carts



Two carts left with non working coin locks



Two kids in one cart



Cart left behind at a station because it was full

Figure 2.14: photographed observations (1/2)

2.4.2 Interviews

Semi structured interviews were done with 19 caretakers visiting the park. Visitors using carts, strollers, other means of mobility support and not using mobility support were interviewed to get a broad overview of child mobility in Artis.

More than half (7 out of 12) of the cart users decided to take a cart and relied on the service before entering Artis. This appeared to be common for visitors going to Artis by means of public transport or by bike. Some did not rely on the carts in the weekend since they knew they would be sold out. Different reasons for using the cart were given: the cart is useful; elongates the visit; lets you go around Artis quicker; and prevents the caregiver from carrying and the child from getting tired. Stroller users mentioned the same reasons however preferred to take their own stroller for convenience or possibility to take luggage. More than half (7 out of 12) interviewees mentioned that they use the cart for fun and to please the child. Comments were:

'He can walk perfectly but really likes to sit in them' 'They are fun, especially useful'.

Thirteen out of 19 interviewees (68%) expressed themselves negatively about the comfort, safety or ease of use of the cart. It was mentioned several times that the cart forms an obstruction at inside enclosures and was considered unsafe for children one year of age. Another annoyance expressed by caregivers was that they need to drag the cart along most of the time when the child is walking. Multiple caregivers with children aged two and three expressed their concern about the lack of control when the child is in the cart. The possibility of the child standing up straight when driving and possibly falling out or hands getting in wheels when driving were a major concern. Two interviewees mentioned the inconvenience of the coin lock, forcing you to have a two-euro coin or it not working properly.

Multiple visitors took a cart after walking through Artis or after noting that the child got tired. The opportunity to return or take a cart at several points in the park was considered useful. However,

it was also mentioned that stations were full at the end of the day depriving visitors of the possibility to lock their cart at one of the exits. Two out of nineteen interviewees expressed positive feelings with the service being free.

Push carts and safety straps were suggested by multiple visitors. Furthermore, adding suspension or softer wheels to the carts were mentioned as a possible improvements. Interviewees with two children mentioned that taking one cart for two children is not an option since they will fight over it.

Insights from Visitor interviews

- Mobility support is considered essential and indispensable.
- It should prevent disappointment of visitors due to capacity problems
- Visitors should be able to predict if mobility support is available
- Leaving the cart should be easy and unobstructed
- The possibility of taking and leaving mobility support at different points in the park could be considered
- If a new cart should be developed, it should be easy to take along or disposed when unoccupied
- It should be safe for all children in the target group
- The way of transport to Artis influences how children move through Artis. To illustrate, parents coming by car are more likely to bring stroller for their children than parents coming by bike.

2.4.3 Online questionnaire

An online questionnaire was sent to several parents with children who visited Artis before. The questionnaire consisted of questions about preparation of the visit, whether strollers or carts were used and why, and how they influenced the day.

The decision to go to Artis is made varying from a few weeks before to on the same day. Types of preparation differed a lot between respondents. Some only prepared only a bag with sandwiches where others decided to take a stroller, diapers,

extra clothing, etc. All participants used a type of mobility support during their visit, strollers, carts or scooters. Mobility support was used during the visit when the child was tired and did not want to walk anymore, to speed up travelling or when covering a large distance. Two of the participants stated that they skipped inside enclosures because they were hard to go through with a stroller or cart. Seven out of nine participants took the cart/stroller along when the child was walking.

Insights from questionnaire

If a new service is designed it could take into account that other forms of mobility support brought by visitors encounter similar problems during their visit.

2.4.4 Immersion

To immerse myself in the experience of visiting Artis with children, I walked through Artis together with a mother (age 29) and a child (age 3). The experience closely followed the observations and findings previously. In addition I experienced that visiting Artis with children involves a constant adjustment of plans, an excited and engaged child, a non-behaving child, a tired child etc. I experienced that the child wanted to hop on and off the cart in a unpredictable way. Leaving the cart in the middle of the visit went smoothly.

Insights from immersion

The immersion was a valuable experience and gave insight in the dynamics of the interaction with the cart. It substantiates the previous conclusions.



Carts left in front of Gorilla house



Carts stalled inside restaurant



Grandfather and child watching penguins

Figure 2.15: photographed observations (1/2)

SECTION 2.5

Designing for children

This project requires some knowledge about child development, the aim of this small literature review is to find out more about child development and how it affects the design parameters in terms of size, suitability and for example safety. This section presents the main insights and implications for designing for children.

Difference between children and adults

Children differ from adults in many ways. Children depend on adults to provide for a safe environment, so they can test their skills, and take risks. They are hardly aware of dangers and the consequences of their actions.

Child development

Children develop a different pace resulting in large differences within and between age groups (Norris & Wilson, 1995). By nine months a child can sit up straight without support. Communication evolves in gestures, pointing and reaching in children 12-24 months old. With increasing age, they like to take more risks and test their physical strength and skills (Leuder & Rice, 2007). With exploring, falling is inevitable.

Insights

- Physical capabilities within age groups differ greatly. Taking into account the motor abilities when designing will increase suitability. However, unwanted exclusion of less capable children within age groups will be inevitable.
- Developmental milestones should be used as guideline to design for the capabilities or determine the target group. 'Sitting without support' would be a natural lower boundary of the target group.

Need of mobility support

Because young children are not capable of walking long distances, different means of transport are used by caregivers and children for long and short distances. The type used depends on the achieved

autonomy of the child. Reasons for using strollers are for example; transportation, storage, leisure, supervision/confinement, parent physical activity and sleeping. Factors influencing the decision to use strollers are convenience, timing, distance, and child preference (Birken et al, 2015). Using a scooter provides the child with more freedom to move and discover. Children love vehicles they can ride on, whether self-propelled or motorized. This way they are encouraged to move on their own and motor and balancing skills are trained. (Leuder, 2007)

Challenges in designing for children

The two books with the titles, "Childdata" and "Ergonomics for children", mention several challenges and guidelines when designing for children. The goal is to give the child support, while restraining his movements. Accidents occur for many reasons, including child behavior, adult behavior or a poorly designed product (Leuder & Rice, 2007). Older toddlers may fall as they try to stand in the stroller or cart. Strollers often tip over when children try to push the stroller but are unable to balance the stroller.

Young children are unable to express their needs and wants in words. Observations in combination with knowledge about their development may be useful. Children use products in ways that make no sense to adults who created them. As Leuder & Rice (2007) noted, products should be designed for how children use them instead of how they should use them.

Insights

- The product must appeal equally to the caregiver and child, since the caregiver will decide whether the product will be used.
- If a new means of transport should be designed, young children must be physically unable to drive or tip over it to prevent accidents.
- Observations are the most useful when in need of usability feedback from children since

- they have difficulties expressing their needs in words.
- The product should be tested by children to be able to find out how it is used.

Anthropometric design for children

'As the average user in terms of size, weight and shape doesn't exist, it is important to gain insight into the variation within the target group, to ensure optimal fit of products to the people using them' (Boeijen et al., 2020) Anthropometric differences between sexes start to appear slowly after birth and increase with age (Norris & Wilson, 1995). Major sources of variability in children are; gender, age groups, disability, cultural differences and the secular trend (Leuder & Rice, 2007). During childhood, body proportions can vary between the sexes. Using the 5th percentile female and 95th percentile male values to set design limits might not accommodate the range of children at a particular age. (Leuder & Rice, 2007). Children do not develop at a steady rate throughout childhood, resulting in rapid change in anthropometric data (Steenbekkers, 1993). Variation between age groups makes it more appropriate to design according to variables other

than age; weight or length. Weight for instance is sometimes used to specify the suitability of baby carriers and nappies (Norris & Wilson, 1995).

Applying anthropometric data

Table 2.1 describes different examples and guidelines for using anthropometric data for different scenario's, the table is based on the book Childdata. If the design scenario is critical, a safety tolerance needs to be added, described in column five.

Insights

- Using the right body dimensions is important for safety, proper application results in for example less entrapment accidents
- Table 2.1 should be consulted when deciding on the right data set per part of the design.
- Due to the large variation in data for different ages, anthropometric data based on length or weight should be used if a new mode of transport should be designed.

Design scenario	Aim	Example	Design to accomodate	Critical design scenario
Fit	Design to ensure user-product match and appropriate and effective use	Childcare products, toys, safety equipment: cots, pushchairs, walkers, strollers bicycles, cycle helmets, ride on toys, puzzles	The maximum range of the population, use at least 5th to 95th percentile or greater extremes	Use both maximum and minimum expected values
Reach	Placement to ensure access and appropriate and effective use	Position of hand rails, step height	The smallest of the target population, use 5th percentile values or smaller	Use minimal expected value
Clearance	Placement to avoid undesirable or unintentional contact	Access hatches, desk seat gap, moving parts out of reach	The largest of the population, use the 95th percentile values or greater	Use maximum expected value
Entrapment	Avoid unintentional retention of the whole body or body parts	Wholebody: railings, head: cot sides, ladders, hand/finger: doors, cupboards, folding pushchairs	The smallest of the population (5th percentile), cannot pass the body part into gaps or apertures or the largest of the population (95th percentile) , can pass into an through the gap or aperture safely	Use maximum expected value
Exclusion	Ensure inaccessibility and inoperability	barriers, railings, guards, packaging	exclude the smallest or weakest of the population, use 5th percentile values or less	use maximum and minimum expected value

Table 2.1: Applying anthropometric data to designing for children

Mobility support in other zoo's

To gain insight in how other public places deal with mobility support for children several competitors of Artis were interviewed about their service approaches and types of carts. This paragraph describes a summary of the results.

Services

Most of the other zoo's and amusement parks have a revenue model for their mobility service. It is not known if any profit is made with the rental. Only Dierenrijk uses the same free self-service coin lock system. Appendix A offers elaborate information about the service of every interviewed zoo. .

Most parks have a manned location where visitors rent a cart, for example inside a shop, at the counter or at a separate rental area. Rent prices range from 2 to 25 euros, deposits range from 8 to 50 euros. In some cases, a cart can be booked in advance or only a deposit has to be made. A manned location makes sure that only visitors in real need of a cart will get one. Tokens and tickets are used to unlock the carts or as a rental certificate.

Different mobility options

In general parks provide three different mobility options; strollers, pull carts, and carts. Most are standard and then personalized for the park with

stickers. The Efteling, Artis and GaiaZoo use the same type cart (pull cart), but all have different appearances. The elephant and giraffe stroller are widely used (Antwerpen Zoo, Blijdorp). They can be nested to take less space when stalled. A comparison of all mobility types can be found in appendix C.

Insights

- The coin return lock or deposit ensures the strollers/carts are returned to the gathering point. Carts can be mostly taken depending on availability.
- Most zoo's have a revenue model for their service. Implementing this in Artis could cover for example the maintenance costs.
- A sense of responsibility is created by having to pay a deposit, assuming visitors will take care of the product when they have paid for it.
- Service systems and corresponding touch points can be used as an inspiration for designing the different service steps. The current self-service system eliminates manned stations and extra steps for the visitor to go through.
- All other parks have one single gathering and distribution point near the entrance, all carts must be returned to the same point.
- Most parks use a service based on availability without the possibility to reserve a cart/cart in advance.

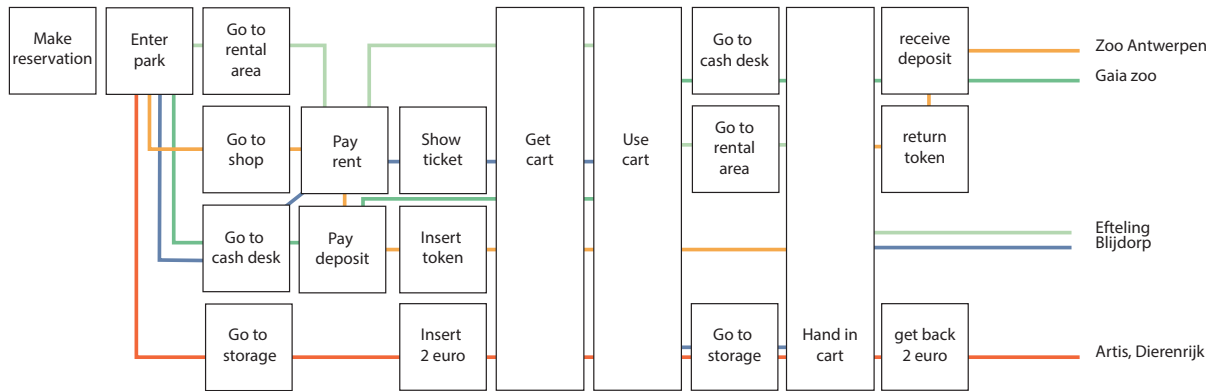


Figure 2.16: Comparison of service concepts in other zoo's



CHAPTER 3

Synthesis

SECTION 3.1

Service blueprint

Interviews, observations, questionnaire and immersion lead to a thorough understanding of the journey of visitors using mobility support provided by Artis. Interviews with stakeholders revealed problems and challenges in the current operation of the service provided. Results are combined into a service blueprint to give an overview of what the service entails from both a visitor perspective and organizational perspective.

Data points and insights from the research were brought together and mapped in the service blueprint. Pain points in the visitor scenario and organization were identified. The service blueprint takes the customer journey as a starting point and helps to spot gaps and irritations in the interactions between the customer and the organization, as well as in the delivery of the service (cf, Reason, 2015). This is represented in the different layers of the blueprint. The service blueprint presented (Figure 3.1 on page 41) is thought to be self-explaining. Readers are invited to study it and to form their insights and conclusions based on the print. Most of these will be discussed in the next chapter.

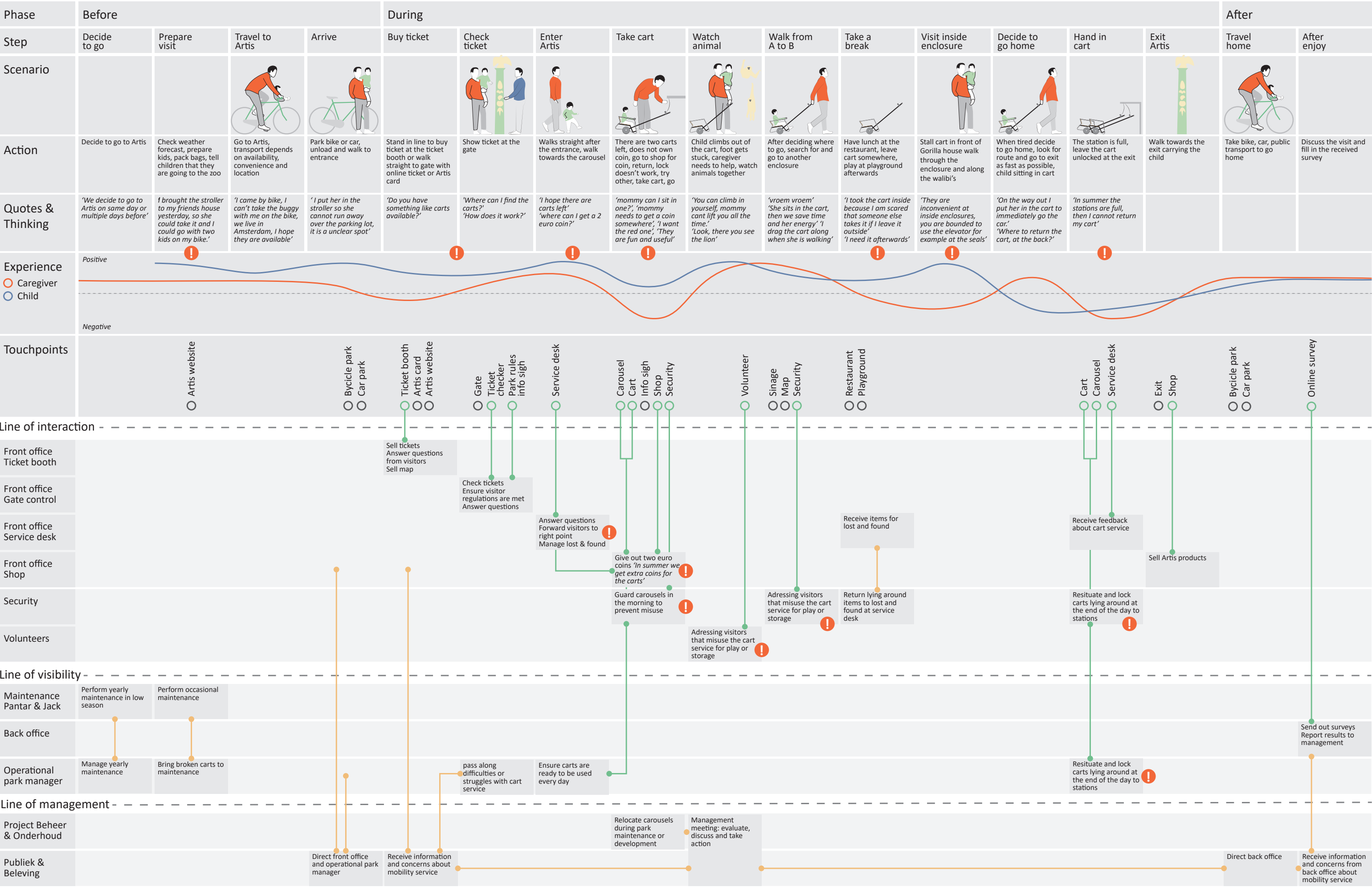
Figure 3.1 on page 41 shows the service blueprint for the cart service presently provided by Artis consisting of four layers separated by

the 'line of interaction', 'line of visibility' and line of management. The first layer of the service blueprint describes the worst-case scenario for visitors using the carts. All pain points of the visitor are indicated with orange circles with exclamation marks. The pain points in the map are self-explaining. For example, during the preparation phase 'before', visitors cannot rely on the availability of the carts or do not know about their existence. During their visit, visitors encounter problems with taking, temporary stalling and returning the cart. This contributes to a negative experience and is shown in the experience line of both caregivers and children et cetera.

Physical and face to face touchpoints connect the top layer with the second, third and fourth layer of the blueprint. Below the line of interaction, touchpoints are connected to Artis employees directly involved with the visitor. Below the line of visibility, actions take place important for keeping the service up and running on a daily base. The bottom layer shows how the management is involved, managing the layers above, constantly evaluating and guiding actions.

Stakeholders experience highs and lows in their experience, orange circles with exclamation marks point to pain points in the organization.

Figure 3.1: Service blueprint mobility support



SECTION 3.2

Main pain points of the current service

Artis provides carts for her visitors to contribute to their experience and ease their visit. The service appears to be much valued and is seen as indispensable by the visitor because it is both fun and useful. Research shows where the present service and cart run into problems. This section describes the main pain points of the current service.

Capacity vs demand

The main problem is the imbalance between capacity and demand. The current number of carts does not meet the number of carts needed on busy days with the expected increasing number of visitors, the problem will become more severe in the future. The current shortage strongly affects how the service is experienced.

Space limitations

The current carts and stations take up a relatively large space in Artis. Space to park the carts is limited. The space taken by the carousels and carts hinders future developments.

Carts

Safety The current cart is unsafe, e.g. children in the cart can get hurt easily.

Suitability for age Children aged 2 and 3 years are able to stand up when riding. Caregivers consider the carts unsuitable for children 1 year of age.

Physical shortcomings Locks are often not working, carts rattle when riding, no suspension etc.

Service experience

Unpredictability Before entering the park, visitors are not sure whether mobility support will be available.

Unavailability Due to lack of capacity, carts are often not available.

Accessibility Two-euro coins to access the carts become less and less current causing problems. Returning cart is problematic when stations are full.

Parking carts Visitors cannot easily put away their cart when temporarily unused e.g. during a break.

Park obstacles Visitors are forced to put away the cart near or in buildings that are difficult to access.

Organizational

Maintenance Yearly maintenance is extensive and costly.

Unwanted demands The front office and security are unwillingly involved in the service.

Daily servicing Daily servicing is needed e.g. locking carts spread around the park by the end of the day.

Although problems presented separately, they are strongly interrelated. Especially the capacity problems affect many others, including: predictability, availability and parking. The capacity problem is also related to expected space problem due to future developments. And finally, maintenance is affected by the many shortcomings of the cart.

SECTION 3.3

Conclusion research and Challenges

This section describes the main conclusions derived from the insights, synthesis and main problems. The conclusions are next translated into several challenges for providing mobility support in Artis.

There is not only a shortage of carts and lack of space, also the current mobility support service does not meet the expectations of the visitor, because it is unpredictable, accessibility is troublesome, often not available, does not support voluntary breaks, is often involuntary interrupted, and disposing the cart is sometimes difficult.

The cart too does not meet visitor's expectations. It is considered unsafe, not suitable for all relevant ages, and shows many physical shortcomings. In addition, the service challenges the organization by high demand on and hidden costs of maintenance, unpredictable daily servicing, unwanted involvement of the front office, and extra demands on security.

3.3.1 Main challenges for providing mobility support in Artis

The challenge of designing a mobility support service for Artis entails a combination of organization, technology and people (cf. Boeijen et al, 2019). Both service specific and cart specific challenges were combined into eight key challenges for providing mobility support in Artis.

The main challenges derived from the research findings and insights are visualized in Figure 3.2 and described below.

- To provide suitable and safe mobility support for caregivers and children aged 1 up to and including 3 years of age
- To provide sufficient capacity
- To use minimal space in the park
- To provide a self-service for the visitor
- To provide a service that is predictable accessible and reliable for the visitor
- To provide mobility support that can be picked up, left and parked at any time
- To provide a service with minimal (daily) maintenance
- To provide a service fitting the park (vision)



Figure 3.2: Key challenges for mobility support in Artis

The next paragraphs elaborate on the major challenges. Challenges result in design criteria described in the next chapter.

Suitable for target group

The target group to design for was determined considering the visitor evaluation of the current service and the wishes of the management of Artis.

The main target group is; children between 1 and 4 years of age and their adult caregivers.

This age range covers the children needing mobility support most when visiting Artis. Children aged two and three years are the main focus, because caregivers with children aged one take their own strollers with them most of the time, whereas children aged four are expected to be able to walk the whole visit.

Measurements children

The literature review revealed age is not a suitable measure to design for. Therefore, suitability requirements should be described in length or weight, which have a strong positive correlation.

Data from DINED and the TNO growth table for the age range considered were translated into the proper measures (appendix X).

Conclusion

The cart should be designed in such a way that children between 75 cm and 110 cm will fit in it, up to 20 kg, whichever comes first. The lower limit corresponds with the p50 of girls aged one. According to data from DINED, by using p50 of stature of one-year old children, no two-year-old children are excluded

The upper limit is in line with the p95 of weight and length of three-year-old boys, according to DINED and TNO. By using the p95 of stature, five percent of the boys and 2 percent of the girls aged three are excluded (DINED). The required measurements for children when seated and standing are described in appendix appendix W.

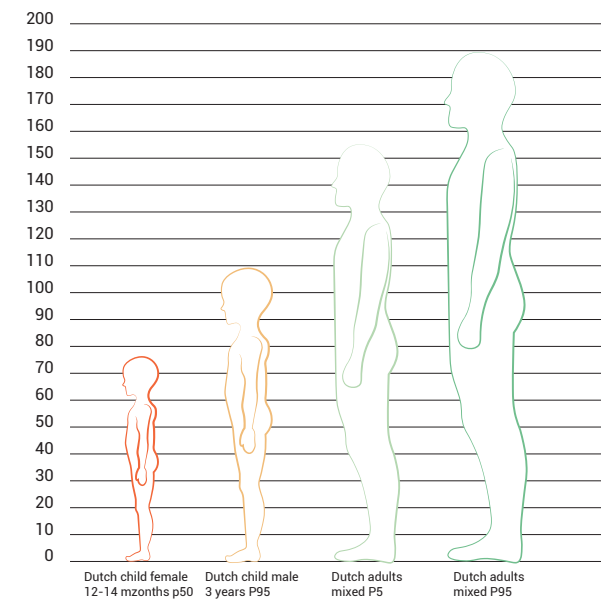


Figure 3.3: Body height (cm) target group children and adults

Measurements Caregivers

Both the smallest and tallest adults caregivers should be able to move the cart with the child inside. The upper and lower were derived from the DINED database, Dutch adults 30-61 years of age. Caregivers with a stature between 155 cm (p5 female) and 190 cm (p99 male) should be able to move the cart. Children or teenagers shorter than 155 cm are excluded from the user group. Figure 3.3 shows the ranging measurements of both children and caregivers to design for.

Safety

To ensure the cart is safe for the target group amongst others, research was done about safety standards.

Carts in Artis do not have to fulfill any standard. However, carts should meet the CE-production standards. To make sure the cart will be safe in use, criteria were derived from the standards for strollers (EN-1888) and toys (EN-71) and the playground standard. Appendix V reviews the three standards. They should be used during a final test of a prototype. At a later stage of the process a discussion with a standard- expert should be arranged to discuss the design.

Sufficient capacity

The present number of carts suffices on 44% of the days, resulting in a shortage of carts on 66% of the days. Approximately 12% of all daily visitors are potential users of the carts, caregivers and children. Using available data a prediction was made for the number of carts needed, both on the short term and long term. (Appendix B elaborates on the calculations and assumptions made).

Increasing the capacity to 100 carts will suffice for 75% of the park days with the present number of visitors (Figure 3.4). In 2030, 100 carts will suffice 55% of the days. Artis expects the number of visitors to grow. For a sufficient number of carts on 75% of the days in 2030, 145 carts will be needed.

Artis is concerned about the number of carts in the park on busy days and does not want to overload the park with them. Furthermore, interviews with other zoos indicated, that demand for carts is without limits since visitors will use them for all kind of other purposes if they are available.

Conclusion

Discussion with main stakeholders within Artis resulted in the following conclusions. Hundred carts should be at least available in the park (sufficient for 75% of the days in 2020 and 55%

of the days in 2030). Hundred carts will be the initial investment. The carts should be scalable in batches of 10 to scale up easily.

Self service

Costs of creating (multiple) manned stations are high. Artis aims to provide their services for free. Employing personnel to distribute the carts should be considered too costly and not profitable. By using a self-service system, the visitors can make use of the service anytime and possibly for free.

Park Context

Artis' lay out will change over the coming years, it is uncertain when and how, plans are still preliminary. Therefore, the current lay out of Artis is chosen to design for as a base. Adaptability of the service is required.

According to Artis' park vision all visitor groups should be able to walk and explore the park choosing their own route. Therefore, trains or other means transporting multiple visitor groups at the same time are not considered.

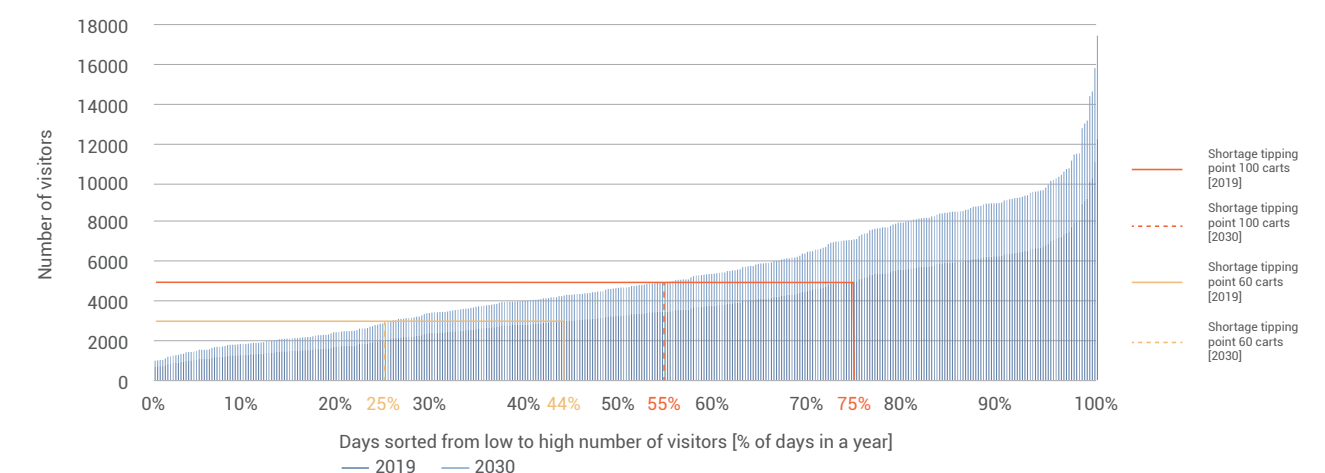


Figure 3.4: Shortage tipping point for number of visitors in 2019 and 2030 sorted from low to high with increase of number of carts

SECTION 3.4

Design criteria

A list of criteria states the important characteristics that a design must have in order to be succesfull (Boeijen et al, 2020). This chapter describes the main criteria for both the service and cart to be succesful.

Criteria are gathered from insights from research and previously defined challenges. Table 3.1 presents the final list of criteria grouped and

devided in requirementents and wishes.The source or origin of the criteria are described in the most right colum.

The list was continuously adjusted during the project and was used as a living document. Criteria no longer applicable were removed.

Theme	Sub-theme	#	Req/whish	Description	Source/related challenge
General		1	Reqw	Service is free of charge, deposit is payed before use and returned at the end of use	Facility vision, function analysis, self-service
		1.1	Req	When stationned all carts are locked and cannot drive	Interview operational park management
User group			Req	Dutch p5 female and p95 male should be able to propell the vehicle, height of the handle bar should be variable between 65 and 95 cm	DINED, suitability for age
			Req	The vehicle should be suitable for children between 9 and 20 kilogram or up to 110 cm, whichever comes first	DINED, suitability for age
Service interaction	Take and return		Req	Unlocking/locking the vehicle should be easy to do by an adult with minimal instructions	Visitor research, accessibility
			Req	The vehicle can be unlocked with means 90% of the visitors carries with them	Visitor research, accessibility, self-service
			Req	Every cart can be locked and unlocked at any station without intervention of Artis employee	Park vision, interview P&B
			Whish	Child can sit in vehicle while (un)locking the cart	Visitor research, safety
			Whish	Two visitors can simoultaneously take/return vehicle at one station	Function analysis, accessibility
	Driving		Req	The vehicle is considered easy manouverable with one hand with child inside over all surfaces (cobblestones and pavement)	Visitor research, ease of use
			Req	The design of the cart prevents the child from falling out of the vehicle to any direction when driving; any openings do not create entrapment, child cannot stand up	Visitor research, safety standards
	Get in or out		Req	Any location/surface likely to cause the unit to tip over when climbing in must support the vertical force (200N) applied for 10 seconds	Safety standards
			Req	The unit is unable to drive when not propelled by the caregiver	Visitor research
	Park		Req	The vehicle cannot be tipped over or moved by the child when outside vehicle; The vehicle must not tip over when horizontal force of max 120N in a horizontal direction and 1500 mm above the horizontal surface or at the top edge is applied	Safety standards
Station	Location		Req	Stations are situated at obstruction points identified or major walking routes	Visitor behaviour, walking routes
			Req	At least one station is visible from the back exit	Visitor research
			Whish	Station including vehicles must not obstruct sight of animals in animal enclosures	Park guidelines

Table 3.1: List of criteria

Group	Subgroup	#	Req/whish	Description	Origin
			Whish	A station is considered recognisable by visitors with or without vehicles	Visitor research, accessibility
			Req	The station including carts should not have protruding parts that can hinder other visitors	Safety standards
			Req	A station can be removed and resituated by Artis's maintenance team by only removing bricks	Park vision, adaptebility service
Provide information			Whish	The number of carts available per station can be found in the Artis application	Visitor research, predictability
			Whish	All stations are visible on the map and map in application	Visitor research, predictability
			Req	Road signs indicate directions to stations	Touch points, predictability
			Req	Information on website and application is considered clear, visitor knows how to use the service, where stations are located before their visit	Touch points
			Whish	Every station provides information about; using the service, other stations	Visitor research, predictability
Cart			Req	The product should be considered 'safe in use' by as many test subjects as possible	Suitability and safety
			Req	The vehicle should not have protruding elements that can hinder other visitors when parked or driving.	Obstacles
			Req	The vehicle should enable full sight for the child when seated	Suitability
			Req	The vehicles can be nested	Minimize space occupation
Space occupation			Req	The station at the papegaaienlaan should be able to host all vehicles on max 48 m²	Space occupation
Aesthetics			Req	The vehicle and station are considered to fit in the classic park theme by main stakeholders	Park vision
			Whish	The vehicle is preceived as attractive and fun by children for as much tested people as possible	Visitor research, desirability
Durability			Whish	Contact points with the ground are made of wear and impact resistant materials	Wear fast, mechanical shortcomings
			Req	Vehicle must be able to stand outside and used for 5 years before repairment of frame and seat.	Maintenance, outside conditions
			Req	Materials used are water,- mildew and dirtrepellent, shall not decolorate and remain stable in a range of temperatures from -10 to +40 °C.	outside conditions
			Req	Parts shall be designed such that precipitation can drain off freely and water accumulation shall be avoided	outside conditions
			Req	The vehicle shall support a static load of 800 N in the center of the area the child is seated.	improper use
			Req	Materials used are recyclable in Artis' containers	Sustainability goals
Safety test			Req	There shall be no protruding nails or pointed or sharp-edged components conform the edge test in the reach area of the child.	safety standards
			Req	When parked (facing up and down the slope) the vehicle shall remain static on a slope (10 degrees) for a minimum of 1 minute including weight child.	safety standards
Mainte-nance			Req	Parts that need common maintenance or replacement should be easily reachable and reparable by Artis' social workers with mostly generic tools	Stakeholder interviews, minimize maintenance
Servicing			Whish	Multiple vehicles can be moved at the same time by one person manually	Daily servicing
Capacity			Req	Minimal 100 vehicles are always available for use in Artis	Lack of capacity
			Whish	Quantity of vehicles is scalable in batches of 10 vehicles	Scalability
Costs			Req	The initial investment costs including installation of station and vehicles shall not exceed 100.000 euros	Costs
			Whish	Yearly maintenance of all vehicles does not exceed 120 manhours equal to 5000 euro	Costs



CHAPTER 4

Summary design process

SECTION 4.1

Service design

This section summarizes the design process towards the service proposal (Figure 4.1). Ideation and clustering resulted in three possible service directions all focussing on different challenges. This section concludes with a substantiation of the chosen service direction.

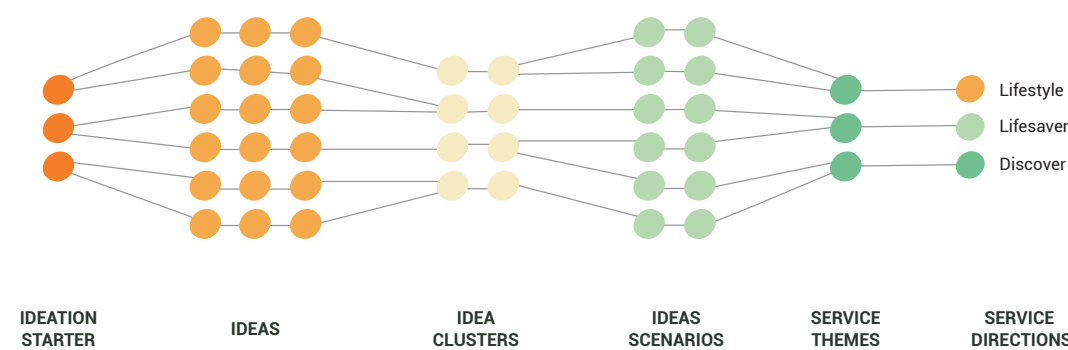


Figure 4.1: Visual illustrating the approach towards the final service direction

4.1.1 Ideation

To start the ideation, one of the starting points was to look at how capacity vs demand problems are solved in other sectors. The general traffic jam problem and how children can move themselves or are moved by caregivers were sources of inspiration.

All different ideas were cut out and clustered into different themes representing parts of possible solutions for service steps or physical parts of the service.

Ideas from several clusters were taken and combined to multiple scenarios. The ideation revealed several criteria, those were integrated in the criteria.

1.1.1 Service themes

To get towards service themes, the scenario's were clustered resulting in three different service themes all with plus, minus and interesting points. All themes focus on different opportunities to improve the service;

1. **Last-mile transport** Provide a service which helps the visitor for short periods of time to cover the distance when the child is tired.
2. **Discover and play** Provide a service focussing on supporting children to move through Artis independently.
3. **Companion for a day** Provide a service focussing on supporting the whole family.

The themes were further defined, combined and equally elaborated on such that they could be compared as service directions.

4.1.2 Service directions

Three directions followed from combining different aspects of the service themes. The directions resulted in a possible user journey and actions for internal stakeholders to provide the service. They were compared, using the previously defined challenges. Appendix N elaborates on the complete process.

Outline service directions

For every direction a service outline was made using the framework in Figure 4.2 to be able to

	Focus challenge	Visitor journey	Park layout	Plus
Title				Minus
Goal		Artis actions		Interesting
				Opportunity

Figure 4.2: Framework used for every direction

compare them equally and discuss with internal stakeholders.

The three proposed service directions are described in the infographics on the next pages. represents the Lifestyle direction (Figure 4.3), the Lifesaver direction (Figure 4.4) and the discover direction (Figure 4.5). Every infographic displays the goal and challenges the direction focuses on (top left). A schematic overview of the service and physical elements in the park is given together with the possible visitor route (top right). The visitor journey steps together with the involvement of different stakeholders is mapped (middle). Coloured bullets indicate if the painpoints identified in the current service blueprint are improved (green), the same (yellow) or aggravated (orange). Positive (+), negative (-), interesting (i) and opportunities (o) for every direction are described (bottom).

Comparing directions

The three directions focus on different challenges. The comparison table in Table 4.1 scores (minuses and pluses) the different directions for how they meet the challenges. An extra challenge was added; minimal demand on front office and security since this is a differentiation point for all directions.

The **lifestyle** direction shows clear pluses for minimal daily servicing, due to the single station and deposit system where visitors are obliged to bring back the cart. There is more focus on suitability since it is family focused. There is a focus on availability and predictability with for example the reservation possibility. Since there is only one pick up and return point, pick up and leave scores low. Visitors that want to exit at the

back need to go to the entrance first to hand in. There is a high pressure on the shop, and self-service is not focused on.

Direction two, **lifesaver**, scores high on capacity since the multiple pick up and return points will stimulate a sharing system. This direction focuses on picking up and leaving any time, showing in the scoring. Rearrangement of the carts might be needed, daily servicing scores low. Security is still involved as the demand on the front office is spread out. No reservation system is in place scoring less on reliability than direction one.

Direction two and three, **discover**, do not differ much in terms of what elements the service entails, however the goal of the service is completely different. Direction three scores less on self-service since every visitor (except for members) needs to go past a token point. The security is less involved in direction three since there is complete control over who can use the service.

1.1.2 Conclusison

Ideation resulted in three service directions. Discussion and evaluation with stakeholders within Artis resulted in a decision for the service direction.

The life saver direction was preferred and considered most valuable for Artis.

It fits Artis' values about sharing and the idea of being able to pick up and leave the cart easily is appealing. Organisational problems are less focused on for now. This should be taken into account during the next project phase. The idea of always being able to take one and use one is most valuable especially for the visitors who mostly use it, the members, accessibility is key. Visitors are still able to take a cart and use it all day, for the smaller legs. This service is flexible and can be used by all types of visitors.

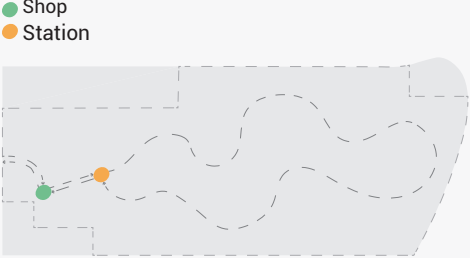
The service outline sets boundaries for the carts and stations which will be designed in the next section.

1. Lifestyle
Family focused

Predictable service for **all day** mobility support, focussing on the challenges; capacity, suitability, predictability and reliability, minimizing daily servicing.

Visitor: Make reservation for cart online or in app, **pick up coin** and **pay deposit in shop**, unlock cart to take along the whole visit (ownership). End of day, return cart to station and return token to shop to receive deposit.

Artis: High demand on shop, managing reservations, no involvement security and operational park management.



Phase	Before				During												After	
Step	Decide to go	Prepare visit	Travel to Artis	Arrive	Buy ticket	Check ticket	Enter Artis	Take cart	Watch animal	Walk from A to B	Take a break	Visit inside enclosure	Decide to go home	Hand in cart	Exit Artis	Travel home	After enjoy	
Scenario																		
Action	Decide to go to Artis	Prepare visit, reserve wagon, information provided website or app, knowledge park rules	Go to Artis, transport depends on availability, convenience and location	Park bike or car, unload and walk to entrance	Stand in line to buy ticket at the ticket booth or walk straight to gate with online ticket or Artis card	Show ticket at the gate	Walk straight after the entrance to the shop	In shop, pay deposit, get token, unlock cart	Get in and out wagon easily	After deciding where to go, search for and go to another enclosure	Park cart at one of the cart parking	Staff cart in front of gorilla house or take inside	Go to front exit	Return cart at shop station, return token in shop, one found in point	Walk towards the exit carrying the child	Take bike, car, public transport to go home	Discuss the visit and fill in the received survey	
Line of interaction		Shop Ensure carts are ready			Ticket booth Give out tokens	Gate control Guide to shop	Shop Manage reservations Reserve deposit Give out	Security/volunteers						Shop Return tokens Return deposit Get service				
Line of visibility		Backoffice Provide information about the service manage reservations			Backoffice Suggest cart service for online tickets Manage reservation									Shop No daily servicing	Backoffice Send survey			

- +** All carts are returned, no daily servicing
- +** Predictable for visitor
- +** Control who uses
- +** Security and volunteers are not involved
- Manned service, reservation management
- More effort to take cart (members)
- No hand in at back exit
- High demand on shop
- Extra cashflow needed in shop
- i** Manage amount of carts
- i** Service and responsibility streamlined to one touchpoint
- i** One gathering point for space occupation
- o** Coin & deposit machine
- o** If new entrance, extra deposit and return point
- o** Add carts on busy days
- o** Easy transform to payed service

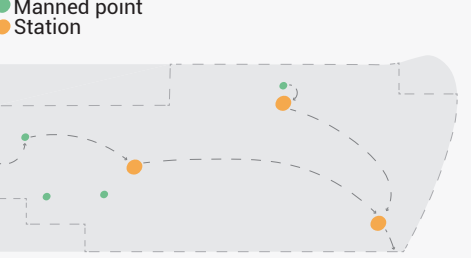
Figure 4.3: Description of Lifestyle direction, presenting a short description, service lay out, pain points

3. Discover
Child focused

Service focussing on **exploring** and **child autonomy**. Focusing on the challenges; Capacity, Suitability, Fun

Visitor: **Get Artis token** at point (members bring own) **unlock 'scooter'** at station, use and devide energy to explore park bring back at other station, take token home.

Artis: Devide demand on FO by free tokens, no demand on security, reorganise carts to front, demand operational park management



Phase	Before				During												After	
Step	Decide to go	Prepare visit	Travel to Artis	Arrive	Buy ticket	Check ticket	Enter Artis	Take cart	Watch animal	Walk from A to B	Take a break	Visit inside enclosure	Decide to go home	Hand in cart	Exit Artis	Travel home	After enjoy	
Scenario																		
Action	Decide to go to Artis	Prepare visit, look info provided by website or app, knowledge park rules	Go to Artis, transport depends on availability, convenience and location	Park bike or car, unload and walk to entrance	Stand in line to buy ticket at the ticket booth or walk straight to gate with online ticket or Artis card	Show ticket at the gate	Walk straight after the entrance to service desk to get token or bring own	Get token at service desk, unlock cart	Get on and of easily	After deciding where to go, search for and go to another enclosure	Take scooter inside or stall in front	Staff cart in front of gorilla house or take inside	Go to the exit	Return 'scooter' at station near exit, take token home	Walk towards the exit carrying the child	Take bike, car, public transport to go home	Discuss the visit and fill in the received survey	
Line of interaction					Ticket booth Give out tokens	Gate control Give out tokens	Service desk Give out tokens	Security/volunteers						Shop Self souvenirs				
Line of visibility		Backoffice Provide information about the service			Backoffice Suggest cart service for online tickets Manage app									Shop Reorganise carts to entrance	Backoffice Send survey			

- +** Little treshold to take cart, control over users
- +** Support child development
- Bring carts at end of the day to entrance
- Endless amount tokens needed (+- 15.000 year), send tokens to members
- i** Devide pressure on F2F touchpoints
- i** Trust visitor to lock and return
- i** Control over who uses the carts
- i** Members have coin, privilege
- i** Focus on fun
- o** If stations have unlimited space, all carts are locked at end of the day
- o** Integrate GPS in carts, show availability and location in app
- o** Add stations on busy days
- o** Split target group

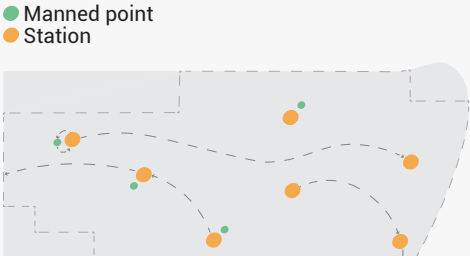
Figure 4.5: Description of Discover direction, presenting a short description, service lay out, pain points

2. Lifesaver
Transport focused

Accesible service for last-mile mobility support, focusing on challenges; shared capacity, self-service, accessibility, take park and leave.

Visitor: When tired, **grab a cart with two euro coin** or **get a free token at manned point** nearby e.g. bakfiets. Return cart near exit, use it when you need it. Easy take and leave.

Artis: Devide demand FO by giving out free coins at several points, similar demand on security and operational park management, several stations to maintain.



Phase	Before				During												After	
Step	Decide to go	Prepare visit	Travel to Artis	Arrive	Buy ticket	Check ticket	Enter Artis	Watch animal	Take cart	Walk from A to B	Take a break	Visit inside enclosure	Decide to go home	Hand in cart	Exit Artis	Travel home	After enjoy	
Scenario																		
Action	Decide to go to Artis	Prepare visit, look website for find info about service	Go to Artis, transport depends on availability, convenience and location	Park bike or car, unload and walk to entrance	Stand in line to buy ticket at the ticket booth or walk straight to gate with online ticket or Artis card	Show ticket at the gate	Walk straight after the entrance to the shop	Get in and out cart easily	Insert 2 euro coin, get token for free at any manned point in Artis, unlock cart	After deciding where to go, search for and go to another enclosure	Leave cart at station, take coin out, take location of other stations at every station	Staff cart in front of gorilla house or take inside	Take cart at station with coin, get token at any manned point close to station	Return cart at any station, take token home for next time	Walk towards the exit carrying the child	Take bike, car, public transport to go home	Discuss the visit and fill in the received survey	
Line of interaction					Ticket booth Give out tokens	Gate control Give out tokens if asked	Shop Give out free token	Security/volunteers Same pressure						Shop Self souvenirs				
Line of visibility		Backoffice Provide information about the service			Backoffice Suggest cart service for online tickets									Shop No daily servicing	Backoffice Send survey			

- +** Predictability by availability and info provided by signs
- +** Accessibility focus
- +** No cash issue for shop
- +** Easy to take and leave
- Reorganize carts at end of the day
- Organisational challenges barely solved
- New tokens needed every day, devide over points
- i** Devide pressure on F2F touchpoints
- i** Increase capacity by sharing
- i** Trust visitor to lock
- i** Semi-control over who uses the carts
- i** Devide space occupation over park
- o** stations have unlimited space, carts are locked at end of the day
- o** GPS in carts, show availability and location in app, in app unlock for accessibility
- o** Self-organising after finding right locations

Figure 4.4: Description of Lifesaver direction, presenting a short description, service lay out, pain points

		1 Lifestyle	2 Lifesaver	3 Discover
FOR ARTIS	Provide service fitting park vision	+	+	+
	Provide sufficient capacity	+	++	+
	Use minimal space in the park	does not apply now	does not apply now	does not apply now
	Service with minimal maintenance	does not apply now	does not apply now	does not apply now
	Minimal daily servicing	++	--	-
	Minimal demand FO + security	-	+-	+-
	Suitable & safe for children 1-4	++	+	+
	Self service	--	+	+-
	Predictable, accessible and reliable	++	+	+
	Picked up, left and parked any time	-	++	+
FOR VISITOR				

Table 4.1: Comparison service directions, description of which challenges they meet or focus on.

SECTION 4.2

Cart design

This sections elaborates on the the design process (Figure 4.6) of the cart aiming for a cart that seamlessly connects with the proposed service direction and that meets the remaining challenges. This section describes the iterative approach and process resulting in a new concept cart.

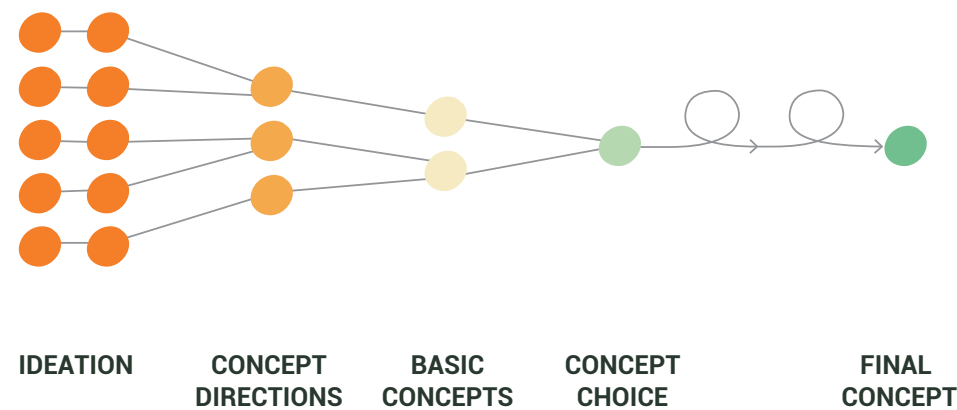


Figure 4.6: Visual illustrating the process towards the final concept

4.2.1 Ideation and concept directions

Brain sketching was used to explore challenges and ideas. The ideation resulted in a lot of ideas, which created a lot of chaos. Ideas were presented and discussed during a brainstorm with Jos Oberdorf and Jan de Boer. Building on existing ideas by drawing resulted in concept directions and new guidelines/requirements for the design. Appendix M and appendix N elaborate on both steps.

The following principles were decided on;

- The concept of a pull cart is chosen to keep the fun and playful character of the carts in Artis.
- To start the movement of the cart, the pull bar is lifted and then pulled to be moved, this is the most pleasant way to drive a pull cart.
- The wheels should be behind the center of mass of the child to make sure the cart cannot tip over backwards and will always tip over to the front resulting in a stable position.
- The carts should be nestable to save space. No big volumes can be used. Forms suitable

for nesting are made of tubes and plates that slide over each other. Materials suitable for this application are for example wood, bamboo and steel, or other outdoor materials.

- The pivot point of the pull bar should be behind the seated child to prevent fingers from getting trapped.

Concept directions

Two main directions followed from the brainstorm all making the pull bar 'locking up' the child to make sure it cannot fall out when driving, resulting in the feeling of safety and control for the caregiver. When standing still, the pull bar drops down or can be pushed upwards, opening the side of the cart so the child can get out or in. Working principles of both concept directions are visualized in Figure 4.7.

For **concept direction A**, the pull bar is lifted from the ground to drive. This cart needs a mechanical stop to prevent the pull bar from getting to high and not lifting the cart to drive. For **concept**

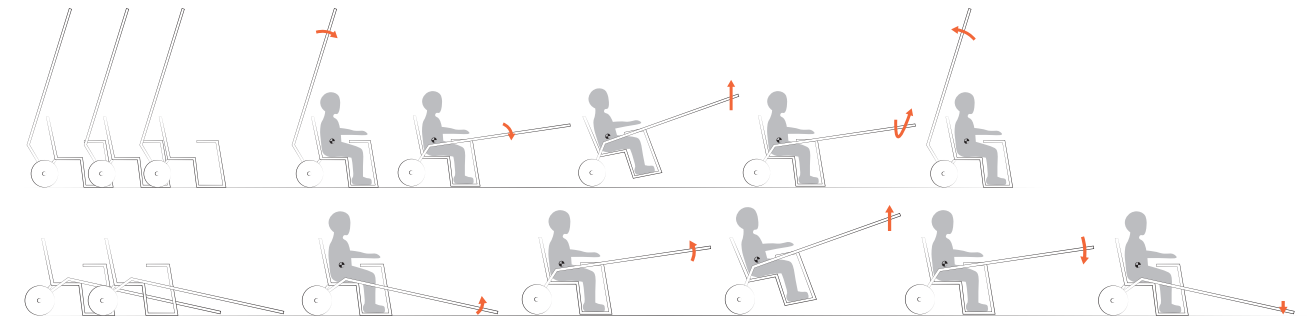


Figure 4.7: Concept direction A (bottom) and B (top) potential movement scenario

direction B the pull bar moves from the top to the neutral position.

A lap bar is integrated in frame of the cart to make sure the child cannot stand up when driving. All concepts require a hinge point, mechanical stop or wedge to enable and stop moving parts. No hazardous situations may occur where feet or fingers get trapped.

4.2.2 Defining concepts

The next paragraphs present both elaborated concept directions. First main characteristics are described and the directions are compared. The paragraph ends with a substantiated choice for the final concept cart direction. The details of both concepts are described in appendix P.

Concept direction A: The giraffe

The cart can be lifted and pulled by a caregiver after lifting up the pull bar to 'close' the cart. When lifted movement of the pull bar is blocked, it can be propelled and drives on two wheels. Once the caregiver lets go of the pull bar, it drops down opening the side of the cart enabling the child to climb out. The user scenario and main elements are visualized in Figure 4.8

For nesting, the cart is tipped over by the user for, resting on the backrest. The ball wheel integrated in the frame on the back rest touches the ground when the cart is turned and enables the cart to drive on three wheels. This way, multiple carts can be moved at the same time. Because the carts are rotated when nested and the pull bar is vertical, they do not take up a lot of space in the park.

Concept direction B: The ring-tailed lemur

The cart can be lifted and pulled by the caregiver after pulling down the pull bar to 'close' the cart. The pull bar locks at the back of the seat, with an indexing pin, to enable the lifting and pulling movement. When lifted, it can be propelled and drives on two wheels. When the cart is in neutral position, the caregiver opens the cart by unlocking the indexing pin and lifting up the pull bar, now the child can climb out. The user scenario and main elements of the concept are described in Figure 4.8.

When nesting, the slots in the backrest and seat slide over the lap bar of the cart behind resulting in minor space occupation when stationed. Two slots together with the tapered seat allow the carts to nest. When in use, the space occupied by the cart is small because the pull bar is rotated upwards.

Choosing the concept direction

A discussion with the team from the TU Delft, taking into account the positive, negative and interesting points presented in Figure 4.8 on the next page resulted in a decision for the concept direction to continue with. The directions were not compared using the design criteria because not all were met yet.

The concept with the most potential was chosen, the Ring-tailed lemur, mainly because of the inviting character of the cart. When the pull bar is up it invites the child to climb in. Furthermore, space occupation of the carts in the park will decrease because the cart is small when opened and allows for easy stalling.

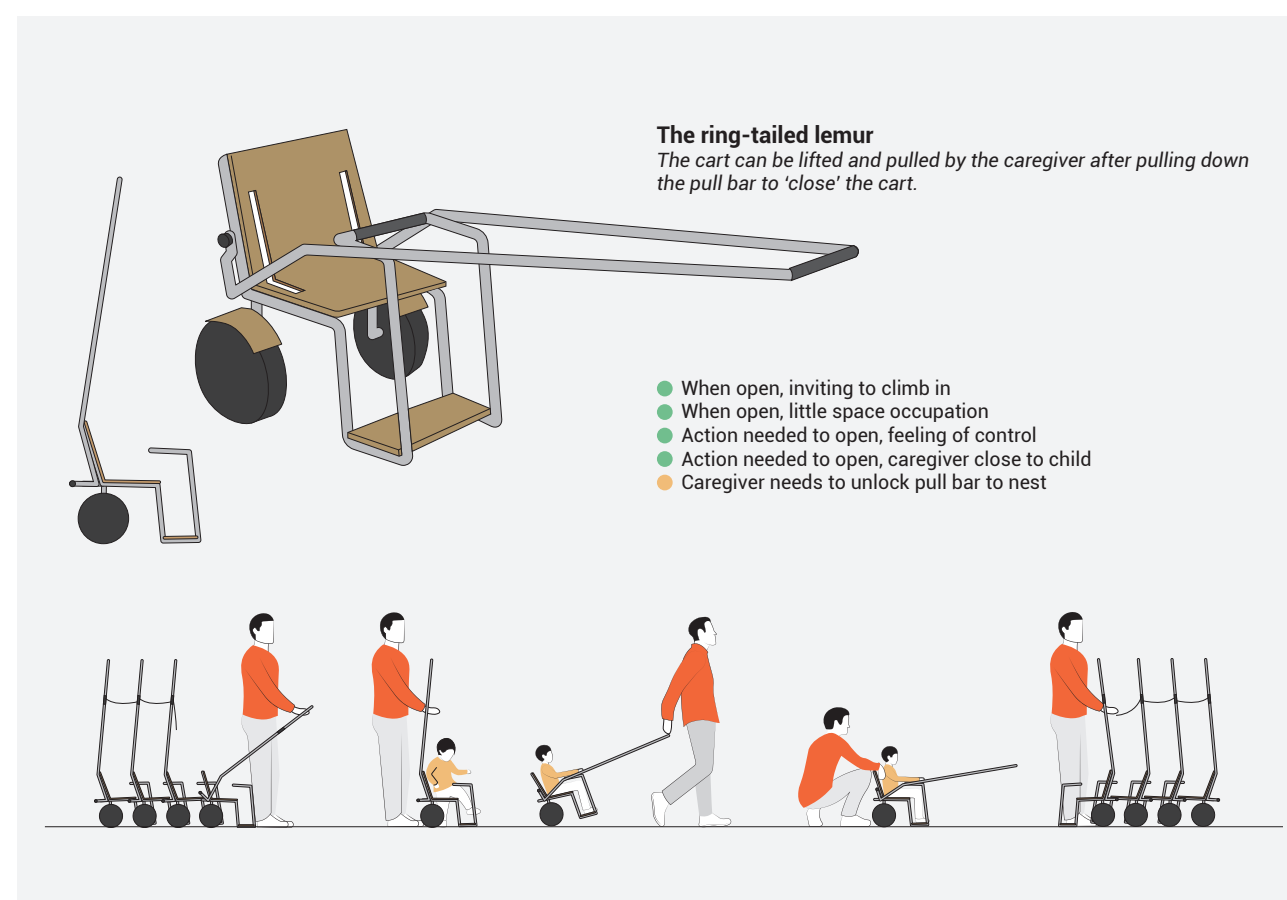
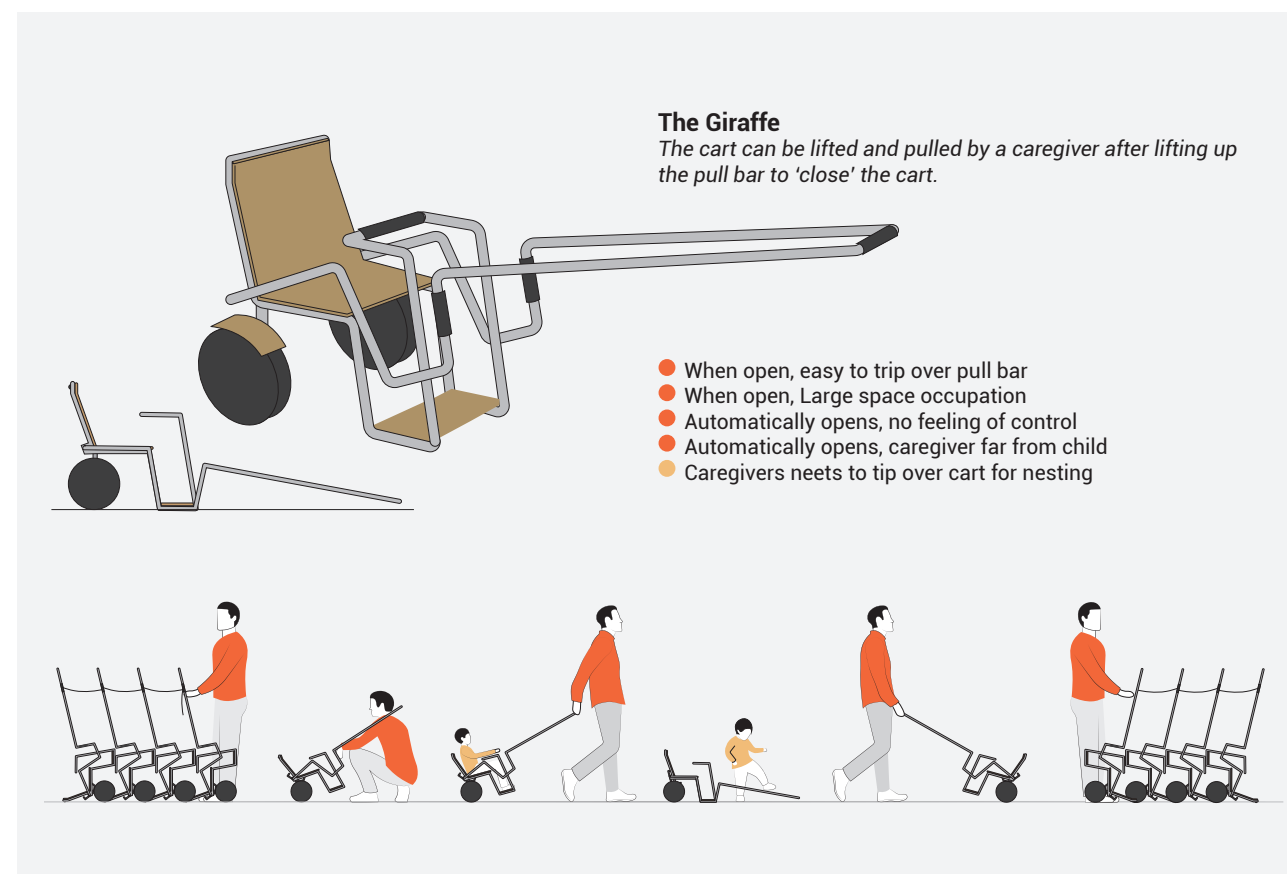


Figure 4.8: Elaboration of Concept A, The Giraffe and Concept B, the ring-tailed lemur

4.2.3 Iterations to final concept

The starting point for further development of the cart was the ring-tailed lemur concept direction. The pull bar, lap bar and other elements were elaborated on. Changes were made to the design of the concept during several iterations, Figure 4.9 shows several process renders of the cart over time. To easily evaluate the design, several 3D computer models were made. The goal of every iteration was to bring the design closer to a feasible and simple concept meeting all requirements. Appendix Q, R and S describe all iterations step by step. The next paragraph gives an idea about the challenges that were tackled. The final concept is presented in the next chapter.

Relationship nesting and lap bar

The carts nest in the station, by unlocking the pull bar and rotating it upwards, it can rest on the cart behind. The rotation of the pull, and thereby its horizontal stops, should not interfere with the lap bar of the cart behind. Every iteration focused on enabling nesting and ensuring all parts were stiff enough to withstand forces.

Changes in the shape and placement of the lap bar influence the shape of the pull bar as well as the location and attachment of the locking mechanism. Figure 4.9 shows the different iterations in which the lap bar changes from a

hardly accessible frame to a T-shaped bar also functioning as a 'steering wheel'. Every iteration, measurements were played with, resulting in a compromise between all.

Relationship pull bar and nesting

The cart is open when nested, the pull bar should be in vertical position. The shape of the pull bar and the location of the rotation point determine its position (relative to other parts) when open and closed. When the cart is closed, the pull bar should close off the sides of the cart. When open, it should not protrude to the back too much and should be as vertical as possible when nested. Multiple iterations resulted in a pull bar with one large bend starting from the wheel axis. Thereafter it is a straight line to the handle.

The measurements of the pull bar were determined taking into account extra space for safety and measurements of both the caregivers and children.

Frame and wooden parts

No big volumes could be used because the carts need to nest. Therefore, the mainframe and parts are made of tubes and plates. Each iteration aimed to simplify the frame such that it can be produced, is cheap and stiff enough. All elements were integrated using as few bends as possible.



Figure 4.9: Images from top left (first) to bottom right (final) show progress of the concept using 3D models



CHAPTER 5

Product-service proposal

SECTION 5.1

Accessible last-mile mobility support for children in Artis

This chapter presents the designed product-service concept, aiming to provide accessible and flexible mobility support by means of a new service and special tailored cart.

In general terms, the proposed service provides readily available and predictable mobility support that fits children and their caregivers with different age-dependent needs. It offers this by a larger number of inviting and safe, one person pull carts. Carts can be picked up and left at any of the ten compact stations throughout the park, thus inviting intermittent use and sharing of carts. It is a non-supervised self-service using tokens. The cart is made of simply bent iron tubes

and weather-resistant wood making the cart durable, relatively easy to produce and maintain. (Figure 5.2 shows a rendered model of the cart and station). The service and its cart adheres to Artis legacy and fits its park vision as it free, unobtrusive and can be scaled up easily.

The next section will shortly clarify the main characteristics of the proposed service concept. Starting from the layout of stations and carts, the idea behind the service is described. Then the main characteristics of the cart are given. The chapter closes by summarizing the main benefits of the new service concept relative to the present iconic Artis cart and its problems.

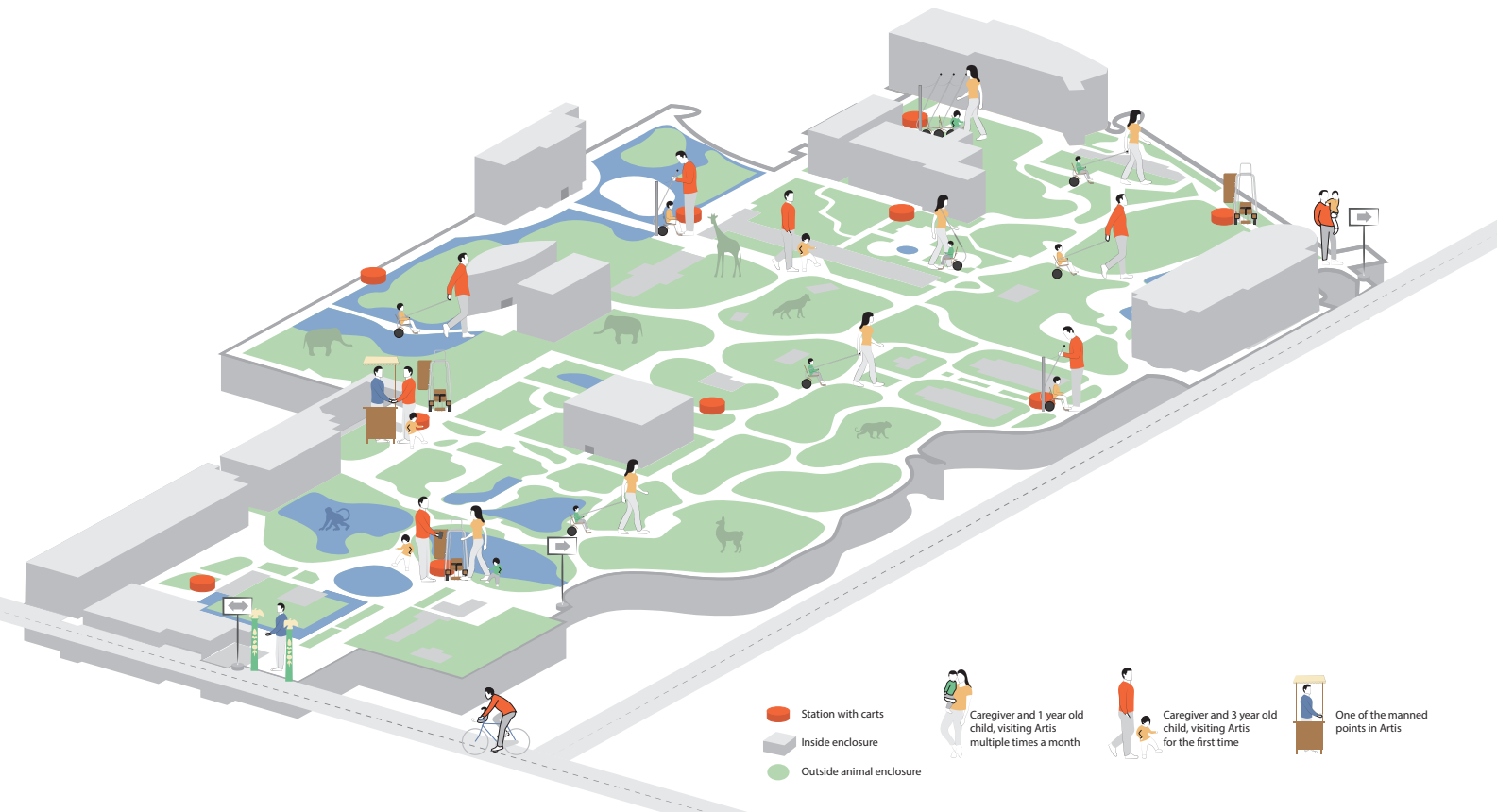


Figure 5.1: Representation of Artis with 10 stations spread out through the park, inside and outside animal enclosures describing two different age-dependent visitor scenarios when using the service



Figure 5.2: Caregiver and child taking a cart in the Dutch park opposite the lions enclosure (left) and Station at the 'Papegaaienlaan' with eight cars (left). The station accommodates small and large numbers of carts easily.

5.1.1 Service proposal

The product-concept proposal is best explained by showing how carts and stations are distributed over Artis. (Figure 5.1 on page 62). The main idea behind the service is that children from one up to and including three years of age and their caregivers differ in their needs for support at different times during their visit. By providing ten compact stations at well-known points together with hundred carts, caregivers can take and leave carts at different stations according to their or their child's needs. As described in Figure 5.1 caregivers with younger children, e.g. one year of age, are more likely to use a cart continuously, whereas caregivers and older children that can walk independently are more likely to leave the cart at a station at one site to than walk for a while to another site and to pick up another cart from there when tired of walking. Intermittent by different visitors encourages sharing which increases capacity of the system.

Both cart and stations are compact, allowing for a large number of carts relative to the space used (Figure 5.2). The places for stations are chosen with the known common visitor routes and obstacles in mind. When a visitor finds an empty station, another station nearby is readily found. Experience with the service will learn

which locations are well-chosen and which are ill-chosen and what number of carts at each station is best to start with each morning. When experience teaches so, stations can be repositioned without much effort.

When at a station, the recognisable open cart invites the child to climb in. The caregiver unlocks the cart at a station by inserting, shopping cart token or Artis token a one-euro coin. When no coin at hand, the visible nearest manned point provides the visitor with a free Artis-coin minimizing the effort for the caregiver. The coin functions as a deposit and is returned when the cart is locked at a station again. When stationed the carts are attached and locked to each other by means of a chain and thus setting no limit to the number of carts that can be stalled at a single station (Figure 5.2).

Although the service explains itself as it is similar to the familiar service of shopping carts special care is taken to inform visitors to increase the predictability of the service. First a single page on www.artis.nl, linked to the page 'planning your visit' describes the aim of the service, for whom the service is meant, mentions the coin system, and offers information on where the stations can be found. Second (during the visit) sideboards



Figure 5.3: Photo of 1:4 scale model with drawn girl, revealing the main working principle the concept cart

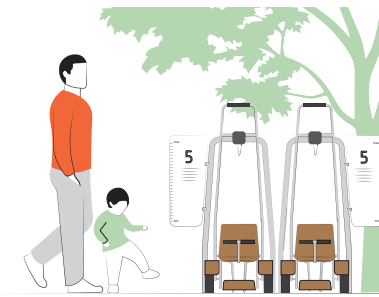


Figure 5.9: Approaching the station. The cart is open, pull-bar in up right position

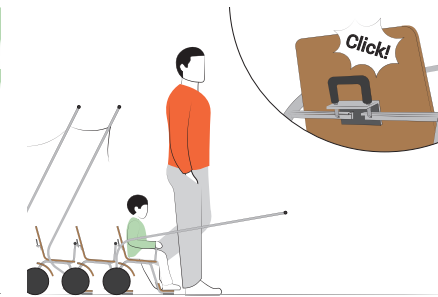


Figure 5.4: Closing the pull bar. When rotated down the the pulbar locks automatically

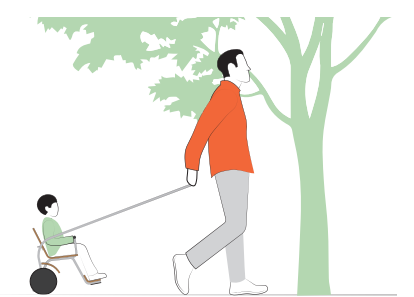


Figure 5.5: Driving the cart. The cart can be pulled after lifting the pull bar



Figure 5.6: Opening the cart. The pull bar can be rotated upwards after pulling the handle .

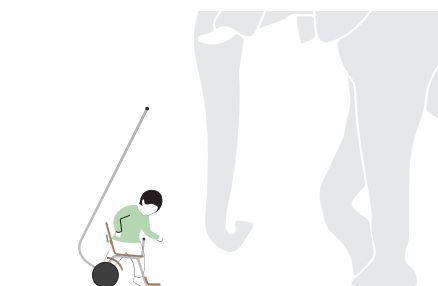


Figure 5.7: Parked cart. When cart is open child can climb in and out independently



Figure 5.8: Returning the cart. Carts are connected to each other when stationed.

attached to the stations explain the service, and third visitors may scan the NFC-stickers at each station and each coin lock which will then open a special webpage.

The service directly affects Artis' employees at the so-called manned points. They will give out Artis tokens to visitors. Helping by giving out coins is pleasurable and there will be no specific demand on the front office. Daily servicing entails reshuffling the carts by the end of the day to balance stations. When the service is correctly installed and optimized this will take less time. Chapter 6 further elaborates on how the service affects the Artis organization.

In line with Artis major aims, the service encourages visitors with small children to explore the park in their own way, it is provided for free and the number and design of carts and stations make it readily available and predictable. Moreover, the design of the cart hints at the iconic design of its predecessor that it is bound to replace.

5.1.2 Carts and stations

The carts fitting the service are simple two-wheeled pull carts made of bended iron tubes with a bended weather resistant beach wood seating, wheel covers and footrest. Figure 5.3 shows a 1:4 scale model of the proposed design, revealing the first of three major characteristics: the pull-bar.

The pull bar can take one of two positions guided by the caretaker wishing to drive the child. When stationed, the pull bar is in the vertical position Figure 5.9. The open and recognizable cart invites children and caretakers to use it. A walking child may climb in the cart independently while the caretaker detaches the cart from its lock and then closes the pull-bar. A non-walking child will be put in the cart by its caregiver after he or detached the lock. Supporting the child, the caregiver closes the pull-bar.

When closed the pull bar snatches in the lock behind the seating (Figure 5.4.) The now fixed pull bar enables the caregiver to drive the child along the lanes of Artis. The closed pull bar and the



Figure 5.10: Photo of 1:10 scale 3D printed models showing how carts nest when stationed.

T-shaped bar in front of the seat prevent the child from standing up. Because the caregiver controls the pull-bar he or she controls the child.

The caregiver starts driving by lifting the pull bar, automatically lifting the footrest from the ground (Figure 5.5). The two wheels placed behind and outside the seated child give stability to the cart. Stops integrated in the frame prevent the cart from tipping over backwards.

To stop, the caregiver lets go of the pull bar, the footrest will touch the ground again, functioning as an automatic brake. The cart is opened by the caregiver by simultaneously pulling the handle at the back of the seat and rotating the pull bar upwards (Figure 5.6), opening the sides of the cart again, enabling the child to get out accompanied or unaccompanied. The pull bar ends in a vertical position (Figure 5.7).

To stall the cart at the station, the cart is pushed back into the station, nesting into the row of carts already parked (Figure 5.8). The caregiver opens the cart. While the child climbs out the caregiver locks the pull bar to the one behind.

The second major characteristics is that the cart is **suitable and safe for boys and girls with body heights ranging from 75-110 cm** corresponding

with the age range one up to and including three. As noted earlier the T- bar and locked horizontal pull bar form a barrier preventing children from standing up or slipping form the cart when riding or pausing. The bent footrest prevents children's feet from touching the pavement or blocking the cart. Children's hands are prevented from touching the wheels by wooden mudguards. Space between (moving) parts is wide enough to prevent crushed fingers and limbs.

The third characteristics of the concept cart is **its nestability when stationed**. Figure 5.10 shows three 3D printed 1:10 scale models nested at a station. Because the pull bar is rotated upwards and the carts partly slide over each other when stationed, space occupation is minimized. The frame of the stations consist of bent tube anchored in the ground.

Forth the **design is plain and simple resulting low production and maintenance cost**. The frame is made of standard steel tubes that easily bent using standard molds and machinery. Seats, footrests and mudguards are made of highly water-resistant layered beach wood that can be produced using standard moulds. The carts can stay outside during the whole year. Chapter 6 elaborates on production, maintenance and costs.

5.1.3 Unique selling points

In short, the proposal features the following unique selling points ;

- The service provides more capacity with less space used in the park. Multiple stations with compact carts allow for sharing and flexible use solving the capacity problem.
- The service is easily accessible self-service for visitors in need of mobility support given enough capacity. Because of multiple stations and universal coin locks carts can be picked up and left at any station.
- The cart is safe and suitable for the children targeted at. The design with the rotating pull bar is tailored to the needs of caregivers and young children.
- The service is cost-effective because no additional personnel is needed to provide the service, low need for maintenance, and the cart is relatively cheap to produce, to be discussed in section 6.4 on page 80.



CHAPTER 6

Concept elaboration

SECTION 6.1

Service and corresponding touch points

This section will elaborate on what the service entails both for Artis as context and the organisation of Artis. Touch points and what is needed to provide the service is elaborated on.

The mobility support service asks for stations and carts. Other physical, digital and F2F touch points strenghten the service. Figure Figure 6.1 presents the touch points integrated in the visitor journey. This figure also describes the role of the different internal stakeholders which will be discussed at the end of the section.

6.1.1 Information channels

Both digital and analog channels provide visitors with information about the use and existance of the service to meet their different needs, they are indicated with yellow circels in Figure 6.1.

When planning a visit to Artis, the website page

“Plan je bezoek” explains how to use the service, tells about the existence of several stations by mentioning stations nearby enclosures in the park. It additionally, mentions that a euro coin should be brought and that carts can be used dependent on availability and not reserved. Under the same heading visitors can easily find to what extend scooters or tricycles can be brought. This way, visitors are more likely to take the right coin to Artis and the right scooter or cart.

Sinage in the park and physical park map indicate directions to all stations, current icons can be reused. The map states that carts can be returned and taken at any station and what coin is needed.

Information about the use of the service or the nearest station can be found by scanning the **NFC-sticker on the station or coin lock with your phone** automatically opening a webpage providing information anywhere and anytime in the park, Figure 6.4 shows a possible interface. As long as

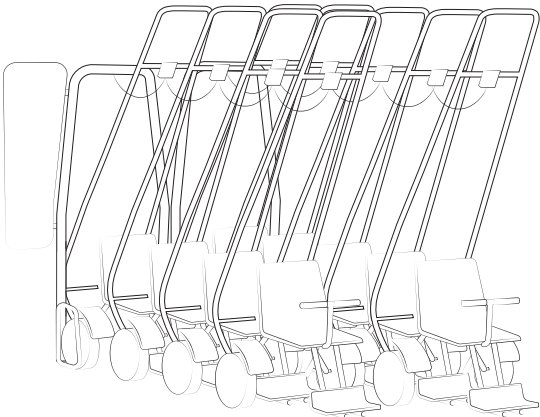


Figure 6.3: Station in park with two docking stations and carts

there is no Artis application readily available, NFC -stickers are a low cost way to provide information digitally.

6.1.2 Stations

Stations form fixed gathering points where carts are stationed, taken and returned. A station consists of one or multiple docking stations with carts (Figure 6.3). Since there is no initial limit to the number of carts per station, carts can be left at each station any time. Carts can be attached endlessly as space around the station allows. At stations with multiple rows, multiple carts can be taken by different visitors simultaneously.

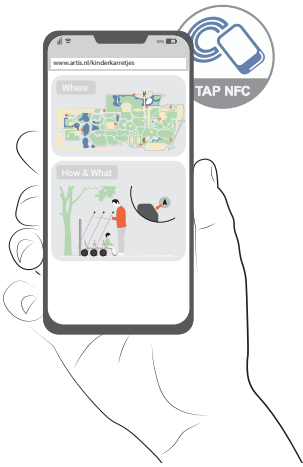


Figure 6.4: Visualization of possible URL after scanning NFC-sticker

Positioning stations parallel to the walkway will make sure carts will not block the road. Space for a path (at least 800 mm) should be considered when two double rows are positioned next to each other. This way of stalling achieves a space reduction of 60% compared to the current carousels.

Locations

Ten stations are distributed over the park and are located at common obstruction points identified during the analysis as well as along or besides popular walking routes. Stations should be visible from the main obstruction points.

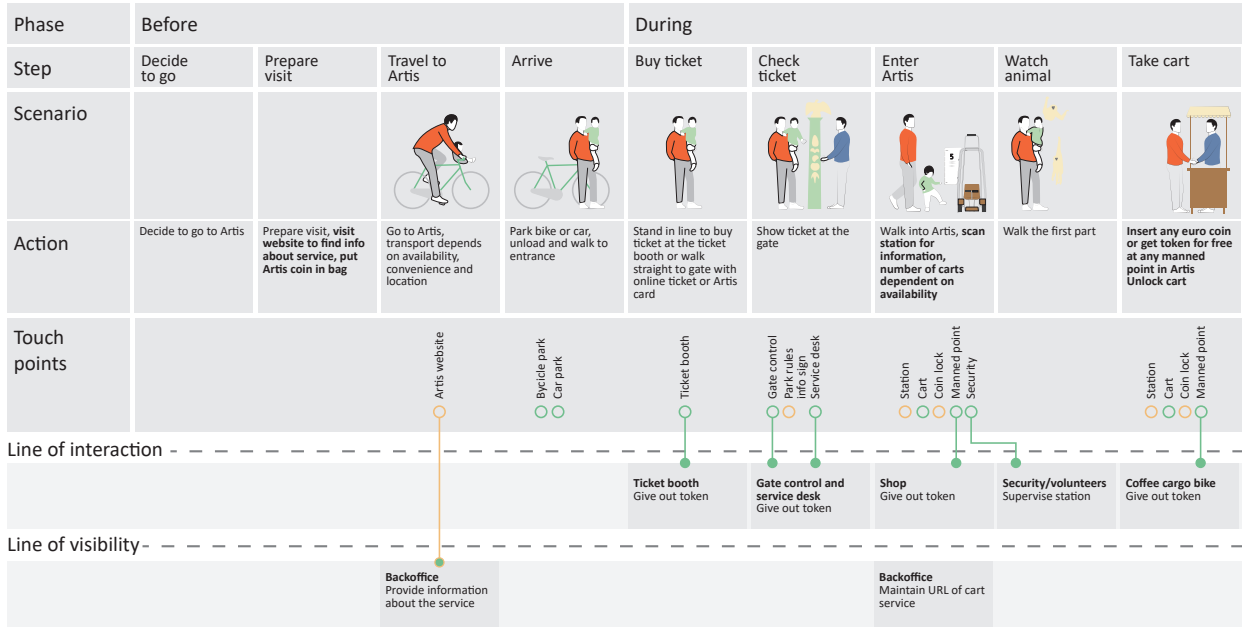


Figure 6.1: Map showing visitor journey, corresponding touch points and the role of involved stakeholders (1/2)

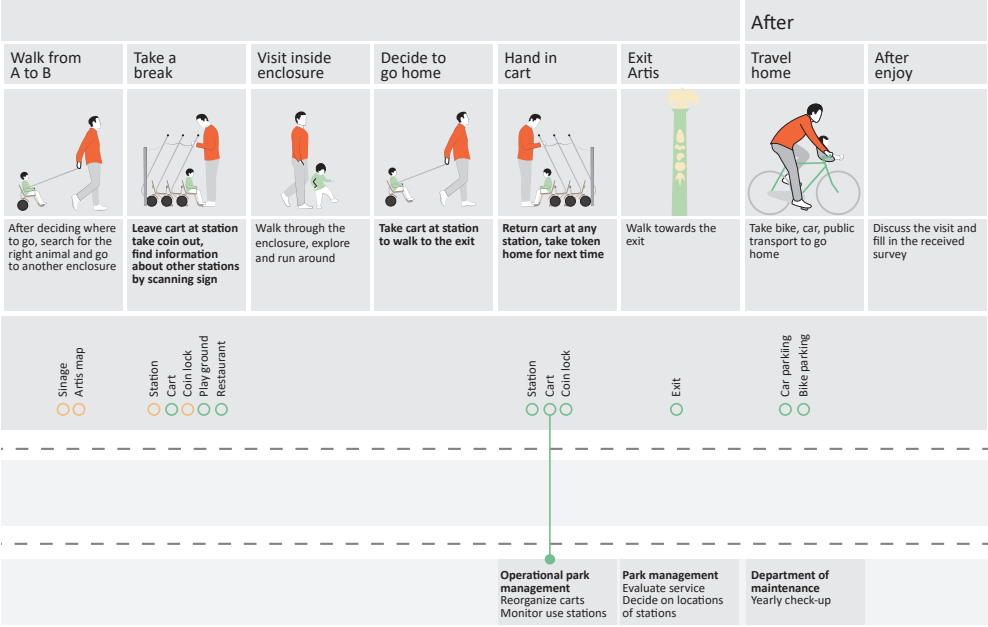


Figure 6.2: Map showing visitor journey, corresponding touch points and the role of involved stakeholders (2/2)



Figure 6.5: Locations stations spread through the park

Figure 6.5 proposes station locations. Reasons and locations of the stations are explained below.

1. **Monkey birdhouse**; close to playing area and one-way walk-through enclosure, end one of the main walking routes from the entrance.
2. **Papegaaienlaan**; end of the main and most popular walking route when entering the park
3. **Lions**; in between most popular enclosures, lions and elephants, catering facility is nearby
4. **Little mammal house**; focus on the middle of the park, next to an inside enclosure
5. **Two Cheeta's**; main walking route towards the main restaurant, close to a large playground
6. **Giraffes**; the main crossroad from the middle to back of the park, main route to the restaurant
7. **Butterfly garden**; hardly accessible enclosure for carts and strollers
8. **Gorilla house**; in front of the hardly accessible enclosure, close to a playground
9. **Aquarium**; inaccessible for carts, covering the lower part of Artis
10. **Back exit**; close to and visible from the back exit ensures visitors exiting through this exit can return their cart.

Most carts will probably gather at the station at the Papagaaienlaan because most visitors enter and leave Artis at the main gate. Multiple docking stations should be considered to allow all carts to be stalled here.

Practice will show which stations will be most regularly used or need to be repositioned. Empty stations during the day will be inevitable because all carts can be in use.

The location of animal enclosures, restaurants and playgrounds in the park influence the visitor flow and possible obstruction points. Therefore, locations of the stations need to be repeatably evaluated and monitored when in use to adapt to the changing context.

Information sign

The sideboard attached to every docking station (Figure 6.6) provides the visitor with useful information about the use of the service;

- A **ruler** on the side indicates the minimal and maximal length of the child suitable to sit in the cart.
- **Text** in both English and Dutch, explaining how the service works; that carts can be taken and returned at any of the ten stations, where Artis tokens can be obtained and how the NFC-sensor can be scanned.
- **Visual indication of the NFC-sensor** which, if scanned with a phone, automatically opens the URL that shows the locations of the stations in the park.
- A **number**, stations are numbered to visually suggest there are more stations.

- By printing the information on both sides of the panes, they can be used on both sides of the station.

6.1.3 Carts and coin lock

A hundred carts are distributed over the stations. Before and during the visit the number of carts available at each station is unknown, carts can be used dependent on availability. The coin lock and chain attached to the cart enable a self-service system similar to shopping carts. It can be unlocked with a 1 euro coin, shopping cart coin or Artis token. The coin, functioning as deposit, together with the willingness of the visitor will ensure that little or no carts will be laying around by the end of the day. Furthermore, the small threshold will keep visitors who do not especially need a cart from getting one.

Increasingly fewer people carry euro coins, these have often been replaced by shopping cart coins. To unlock the cart, both can be used. If the visitor does not carry one or the other, a free Artis coin can be obtained at one of Artis' employees at a manned point near the station, for example at a cargo bike. Because not all manned points carry cash money or an ATM, the tokens are distributed for free, enabling all Artis employees to give out coins which will shorten the quest for a coin for the visitor.

Accessibility of the service is guaranteed by allowing the lock to be opened by these three types of coins. The demand at the manned points will be low because not every visitor

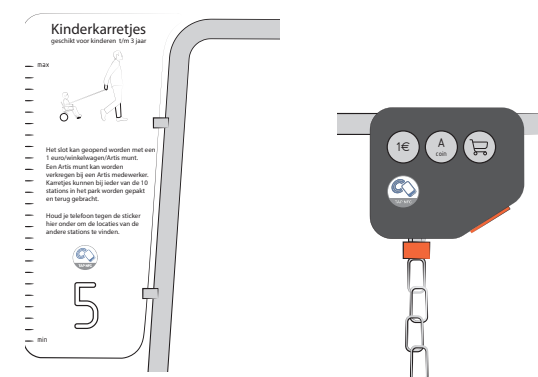


Figure 6.6: Left figure shows the information board at a station, the right figure shows the coin lock attached to the pull bar of the cart.

needs an Artis coin. The coins could also be used for other services in the park, such as lockers or wheelchairs.

NFC sticker providing information

To provide the visitor with information about the location of nearest station NFC sensors are stuck on the coin lock. By scanning the lock, a webpage opens, showing all stations. Placement of the sticker on the coin lock provides the visitor with information anywhere in the park increasing predictability.

6.1.4 Role visible and invisible stakeholders within Artis

Visible and invisible stakeholders will make sure the service can be provided. The roles of the internal stakeholders will change relative to the current service. This subsection describes the different roles.

The service directly affects personnel at the so-called **manned points**. Although the system is self-explaining they will get questions for information and Artis coins. Distribution of the Artis coins over the manned points needs to be done regularly. The Artis coin mitigates the demand on the **front office or shop**, all can serve the visitor immediately.

Daily servicing entails reshuffling the carts by the end of the day to balance stations, this will be done by the **operational park management** (Diede). When the service is correctly installed and optimized this will take less time. Demand on **security** will stay more or less the same because the threshold for taking a cart does not change. The design of the cart and stations, presented in the previous chapter, call for little maintenance. Incidental and yearly maintenance will be done in house by the **department of maintenance** (Pantar and Jack).

The **back office** is responsible for maintaining the webpage providing information about the stations. Both **management departments**, 'Project management & Maintenance as well as 'Park & Experience' will be involved with finding the right place for the station and continuous evaluation of the service.

SECTION 6.2

Design of the station

The carts are stored and nested at stations. This section clarifies the design of the docking station and how they can be used in the park.

6.2.1 Design of the frame

A single docking station consists of a powdercoated steel bent main frame (40 mm diameter, bend radius 80 mm) with two bent side tubes (20 mm, bend radius 40 mm) and an information board. The side parts making sure the carts are guided in the station, are bolted to the main frame. The cart stops when the back of the wheels touch the main frame (Figure 6.7). The chain connected to the frame enables the first cart to be locked to the station.

The main frame is grounded with concrete supports (Figure 6.8), similar to the current stations allowing for reuse of the current stations and easy translocation when needed.

6.2.2 Space occupation

The width of a station including the sign is 850 mm (600 mm without sign). With one cart stationed, the station occupies 640 x 850 mm, Every additional cart adds 310 mm (the nesting distance is 310 mm). Resulting, a row of 10 carts will be 3.4 meters long. The position of the sign on the frame makes sure that there will always be enough space next to the carts to take a cart. When a station unused, the station does not take up space but is still recognisable as a station from a distance.

Two stations can be positioned opposite or next to each other, with the information signs on both sides. Space for a path (800 mm) should be considered when two double rows are positioned next to each other (Figure 6.9).

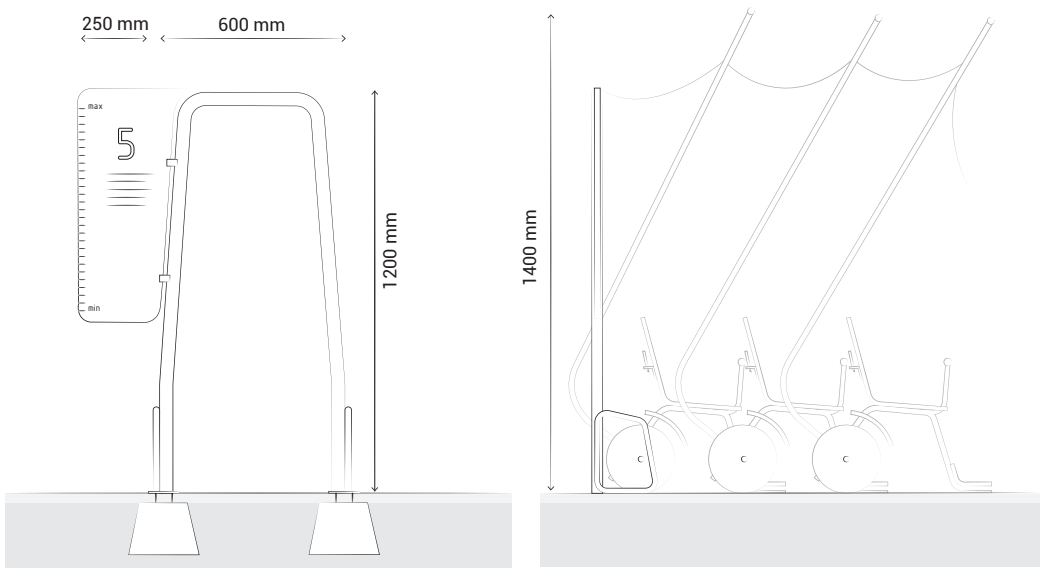


Figure 6.8: Station with concrete support front and side view including main measurements



Figure 6.7: Scale model (1:10) of carts in docking station, showing main frame and information sign

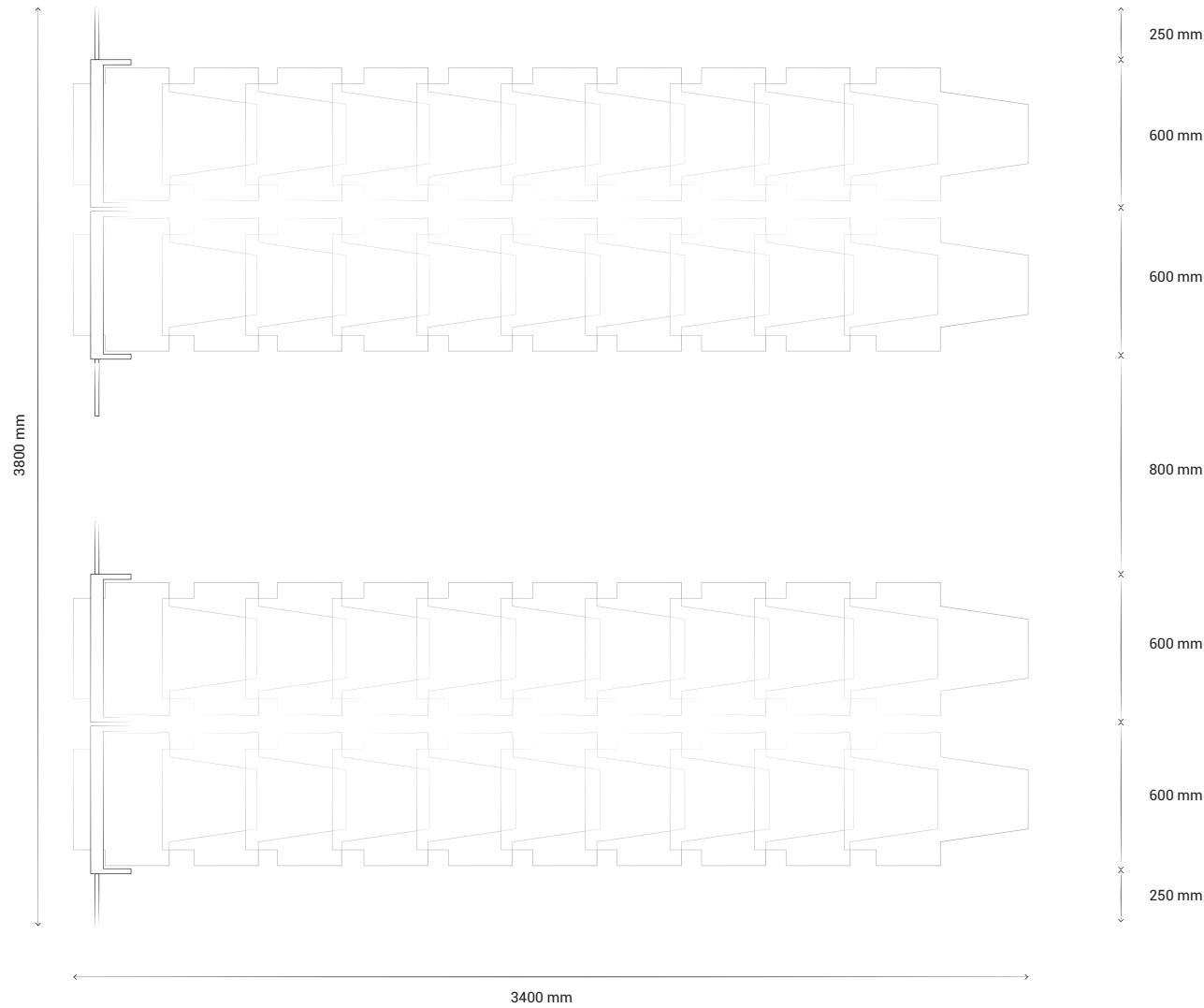


Figure 6.9: Top view of four docking stations with a row of 10 carts including measurements

SECTION 6.3

Elaboration on the design of the cart and its main parts

Ideation and several iterations by using hand sketching, building prototypes and 3D models result in newly designed concept cart that complements the service proposal. This chapter elaborates on the main design features, measurements and material choice. It closes with an assembly plan.

6.3.1 Description of main parts of the cart

Figure 6.10 shows the cart in an open and closed position. This paragraph elaborates on the parts and associated functions indicated in the figure.

The **pull bar** rotating around the wheel axis enables the open and closed position of the cart. When closing the cart, the pull bar rotates forward, two L-shaped **horizontal stops** connected to the pull bar stop its movement. Both stops automatically snatch into the lock at the backrest. The **locking mechanism** attached to the backrest of the seat by a L-profile consists of two indexing

pins connected by a handle. When rotating the pull bar downwards, both stops slide along an indexing pin pushing them up. When past the pins, the horizontal stops are blocked by the backrest and the pins automatically close, restraining further movement of the pull bar. By pulling up the **handle**, the indexing pins lift, allowing the pull bar to rotate backwards and opening the cart. After releasing the handle, the indexing pins automatically close (visualized in Figure 6.12).

The **rubber handgrip** at the end of the pull bar indicates where to hold the pull bar and comforts the caregiver when driving. An extra horizontal bar attaches the **coin lock** and connection chain to the pull bar and provides extra stiffness. The **gas spring** connected between the mainframe and pull bar guides the movement of the pull bar. It dampens the rotation forward and backwards and stops the pull bar from rotating further backwards making sure it stays upright when open and cannot accidentally fall down.



Figure 6.10: Two renders of the cart in open and closed position, arrows point at main elements

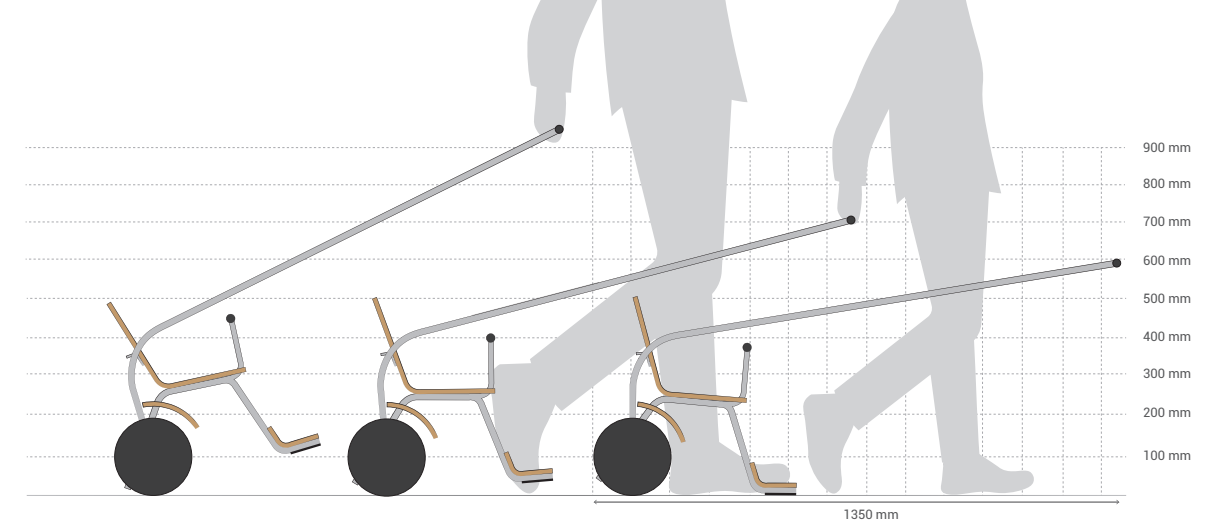


Figure 6.11: Seat angle of cart when lifted by the tallest (1950 mm) and smallest (1550 mm) caregiver

The **mainframe** functioning as the base of the cart consists of two tubes connected in the middle. Both ends of the main tubes function as **stops** preventing the cart from tipping over. **Rubber parts** connected to the frame at the footrest eliminate direct contact of the frame with the ground, limiting wear. Two separate **wheel axes** connect the pull bar and elastic **rubber wheels** to the mainframe.

The **T-bar** above the seat which is part of the main frame enables the child getting in and out when the cart is open from both sides, however this will take some effort the child. **Rubber handles** invite the child to hold on tight when driving, giving comfort and the feeling he/she can steer the cart.

Bolts connect the seat, footrest and mudguards to the mainframe. The angle between the **seat** and backrest is 110 degrees. The seat slopes downwards (5 degrees) making sure it stays in a comfortable horizontal position when a tall caregiver drives the cart, this is visualized in Figure 6.11. In neutral position, the slope allows rain to drain of freely.

The **footrest** enables the child to rest his or her feet. Small children can rest their feet on the

raised edge, it also prevents feet from moving underneath the footrest. **Mudguards** protect the child's hands from getting in the wheels and give the cart character.

6.3.2 The cart is suitable for the target group

Both children need to fit in the cart and caregivers need to be able to easily lift and pull the cart. Furthermore, the cart should be safe in use to prevent accidents or hazards situations. This paragraph discusses how both requirements are fulfilled.

The measurements of the cart for children aged one up to and including 3 were determined after analysis of anthropometric data and dimensions of strollers (appendix T). Measurements were validated with children using a 1:1 scale wooden mock-up (appendix U describes the evaluation). The height of the pull bar handle (600 mm) is determined using measurements from DINEN and a small experiment aimed to determine the difference in fist height in standing position when lifting and pulling, and standing still (appendix I). The handle height is suitable for all caregivers in the target group.



Figure 6.12: Movement of indexing pins, pull bar approaching the lock, indexing pins moving upwards, indexing pins automatically lock the horizontal stops

Main measurements can be derived from Figure 6.11 on page 77. When closed, the length of the cart is 1350 mm, when open, the length of the cart is 640 mm. The width of the seat is 300 mm and tapers to the front with an angle of 4 degrees, the total width of the cart is 500 mm. The width of the footrest is 260 mm to enable nesting and the vertical distance between the seat and footrest is 220 mm. The distance between the top of the raised edge of the footrest and the seat is 158 mm.

Safety considerations

Carts in Artis do not have to comply with safety standards. Nevertheless, the cart is designed taking safety standards into account, to make sure no hazardous situations will occur. There is at least 25 mm space between all parts in reach of the child where fingers can get trapped, indicated yellow circles in Figure 6.13. Mudguards protect hands from getting in the wheels. The locking mechanism with moving parts is positioned out of reach when the child is seated. Only the caregiver can open the pull bar giving him/her full control about the movement of the cart. Furthermore, when opening the pull bar, the caregiver is close to the child making assisting the child easy.

Wheels are next to and behind the centre of gravity of the cart at any time, because of this, the seat will always tilt forward. Stops, which are part of the frame protrude a little from the back, visible in Figure 6.10 on page 76, to prevent the cart from tipping over backwards while driving and when opened. The height of the stops was determined using the maximal rotation angle of the cart when pulled by the tallest caregiver.

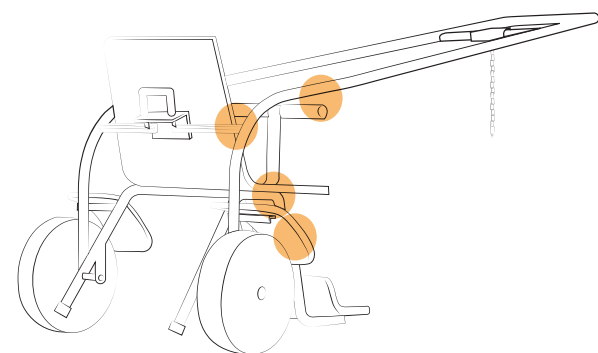


Figure 6.13: Circles indicate where extra space is added to make sure fingers cannot get trapped

6.3.3 Design of cart enables nesting

The design of the cart enables nesting and thereby efficient use of space. How it enables nesting is best described looking at the scenario of returning a cart to a station (Figure 6.14 on page 79). First, the stops at the back of the frame slide around the footrest of the cart already stationed to align the carts. The footrest can slide underneath the seat because of the two separate wheel axes. The movement of the cart is stopped by the rubber of the T-bar of the already stationed cart. After unlocking the pull bar, the pull bar can be rotated upwards because of the two horizontal stops that slide along the T-bar. Last, the stops rest on the seat of the cart behind.

6.3.4 Use of materials and the design of separate parts

Volumes do not nest well, therefore, the carts are made of plate material and bent tubes. Natural materials often used in Artis used for the cart add to the simplicity of the design. This paragraph describes the materials used and how they complement the design.

Steel mainframe

The powder-coated steel frame (weather resistant) consists of two identical bent tubes (diameter 20 mm, the radius of all bends is 40 mm). The similar bend radii and the low number of bend that are bent using existing bending blocks allow for cost-efficient production. Tubes are connected with a horizontal tube providing extra stiffness and functioning as the welding point of the T-bar. L-profile's connected to each of the main tubes support the wheel covers. At the back of each tube, an extra tube is welded providing support to the wheel axis.

Steel pull bar

The symmetrical pull bar (20 mm diameter), made out of one tube has one large rolled bend (radius 140 mm) and two small bends with the same bending radius as the mainframe at both sides. Horizontal stops, made out of L-profiles are welded to the bar. After the main bend, the pull bar tapers inward to end in the handlebar for pulling. The extra horizontal bar provides stiffness and a spot for the coin lock.



Figure 6.14: Render of two carts, pull bar sliding along T-bar of the cart behind when rotating pull bar upwards.

Weather resistant beech wood Seat, mudguards and footrest

The carts are always outside enduring all weather conditions but should be low maintenance and cost-effective. Furthermore, the cart should have a natural look, fitting the facility park vision. Therefore, bent beech wood (12 mm) is used for the seat, mudguards and footrest.

Laminated beech wood is flexible and strong and when specially treated with melamine it is low maintenance and has a long lifespan making it durable. It is widely used for outdoor chairs. Contact with Van Drenth Buighout (Mr Erwin Maton) gave insight in the many possibilities for using laminated beechwood, it appeared that standard available moulds can be used to bend all parts reducing costs. After bending, the contours of the seat are CNC milled together with holes for the bolts. Threaded tubes are pressed in the holes to enable screwing the seat to the frame. The treatment darkens the colour of the beech, the wood structure will still be visible giving the whole

a natural look. Figure 5.14 shows an example of the colour which will be similar for the cart. Appendix H elaborates on the production process and requirements for manufacturing the wooden parts.

Elastic hard rubber wheels

The cart drives best on two (diameter 200 mm, width 60 mm) low wear, elastic hard rubber wheels. Contact with Blickle (company) gave insight into the different type of wheels used for similar purposes. The proposed wheels provide the cart with suspension and low rolling resistance. The wheels are connected to the wheel axis on a threaded end.

The natural grey colour of steel, beech wood and black rubber, form the color palette used in all elements of the cart. By using materials the way they are, the design pays tribute to the materials used which fits Artis park vision.

6.3.5 Assembly

Assembly can be done in a social workspace. Wooden parts, the mainframe and pull bar are delivered as finished pieces including holes for bolts. Two separate wheel axes allow easy assembly of the pull bar. By positioning the pull bar around the mainframe, axes can be pushed through connecting both (Figure 6.15). Spacers make sure the right amount of space is kept between the mainframe and pull bar. Afterwards, the wheels are screwed on the threaded end and the gas springs are connected to the mainframe and pull bar. Second, the wooden parts are bolted to the mainframe and the locking mechanism to the backrest. Attaching the rubber protective parts and the coin lock to the frame finalizes the cart.



Figure 6.15: Description of the assembly steps of the cart, adding components from left to right

Costs and maintenance

This section will present both the initial investment costs for implementation of the proposed product and service in the park as well as the yearly costs to maintain the service.

6.4.1 Production costs carts and stations per piece

Table 6.1 and Table 6.2 present cost estimations for both the cart and stations. The last column describes the sources of quotations. Preliminary estimations based on contact with production companies and educated guesses result in the price per piece when produced in batches (100 carts, 10 docking station). Appendix H presents evaluations of manufacturability of all components and several insights for reducing costs. Both the wooden parts and steel parts can be produced using standard molds reducing costs. Costs can be reduced by using more standardized parts, such as common tube sizes and standard moulds. Outsourcing the production to a production company or social workplace will reduce costs. Since not all parts are fully designed yet, some price indications are excluded.

6.4.2 Initial investment costs

Launching the newly designed concept asks for an initial investment, Table 6.4 presents the cost overview. Hundred carts and fourteen docking

Unit price station

#	Description	Unit price	Total
1	Frame	€ 112.00	€ 112.00
1	Powder coat	€ 20.00	€ 20.00
1	NFC sticker	€ 0.30	€ 0.30
2	Info sticker	€ 5.00	€ 5.00
1	Plate	€ 12.17	€ 12.17
Total excl VAT			€ 154.47
21 % VAT			€ 32.44
Total incl VAT			€ 186.91

Table 6.1: Cost overview of unit price per station based on quotations for a batch of 10 pieces
* excl man hours for integration in park

stations (larger stations consist of multiple docking stations) should be made initially to amongs others solve the capacity problems. Expenses for integrating the stations in the park and CNC moulds are added. Development costs for the CNC molds are 600 euros per different design including programming costs, molds and test model. Costs for further development of the cart and station are not taken into account.

6.4.3 Yearly (maintenance) costs

Because the service is free in use for visitors, maintaining the service will cost Artis money. Yearly maintenance of carts entails cleaning with water and replacement of rapidly wearing or vulnerable parts, such as wheels and coin locks, this can be done in Artis' workshop. Table 6.5 presents the yearly costs for maintenance, including spare parts, PANTAR's manhours an a new annual supply of Artis tokens. Depreciation of the investment and long term reservations have not been included. The wooden parts and frame are expected to last at least 10 years before replacement when well maintained.

Concluding, the initial investment costs and yearly maintenance costs in man hours do not exceed the budgeted costs presented in the design criteria (section 3.4). Maintenance costs per cart are below the costs of the the current.

Source

Personal contact VanDrenth Buighout
Quotation JansenBuigservice
Drukenbestel.nl
Educated guess
kunststofplatenshop.nl

Unit price cart

#	Description	Unit price	Total
1	Pull bar	€ 69.00	€ 69.00
1	Mainframe	€ 84.00	€ 84.00
2	Powder coat	€ 20.00	€ 40.00
1	Seat	€ 50.00	€ 50.00
2	Wheel cap	€ 40.00	€ 80.00
1	Footrest	€ 40.00	€ 40.00
2	Wheel POEV	€ 25.00	€ 50.00
2	Indexing pin	€ 5.08	€ 10.15
1	Coin lock	€ 5.33	€ 5.33
1	NFC sticker	€ 0.30	€ 0.30
2	Gas spring	€ 15.80	€ 31.60
2	Assembly/hour	€ 35.00	€ 70.00
Total excl VAT			€ 530.38
21 % VAT			€ 111.38
Total incl VAT			€ 641.76

Table 6.2: Cost overview of price per cart based on quotations for a batch of 100 pieces
* excl start-up costs, grip and plate for the locking mechanism

Additional costs

#	Description	Unit price	Total
3	CNC molds	€ 600.00	€ 1,800.00
1000	Tokens	€ 0.10	€ 100.00
4	Placement stations	€ 45.00	€ 180.00
Total excl VAT			€ 2,080.00
21 % VAT			€ 436.80
Total incl VAT			€ 2,516.80

Table 6.3: Cost overview of additional costs for producing the carts and implementing the stations in the park.

Initial investment costs

#	Description	Unit price	Total
100	Cart	€ 530.38	€ 53,037.80
1	CNC costs	€ 1,800.00	€ 1,800.00
14	Station	€ 154.47	€ 2,162.51
1000	Artis coin	€ 0.10	€ 100.00
14	Integration in park	€ 180.00	€ 2,520.00
Total excl VAT			€ 59,620.31
21% VAT			€ 12,520.27
Total incl VAT			€ 72,140.58

Table 6.4: Cost overview of initial investment costs complete service and product

Source

Quotation Thermcontrol
Quotation Thermcontrol
Quotation Thermcontrol
Personal contact VanDrenth Buighout
Personal contact VanDrenth Buighout
Personal contact VanDrenth Buighout
Personal contact Blickle
Quotation Kipp
Alibaba
Drukenbestel.nl
Educated guess
Personal communication

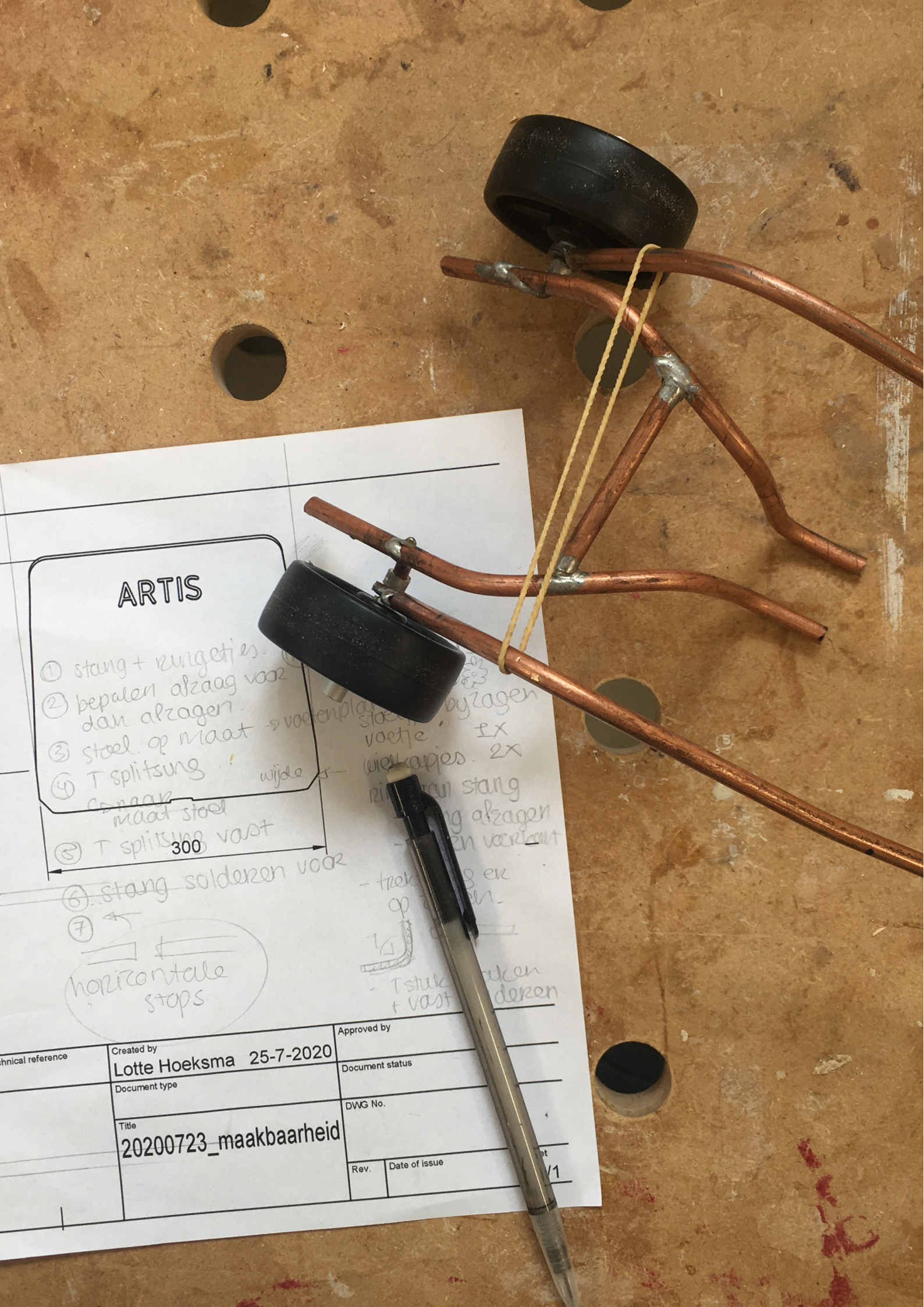
Source

Personal contact VanDrenth Buighout
Orakel.com
Personal communication Artis

Yearly costs for maintaining the service

#	Description	Unit price	Total
5000	Artis coins	€ 0.10	€ 500.00
100	Wheels	€ 25.00	€ 2,500.00
10	Coin locks	€ 5.33	€ 53.30
60	Hours PANTAR	€ 35.00	€ 2,100.00
Total excl VAT			€ 5,153.30
21% VAT			€ 1,082.19
Total incl VAT			€ 6,235.49

Table 6.5: Cost overview of yearly costs for maintenance and parts



CHAPTER 7

Evaluation

SECTION 7.1

Scale models

To be able to evaluate both the design of the cart and the service proposal several models and tools were made. This paragraph describes the approach and models used for the evaluation.

7.1.1 Building models

Models were built and used during all evaluation sessions with stakeholders, functioning as show model or clarification of the design proposal. Appendix J presents the prototyping process of all models. Figure 7.1 shows the results.

1:10 scale functionality model

To test how the carts slide into each other for nesting and how they interact with each other, 3D printed 1:10 scale models of both the carts and stations were made using a simplified model with the right measurements.

1:4 scale aesthetic model

To be able to evaluate the looks and working principle of the cart with the user and to show all stakeholders how the concept design would look like, a 1:4 scale model was made. The frame is made of spray-painted copper rods. Veneer layers were glued together and bent to form the seat and other wooden parts.

Laser-cut Artis map

To indicate the locations of the stations as well as to give all stakeholders insight into how the service would look like Artis' map was simplified and laser-cut. Mini animals are placed on the map to give context and points for orientation.

7.1.2 Evaluation

The evaluation of the concept proposal consists of three parts; a design evaluation, concept evaluation with possible users and the main stakeholders involved in Artis. The evaluation is used as a starting point for the recommendations presented in the next chapter.



Figure 7.1: Several hand scale models

SECTION 7.2

Design evaluation

This section evaluates the design of the cart and station and shows which areas need more attention during further development or need to be validated, focusing on the feasibility of the design.

First, the interaction between carts and the suitability, measurements and safety aspects of the cart will be evaluated. Next, areas for further detailing of the concept are described. The section ends with considerations for the proposed capacity needed. Appendix F presents the evaluation of all design criteria.

7.2.1 Nesting carts at a station

Interaction between carts when nesting and at a station was evaluated by simulating the interaction with two 1:10 scale models.

Nesting two carts

When the visitor stalls the cart, to the cart must be opened and parked in line with the others, Figure 7.2 shows the nesting movement. From experimenting with the scale models, the following conclusions can be drawn: The stops at the back of the frame slide well along the footrest of the already stationed cart, ensuring the cart can

only drive in straight. However, after passing the footrest, the cart can rotate. The rotated position could result in an uneven row of carts. The distance between the ends of the horizontal stops suffices for opening the pull bar when rotated.

Move multiple carts at the same time

To ease reshuffling carts at the end of the day, the responsible employee should be able to move multiple carts at the same time. Because of time limitations, this feature is not integrated into the cart yet. Building two 1:1 scale models could help to explore opportunities to integrate this function which will increase the value of the total concept.

Driving in station straight

The mainframe of the station stops the wheels when a cart is parked and prevents to let the carts slide through diagonally. The sidebars make sure the first cart is positioned perpendicular to the station making sure the row of carts will start straight.

It should be mentioned, that interacting with scale models is, of course, different from operating a 1:1 scale prototype. Therefore, it is advised to simulate all possible interactions with carts 1:1 prototypes.

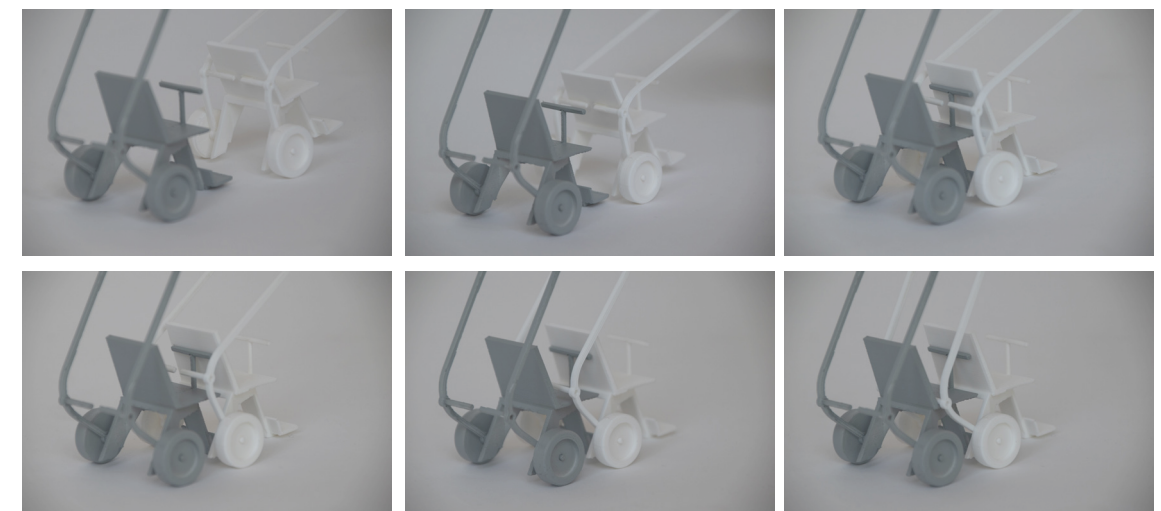


Figure 7.2: Simulation of movement of carts nesting

7.2.2 Suitability and measurements

Measurements of the cart were determined using different sources and methods, taking into account the difference in length of the target group. A compromise was found between all elements because all measurements are strongly related to each other. Therefore measurements need to be evaluated with a physical 1:1 scale prototype. Appendix I presents points of attention for measurement evaluation.

7.2.3 Safety

During the design process, a lot of attention was paid to the safety of the child when seated and when climbing in and out of the cart. There is at least 25 mm space between all parts in reach of the child where fingers can get trapped. They are indicated by green circles in Figure 7.3.

It may be assumed that fingers will not get trapped between the horizontal stops and the backrest and between the pull bar (when closed) and wheel covers since both stops behind the child. The distance between the parts, when the cart is closed is 7 mm, indicated by the orange circles in Figure 7.3. Real behaviour of children should be analyzed to validate this assumption, As well known, according to Leuder & Rice (2007) products should be designed for how children use them instead of how they should use them.

During nesting, the lock on the back of the cart touches the T-shaped bar of the cart behind, this can be seen in the abstracted model in Figure 7.2.

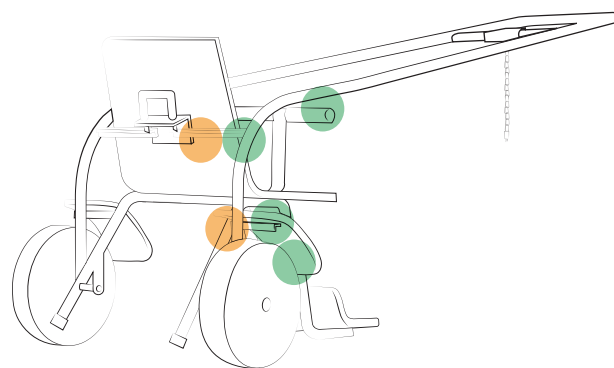


Figure 7.3: Back of the cart in closed position. Green circles indicate focus safety spots already tackled. Yellow circles indicate parts that need more attention.

There is little space to pull up the handle top open the pull bar. It is advised to pay more attention in terms of safety and measurements to the interaction point of two nested carts.

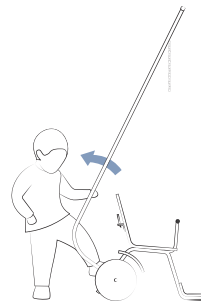


Figure 7.4: Cart in open position with child, the cart should not be able to tip over when a child pulls it backwards when the cart is open.

Tipping over

The movement of the pull bar is damped by the gas spring, it makes sure the pull bar stays upright. The stops integrated into the frame should make sure the cart cannot tip over backwards when the pull bar is pulled backwards (Figure 7.4). A child should not be able to tip over the cart, This has to be validated in real life to ensure safe use. Accidentally falling of the pull bar should also be prevented.

7.2.4 Further development cart design

Time restraints prevented the making of 1:1 prototype, however, the 1:5 model and 3D model were useful to evaluate the design. Several parts of the cart need further development and testing with 1:1 scale prototypes before the cart is production-ready. Blue circles in Figure 7.5 indicate these parts.

- Separate wheel axes connect the frame, pull bar and wheels. **The connection between the pull bar and axis** needs more detailing. This can be done using a rod end. Strength of the construction needs to be simulated or tested.
- The locking mechanism uses two indexing pins. The **lock handle** to connect the pins needs to be designed. Suitable indexing pins can be found in appendix H. In the current design, an L-shaped profile is connected to the backrest and is used to support the pins. The position needs to be carefully chosen such that the

horizontal stops of the pull bar have the largest contact area with the pins as possible. Safety and measurements of the pins in combination with the handle need to be looked at.

- The **stiffness of horizontal stops** of the pull bar is questioned multiple times. Using triangular profiles will increase the stiffness. If the stiffness suffices should be tested when a 1:1 scaled prototype is built.
- The **type, number and size of the gas spring** to be used has to be determined and calculated.
- An L-profile connected to the mainframe connects the wheel covers with the frame. When climbing in, children could try standing on them. If the connection does not suffice, the **shape of the wheel cover support** could be reconsidered.
- The **length of the locking chain** has not been determined yet. It should be minimal such that it is not in the way when during use. It should make sure the visitor can only stall the cart with the pull bar upright.
- The best way to include **rubber stops** at the bottom of the frame (footrest) such that they do not wear out fast needs to be elaborated on.
- The **wheels** are positioned such that the center of mass of the cart when occupied and driving is always in front of the wheel axis. As a result, the cart may be heavy to drive. Doing

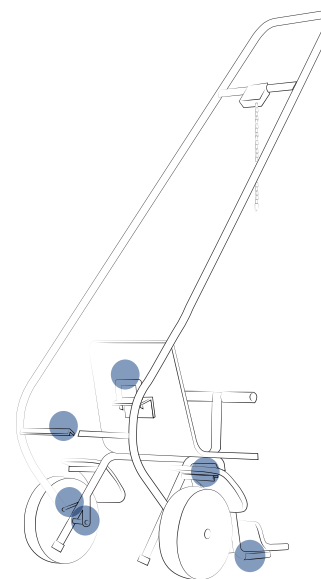


Figure 7.5: Back of the cart in open position. Blue circles indicating points for further development of the cart.

simulations and tests should reveal the best position. The wheels should be placed as much below the center of gravity as possible.

7.2.5 Further development of the station

The design of the station needs to be finalized. The information that should be displayed on the information sign was described However, the visual style needs to be developed. Furthermore, the text should be simplified taking the information needed into account.

7.2.6 Capacity and empty stations

The number of carts needed to increase capacity was estimated using data gathered before the service concept was decided on. The proposed system stimulates the distribution of carts across multiple stations and the flexible use of carts which increases the capacity. The risk of empty stations was not considered. Practice will show whether 100 carts suffice or more are needed.

Furthermore, empty stations will be inevitable because the carts will not be reshuffled during the day and they may all be in use at some time. Additionally, possessing the right coin does not guarantee the availability of a cart. How visitors possibly use the service and will react to an empty station is described in the validation study in the following section.

7.2.7 Conclusion

Time constraints of the project limited further detailing of both the cart and stations. Some parts of the design need to be further detailed or designed to improve safety and feasibility. The possibility of evaluating interactions with scale models is limited. All interactions with the cart and station should be evaluated with a 1:1 high feasibility prototype. This way, more can be learned about how visitors use the cart, the interaction between carts and stations and about the suitability of the design for the target group.

Some parts can only be evaluated in practice, for example, if the capacity suffices for the proposed service and sharing system. Section 8.3 presents the recommendations resulting from the evaluation.

SECTION 7.3

Visitor evaluation

To evaluate the overall service concept and to validate the interaction with the cart a user test was done with caregivers. Scale models were used. This section presents the main conclusions and insights focusing on the desirability of the proposal from the visitors perspective.

7.3.1 Method

Four caregivers with small children aged between two and six who have visited Artis before participated in the user test. First, a storyboard displaying common situations and describing a possible end to end visitor journey was discussed, giving insight into possible actions and thoughts of the participants. For every situation, the participant was asked what would be his/her next step. Next, several questions were asked; How would you use the service? How does the age of your child influence the use of the service? Do you perceive the cart as safe and easy to use? Physical scale models supported the conversation and were used by participants to clarify their thought process. Appendix G elaborates on the discussed storyboard, method and results. The next paragraph summarizes the results.

7.3.2 Results

Results are categorized into three groups; service experience, interaction with the cart and safety

and suitability of the cart. Quotes displayed in Figure "Figure 6.6: Participant's quotes; reaction to different situations during the user test" refers to quotes of participants during the user test.

Service experience

Half of the participants **carried a shopping cart token and would be able to unlock the cart**, the other half said they would go to the service desk to get a coin. The information sign is not read unless the interaction with the station is unclear. NFC-stickers are relatively unknown, however, three out of four participants would scan the sticker and would look at the website to find stations during the day to take or leave a cart. Visitors are **confident they will bump into another station** with carts again after they have left the cart at another station. **The availability of information** about the locations of the stations makes the service accessible and was considered crucial.

Visitors would take and leave a cart multiple times at different stations **dependent on the age of the child and how eager the child is to walk**. One-year-old children would sit in the cart all day because they can only walk for short amounts of time. Most visitors would take a cart right away when entering the park and are willing to leave it at another during the day when the child wants to walk. Visitors would lock the cart at inaccessible enclosures, mainly because of the

risk of losing the cart if left unattended. The carts are considered most useful at the end of the day. All participants would take a cart on the way back. Some prefer to take the cart along the whole day.

Interaction with cart

Looking at a scale model of the cart in a station, Three out of the four participants would close the pull bar first when the cart is stationed and then lift and pull to drive the cart. One of the participants mentioned she would probably try to push the cart first, but would quickly find out that that would not work because of the size of the pull bar. Half of the participants would try to **lift the child from the cart before opening the cart**. The others would open the pull bar immediately by just pulling it upwards.

Safety and suitability

All participants perceived the cart as safe for the reason that their child cannot get out of the cart because movement in all directions is restricted. One of the participants mentioned he would still feel the need to check on his child regularly. All caregivers would use the cart as soon as their kids could sit independently for a longer period.

7.3.3 Conclusion and insights

According to participants, the high number of stations makes the service accessible. The intensity of use and frequency of taking and leaving a cart during the day appears to be age-dependent. Leaving a cart at one of the stations during the visit is thought to be dependent on the number of carts present at the station and previous experiences. If the number of carts observed in the park is low, visitors are hesitant to return the cart. Caregivers seem to prefer to leave the cart at a station instead of leaving it unattended.

Most visitors would take a cart at the beginning of their visit. Carts are considered the most useful at the end of the visit. It is expected from this that most carts will be gathered at the stations close to the exit by the end of the day.

NFC-stickers make the service more predictable. However, when the visitor is unfamiliar with the NFC-technology and does not notice the stickers, the threshold of scanning is considered too high, affecting the predictability negatively.

The NFC-stickers at the station are easy to miss. Stickers on coin locks will be more easily scanned because visitors have to interact with the lock when unlocking a cart. Predictability of the service can be increased by adding a separate sign at the beginning of the park and integrating GPS sensors in the carts to show the exact number of carts at a station.

The interaction with the cart at the station is self-explaining. Most participants indicated they would open the pull bar to let their child climb out. It was, however, not clear that it does not open automatically without pulling the handle. The cart is perceived as safe.

7.3.4 Discussion

Shortcomings of the scale models may have influenced the answers of the visitors, participants mentioned that it was hard to imagine the real dimensions of the cart.

One of the scale models had an improvised lock and the 1:10 model did not have a lock at all. When taking a cart from the station, the lock on the back of the cart is not visible, this could also explain why the participants did not know how to interact with the cart to open it. Among others, for this reason, the interaction with the cart should be validated again with a 1:1 scale prototype.

All in all, it appeared that most participants perceived the intended characteristics of the service quite well and were favorable about the design.

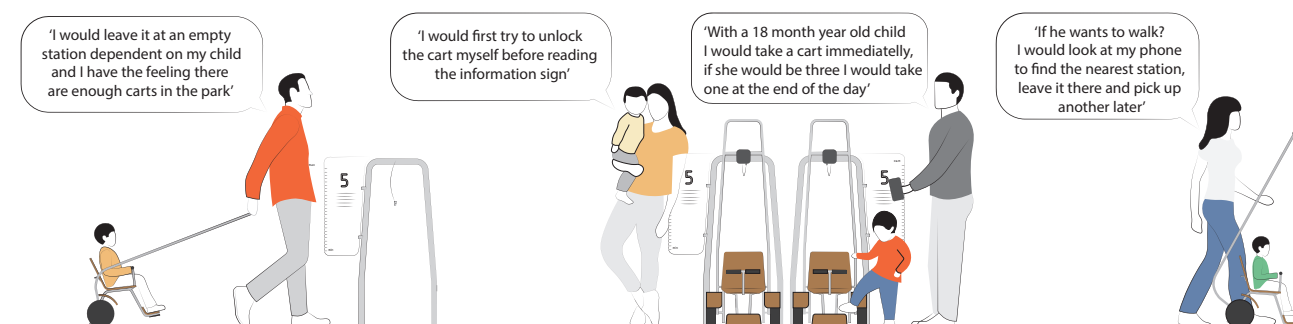


Figure 7.6: Participant's quotes; reaction to different situations during the user test

SECTION 7.4

Stakeholder evaluation

The proposal was also evaluated in a round table conversation with three important stakeholders of the Artis organization, Caspar van Baal and Linda van Leeuwen (Project Management & Maintenance) and Suzanne Brinkman (Visitors & Experience). The evaluation resulted in insights on the viability and implementation of the proposed product-service concept in the park. This section describes the main conclusions.

The concept fits the park vision

According to the three stakeholders, the design of the cart pays tribute to the current cart and her nostalgic value. The new cart is considered as an identified part of Artis. Its neutral colours and the use of wood make sure the carts do not attract too much attention and blend well with the environment. Stakeholders think that children will immediately recognize that the carts are meant for them. The wheel covers make them fun.

Stakeholders said that sharing carts and the idea of being able to pick up and leave the carts easily fits Artis' values. This service is flexible and can be used by all types of visitors which makes it inclusive.

Caregivers with little children can now also make use of the carts and older children will be encouraged to walk themselves. This way, Artis

supports the ones who need it the most. Also, everyone in Artis can explore Artis in his or her way.

The introduction of the Artis coin is thought to make the service more accessible. The principle of the self-service makes the concept viable for Artis because there is no need for extra employees to manage the service. All Artis employees could carry some coins in their pocket, this way they can always help visitors. Distribution of the coins over the employees is not considered troublesome. The coins will shorten the route for the visitor, which is a big advantage for a little extra effort from Artis.

Electronic locks and the Artis application, are considered not viable for now, and might never be because the service is only a small part of what Artis has to offer but could be considered on the long term.

Reconsider locations of stations

The snakes of carts at the stations are less invasive than the current carousels and save a lot of space. However, their positioning looks a little like shopping carts where the carousels present the carts more creatively. The improvements in the amount of space occupation make up for this.

Finding the right locations for all the stations will take some time and discussion. Planting should not be moved and all sightlines for every enclosure

should be considered. Location of the station close to the lions might be difficult because this is a very crowded area. The station in front of the small-mammal enclosure could block the sightline. Because the stations can be easily moved, experimenting with locations is thought viable and will, and likely improve the service.

Orientation of stations in the park

Long snakes of carts should be avoided, therefore, the number of docking stations at one station needs to be determined making sure they will not block the road. Having multiple docking stations next to each other will result in long snakes of carts, similar to shopping carts at the supermarket. This is a risk because stations could then obstruct walkways. This visitor behaviour cannot be influenced, the positioning of the stations should avoid this.

Because an unlimited number of carts can be attached to a single station in a compact way, stakeholders are enthusiastic space problems are solved and that all visitors can easily return the cart without obstructions. This is considered very valuable.

Predictability by providing information

Improving the provision of information is in the focus of attention right now in Artis and something that can be experimented with by using the NFC sensors. Adding QR codes may improve the recognizability. Artis wants to prevent visitors from only focusing on their phone. A balance needs to be found into what extend information is available in the URL. Provision of information should be integrated and fit Artis information strategy.

Costs

The research of the present project revealed hidden costs of the current carts. The new proposal implies less annual costs for more carts. This is considered a big advantage. To reduce costs for the production stakeholder suggested that it would be nice to assemble the carts in a social workshop nearby.

Adding depreciation, reservations for long term maintenance (for example; costs for replacing the wooden parts after ten years) and 10% unforeseen costs to the cost estimation would add to the reliability and viability of the business case of implementing the new product-service concept.

Daily maintenance

The need for reshuffling the carts at the end of the day is not a deal-breaker. It would, however, be nice to still integrate the possibility to move multiple carts at the same time to ease this.

Conclusion

The evaluation with the staff leads to the following conclusions. The proposed product-service concept builds on the strong points of and pays tribute to the current service. It solves the identified problems efficiently. Integration in of the service in the park; locations of stations, the provision of information related to Artis information strategy, has to be discussed in a later stage. A sound business case for introducing the service concept has to be made. Low maintenance costs of the carts and the self-service system require minimal effort from the Artis employees is cost-effective, making the concept an interesting investment. The concept is considered valuable in the short term and long term can easily be adapted and is useful for Artis' visitors.

The Covid-19 pandemic has a big influence on a company like Artis. Its turnover depends on the number of visitors. At this moment investing in new carts is considered not viable because replacing still working facilities has no priority. However, short term, low threshold recommendations for improving the current service are very valuable. Quick-wins can be implemented as soon as possible.

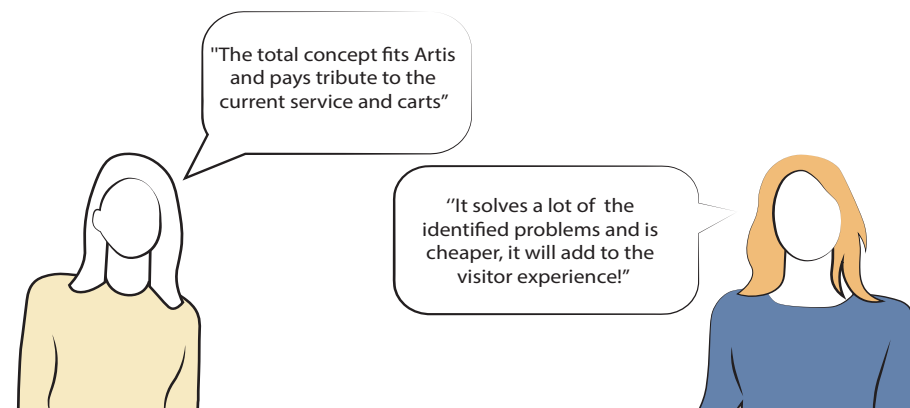


Figure 7.7: Stakeholders quotes; reaction to the concept presentation



CHAPTER 8

Conclusion

SECTION 8.1

General conclusion

This concluding chapter presents some general conclusions, discusses to what extend design challenges were met and gives several recommendations.

The seemingly simple question about the design of the currently used carts and its associated capacity problems resulted in a redesign of Artis' service for mobility support including it's carts. Both management and visitors of Artis appeared to be strongly attached to the current cart. They like its design because it is fun and useful and take many of its shortcomings for granted. Initially, these stakeholders seemed hesitant to changes.

At the end of the project, after evaluating with main internal stakeholders, and talking to caregivers and their children they all seem willing to change. It can be concluded this results from the improved qualities of the redesigned service. There at least three arguments for this conclusion.

First, the blueprint (section 3.1) revealed that the on the face of it small service has many touchpoints in the organization. The evaluations of the design proposal showed that those involved have become more aware of current problems and very much appreciated how these can be solved. Many of the solved design-challenges discussed in section 8.2 appeal to the management. A sound business case for a renewed service can be made.

Second, the new service is meant for young children who can't walk the extensive paths of Artis on their own. One of the main benefits for them and their caregivers is that the proposed cart is much safer than before. The concept of sharing

carts offers the possibility of taking and leaving carts according to individual needs.

Third, management and caregivers said during the evaluations that they liked the design of the cart with its bent tubes and beechwood seat. The management mentioned that the design improves on the current cart without losing its much-valued character.

Some restrictions of the proposal and areas for future development should be mentioned. Because, both the service and cart were redesigned in the project, time restraints prevented further development of the cart. Several parts of the cart need further development and testing with 1:1 scale prototypes before the cart is production-ready. Furthermore, some of the interactions with service touchpoints can only be validated in the park. The practice must show if the stations are located in the right place, NFC stickers are used and if the number of the proposed carts and stations suffices to stimulate the sharing of carts.

SECTION 8.2

Tackled challenges

The product-service concept aims to meet many if not all challenges resulting from the research reported in chapter 3. This section will elaborate on how the proposal meets these challenges and how the concept corresponds and deviates from the current service. All challenges are considered individually.

Provide sufficient capacity

One hundred carts could be manufactured initially to meet the present shortage, sufficing for 75% of the days in 2020. The capacity of a hundred carts is expected to suffice for 55% of the days in 2030 when the number of visitors is expected to increase to two million. Furthermore, the large number of stations and easy storage of the carts will lead to **sharing carts thereby increasing the capacity**. Visitors with older children will likely use the carts for intermittent shorter periods leaving it behind at one of the stations, where another visitor can pick it up again. For future growth, the number of carts can be easily increased. The number of stations can stay the same but can also be extended easily. Stations can be moved to other places when future developments ask for it.

Use of minimal space in the park

The orientation and configuration of the carts within the stations allow for **minimal space requirements taking up n twice less space relative to the current carousels**. Carts nest automatically when returned to the station. Because of the rotating pull bar, space occupation is minimal when the cart is temporarily parked. The new setup has more stations spread out through the park, as a result, each station has fewer carts and thus a smaller size. However, some of the more popular stations might need room for more carts. To guide the space occupation per station, multiple docking stations can be positioned parallel or opposite to each other.

Minimal (daily) maintenance

The newly designed carts require low maintenance because of the used **weather-resistant materials**. The treated beech wood seats eliminate the most time-consuming part of the current maintenance, repainting all every year. One hundred new carts require less maintenance than the current 60 carts. Maintenance can be done in Artis' workshop and only entails **cleaning the carts with water and replacement of fast wearing parts** once a year. In total, yearly expenses for maintenance of all carts will be reduced by 50%.

The new system **eliminates the need for locking carts lying around** at the end of the day. Because the carts are attached, every station can host an unlimited number of carts. The coin lock attached to the pull bar, functioning as a deposit system, stimulates the visitor to return the cart in the right position. Daily servicing will entail **reshuffling the carts by the end of the day** to balance stations. When the service is correctly installed and optimized this will take less time. Security demand will stay the same.

Service fits the park vision

Low operational costs, ease of maintenance, the flexibility of the service and the ease of scaling make the service proposal fit Artis' facility vision. The use of **materials and simple design** make the carts and stations blend in with the park. The design is uniform, every station and cart is the same. The newly designed pull cart **pays tribute to the iconic carts that have been in Artis since 1975**. The recognizable and inviting cart together with a large number of stations keeps the fun and useful character of the service alive.

The current service aiming at children aged two up to and including five years of age, excludes one-year-old children, those who need it the most. The new service meets the park vision by providing

the service for the children in need of support **aged one up to and including three** and by letting the older kids explore. The service with multiple stations allows for age-dependent use, only providing support when needed.

Picked up, left and parked any time

Carts can be picked up and left at **any of the ten recognizable stations** spread through the park located at common obstruction points, park obstacles and busy walkways. The self-service, using coins, enables visitors to take and leave a cart at any station. The option to take and leave carts at all stations stimulates intermittent use fitting age-dependent needs.

There are no facilities for temporarily parking without the risk of losing the cart. Stations at common obstruction points allow the visitor to lock the cart. And when a visitor finds an empty station, another station nearby is readily found.

Suitable and safe mobility support for children aged one up to and including three

Measurements of the cart are tailored to children representative of the target group. The raised edge of the footrest enables the **smaller children to rest their feet on the edge**. Young and older children can hold on to the T-bar in front for balance. Children of all ages can get in the cart supervised and unsupervised without the risk of tipping over. Moreover, the height of the handlebar is raised compared to the current cart, making it more suitable to use for caregivers.

When driving, **the child is unable to get out or stand up straight** in the cart due to the T-shaped bar above the seat giving the caregiver the feeling of control while their child is behind him or her. The child cannot get out unless the caregiver opens the cart. When opening the pull bar, the caregiver is behind the child, making sure the child can be monitored. Children get easily hurt in the current cart because of the moving parts within reach. Extra **space between moving parts** and mudguards prevent limbs from getting trapped in the newly designed cart. Stops integrated into the frame and the placement of the wheels make sure the cart cannot tip over backwards.

Physical shortcomings of the current cart have been taken into account while designing the new. **Rubber handles** provide comfort to both the child and the caregiver. The wheel type gives the cart some **suspension**. The total comfort of the cart has not been improved on purpose because children should be stimulated to walk.

Self-service

The use of universal coin locks **enable the visitors to unlock and lock the carts themselves** but also eliminate the need for extra employees to manage the service. Therefore, universal coin locks are proposed again, however, in a more accessible way. Three different types of coins; **1 euro, shopping cart coin, and Artis token** can be used to unlock a cart instead of one not used two-euro coin. Multiple, already manned points will get involved in providing visitors with tokens **mitigating the demand on the front office**. No extra employees are needed.

A service that is predictable, accessible and reliable for the visitor

The new type of coin locks improves the **accessibility** of the service. Shopping cart coins are widely used and visitors can get an Artis token at any manned point instead of only being able to withdraw cash at the shop. Similar to the current service, visitors are **dependent on the availability** of carts, this cannot be assured but is largely improved due to the increase of carts and the flexibility to drop a cart and take one somewhere else.

The increased number of carts makes the service more available and predictable. **Information about the use of the service and locations of stations** is readily available before and during the visit. The Artis website, paper map, signage and scannable coin locks and signs provide the visitor with both digital and analogue information, suitable for all generations.

SECTION 8.3

Recommendations

This section presents recommendations in the form of a recommendation roadmap. The roadmap offers quick-wins for Artis and long term recommendations.

Figure 8.1 presents the recommendation roadmap. Recommendations are split in short-term, medium-term and long-term (columns). Three main themes; Service, Cart & Station and Technology (rows) divide the different recommendations. Numbers refer to the paragraphs in the text. Independent of further development of the concept, proposed elements of the service can be integrated to improve the current service. These recommendations are indicated in Figure 8.1 by a star.

8.3.1 Short-term recommendations

1.1 Improve available information

The proposed information strategy presented in section 6.1 could be implemented in the current service to improve predictability and visibility of the service e.g.; adjusting the website, replacing information signs and experimenting with NFC.

1.2 Integrate Artis coin to improve current service

To smoothen the current service experience, the Artis coin could be introduced (suitable for the current coin locks) improving the accessibility of the service. Manned points close to the stations should be provided with the coins. Additionally, the coins could be used for the wheelchairs.

1.3 Relocate station aquarium

The station near the aquarium is invisible, relocating the station to the enclosure of the penguins could make it more accessible and visible for visitors visiting the aquarium or leaving Artis at the back exit.

1.4 Use the blueprint for evaluation

To ensure a smooth service experience for the visitor and to streamline processes within the organization the service blueprint could be used as a tool to evaluate the current service periodically. By regularly doing this insight in the current state and pain points will be gained and can possibly be solved. (Note that this recommendation is given repeatedly in the roadmap.)

1.5 Build two high fidelity prototypes

Time restraints prevented the making of 1:1 prototypes. Two high fidelity prototypes could be built to in order to evaluate the user interaction with the carts, the relationship between carts when nested, and the appropriateness of the measurements. A user test with both children and caregivers could give insight in the child's behaviour around and inside the cart and possible unsafe situations that can occur. The ease of use and interaction with both the cart and station should be evaluated to validate the design. Furthermore, building a model could give ideas on how multiple carts could be moved at the same time.

1.6 Concept development

Before the cart can be used in real by visitors in Artis, the concept needs to be developed further. The design evaluation presented in section 7.2 can be used as a starting point. It is advised to do this simultaneously with building prototypes, so one can learn and adapt fast. During further development, standardized parts, for example common steel tube sizes for the frame, could be considered to reduce costs.

Locations of the proposed stations should be looked at with all involved stakeholders in Artis as well as the amount of docking stations needed per station. A sound business case for introducing the service concept can and should be made.

1.7 Testing for safety standards

Conversations with experts should be arranged to make sure the design conforms the CE standards.

1.8 Improving physical shortcomings of current cart.

Replacing the wooden parts of the current carts with beech wood will increase the durability and decrease the need for maintenance. Investment costs would be around 5020 euros (80 euros per cart + 250 euros programming costs) which could be recouped within a year. Replacing the wheels for elastic massive rubber wheels should be considered. This will result in a more comfortable cart but will increase the yearly costs.

1.9 Production

After finalizing the cart and station, both could be produced at a social workshop.

8.3.2 Medium-term recommendations

2.1 Launch service

The new carts, stations and other touch points could be launched after production. Already adjusted touch points should be updated.

2.2 Evaluate station locations

Some stations will be used more than others; carts could be unevenly distributed causing trouble. Therefore, it is recommended to evaluate the locations of the stations regularly and relocate them when not in use or make one extra when needed.

2.3 Yearly check

Planning a yearly check-up during winter time, to check the wheels and clean the seats is advised to maximize the durability of the carts.

2.4 Opportunities for using technology

Artis is working on their own application. Locations of stations and information about the use of the service could be integrated, as well as GPS sensors to provide visitors with information where carts are. This would contribute to the predictability and accessibility of the total service.

2.6 evaluate capacity

Capacity of the carts should be evaluated to maintain the visitor experience. Increase in visitors, evaluation of the service or change in need for mobility support could result in the need of extra carts.

8.3.3 Long-term recommendations

(3.1) Depending on the wear of the carts, the wooden parts of the cart have to be replaced. If new carts should be made, resulting from the capacity evaluation, this could be done simultaneously. (3.2) In ten years, the use of electronic locks on the carts could be considered. In combination with the application this would open up more opportunities.

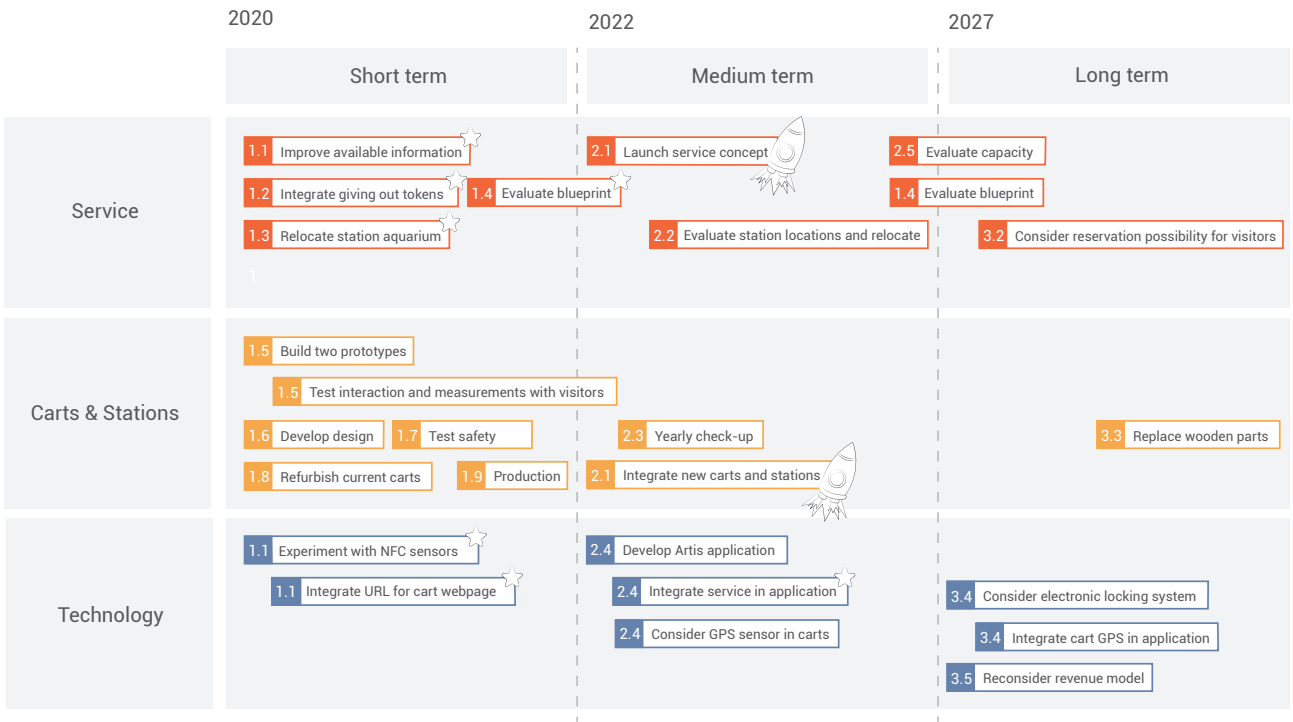


Figure 8.1: Recommendation roadmap (coloured blocks represent starting point in time)

SECTION 8.4

Reflection

The first time I went to Artis to discuss a potential assignment, the quote presented on the next page stated what I imagined to do in Artis. Looking back now, I have not only learned to understand Artis' visitors better but also myself. In this final section, I would like to take the opportunity to look back on the project and reflect on my learnings over the past months.

The past half-year there were a lot of firsts. It was the first time working closely with a client, designing a product-service system and designing for children. There have been many times I felt uncomfortable and did not exactly know where I was going. First designing the service outline without thinking about the cart felt uncomfortable but pushed me to think about the goal of the service and the impact of a new service layout on the organization. I see now that this broader perspective was needed to be able to then design a cart fitting in the service. One of the things I have learned about service design is that the service, product and organization are inseparable, and that by having a holistic view impact can be achieved on all levels.

The uncertainty of the design process sometimes made me jump to conclusions, because I wanted to solve everything at the same time. When I took the time to step back and look at my project from a distance a step by step approach always resulted in better outcomes. By doing I gained confidence and trust in the design process, in the end everything falls into place.

Over the past months, I have experienced high levels of stress. There were times I got personally involved in the project. When this happened, small comments in meetings would get me down and made me question myself. During those moments I had a hard time putting everything in perspective. Furthermore, I tend to work harder when I have the feeling I am losing control while this is often counterproductive and it is better to take some distance. However confronting at times, I gained insight in my way of working and learned that I

need to maintain a healthy work-life balance to be able to achieve my goals.

I have spent most of my graduation at home behind my desk. One of the things I have missed most are the white tables in the faculty hall with students from which you know they are in the same boat. A quick conversation with a fellow student can lead to a great idea or a problem is easily solved. I have been stuck multiple times trying to prove my ideas or look for solutions where I would have otherwise consulted someone about how they would do it or what they thought about it. Brainstorming at NPK and working two days with a friend gave me energy, confidence and a lot of new insights. I have learned that I need to ventilate my ideas to be able to test them and that by consulting experts I can achieve more than I think.

In the final stage of the project I have significantly improved my skills in 3D modelling. Getting familiar with 3D modelling made me realize how much all parts of a design are related and how one adjustment can change all others. In the final stage of the project, I was focused on improving and adjusting every detail that it would sometimes make me forget about the user. And even though I have made a wooden mock-up to validate dimensions with children, I found it hard to imagine the real scale. Next time, I would put more effort into finding the right mannequins, to validate dimensions and keep the user in mind. I have also improved on my visual skills, visuals can make information easier to discuss and to comprehend. For example, the service blueprint helped me to structure my findings and thereafter functioned as a tool to discuss and evaluate the challenges. Using visuals as tools is something I want to develop further.

With this research I conclude my studies. Eight years of studying might not have always been easy, but it got me where I am now. I am proud to say I have become a design engineer.

***"Elke keer als ik in artis
ben geweest begrijp ik de
mensen weer zooveel
beter"***

J.H. Leopold, 1922

SECTION 8.5

Literature

Artis (2019) Factpack Horeca en overige faciliteiten. Internal document: unpublished

Artis. (2019). Jaarverslag 2019. Geraadpleegd van https://www.artis.nl/media/filer_public/2b/85/2b85b695-48af-422b-8a80-23bdea016a43/artis_jaarverslag_2019_definitief.pdf

Birken, S., Lichtblau, B., Lenton-Brym, T., Tucker, P., Maguire, J. L., Parkin, P. C., & Mahant, S. (2015). Parents' perception of stroller use in young children: a qualitative study. BMC Public Health, 15(1). <https://doi.org/10.1186/s12889-015-1989-6>

Boeijen, A., Daalhuizen, J., Zijlstra, J., & Schoor, R. (2020). Delft Design Guide (revised Edition). New York, Verenigde Staten: Macmillan Publishers.

Bureau van publicaties van de Europese unie. (2013, 12 september). CE marking for the toy industry. Geraadpleegd op 28 april 2020, van <https://op.europa.eu/nl/publication-detail/-/publication/90058baa-00c8-4f33-973d-b4c-48158be96/language-en>

Dirken, J. M. (1997). Productergonomie : ontwerpen voor gebruikers (1e druk). Amsterdam, Nederland: Amsterdam University Press.

History. (z.d.). Geraadpleegd op 5 juli 2020, van <https://www.artis.nl/en/footer/about-artis/history/>

Lueder, R., & Rice, V. J. B. (2007). Ergonomics for Children. London, Verenigd Koninkrijk: Taylor & Francis.

Manufacturers. (2017b, 28 juni). Geraadpleegd op 28 april 2020, van https://ec.europa.eu/growth/single-market/ce-marking/manufacturers_en

Metropolitan Analysis, Design & Engineering. (2020). ARTIS Living Lab. Amsterdam, Nederland: Artis.

Molenbroek, J., & de Bruin, R. (2000). Enhancing the use of anthropometric data. -. Geraadpleegd van https://www.researchgate.net/publication/228688167_Enhancing_the_use_of_anthropometric_data

Norris, B., & Wilson, J. R. (1995). Childata: The Handbook of Child Measurements and Capabilities. Nottingham, UK: Department of Trade and Industry. <https://doi.org/10.1177/106480469900700309>

Reason, B., Løvlie, L., Flu, M. B., & Løvlie, L. (2015). Service Design for Business. Hoboken, NJ, Verenigde Staten: Wiley.

Siteworkers BV. (z.d.). Veiligheid van Speelgoed. Geraadpleegd op 28 april 2020, van <https://www.nen.nl/NEN-Shop/Speelgoed.htm>

Siteworkers BV. (z.d.-a). Norm voor kinderwagens geheel herzien. Geraadpleegd op 28 april 2020, van <https://www.nen.nl/NEN-Shop/Nieuws-berichten-Consumentenzaken/Norm-voor-kinderwagens-geheel-herzien.htm>

Standard Consumer Safety Performance Specification for Carriages and Strollers. (z.d.). Geraadpleegd op 29 april 2020, van <https://law.resource.org/pub/us/cfr/ibr/003/astm.f833.2013.html>

Steenbekkers, L. P. A. (1993). Child development, design implications and accident prevention. Delft, Nederland: Delft university press.