

A NEW PERSPECTIVE
MRI Patient handling system for a novel
head-only MRI system

Victoria University of Wellington, New Zealand
Smart Interactions Design

Documentation



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MRI PATIENT HANDLING SYSTEM FOR A NOVEL HEAD-ONLY MRI SYSTEM

Magnetic resonance imaging (MRI) is the gold standard in medical practice for non-invasive tissue imaging. However, current devices are expensive to produce and require users to remain in a lying position during the scanning procedure. This can cause a negative patient experience, anxiety, claustrophobia and consequent fear of this medical technology. A current research initiative investigates the potential to position patients in an upright position inside a head-only MRI scanner. We developed a patient-handling system for this novel medical technology. The new patient position offers the possibility to address the current shortcomings of conventional MRI scanners but poses a unique challenge to the patient to keep the head still for up to 20 minutes to secure high-quality scans. Patients in a lying position need

to minimise head movement in two axes, however, in a seated position there are three. The project was conducted from a user-centred design perspective involving explorative research methods to develop an understanding for the context of use; the development of numerous design prototypes; usability tests with participants and MRI experts; and the production of a full-scale prototype. Our final full-scale design system consists of a movable chair that positions the user correctly inside the magnet bore. The patient can control the chair with a remote control which is a new and unique feature in the context of MRIs to reduce any feelings of anxiety and lack of control. Once the patient is positioned correctly inside the system, an inflatable head support system starts to expand around the neck, forehead and sides of the head to reduce head movement. We tested the final chair and head support system with qualitative and quantitative methods including a motion head tracking system to secure high usability of the novel system for patients and technical staff alike.

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2018

January - June

- Literature review related to MRI, patient experience, chair comfort and head support
- First sketches and concepts for the head support
- Scale models of chair
- Explorative research involving hospital visits and talking to MRI technicians

July

- Sketches of ways to position the patient inside the bore
- Review of literature in the area of human factors, medical MRI requirements, MRI design, automotive seat design, end consumer chair design

October

- Low fidelity prototype testing for the head support
- Analysis of initial user testing results of low fidelity testing
- Refinement of user testing protocol for the overall system, chair and head support components

September

- Solid head support prototypes are developed
- Low fidelity prototype testing for chair components with participants to investigate potential comfortable positions for 20 minutes

August

- Start of human ethics application to involve participants in the process
- Outline of research milestones
- 1:1 scale model of the MRI magnet

November

- Visualizations of potential design aesthetics
- Definition of technical requirements for the frame that holds the magnet in place and potential patient position inside the system

December

- First 1:1 model of the chair
- Development of inflatable head support prototypes
- Test of medical head restraint devices e.g. cervical collar

PROJECT TIMELINE

The project took two years from the initial briefing to the development of the full scale and fully functional prototype.

2019

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January

- Chair No1 and No2 are CNC cut and fibreglassed
- Modular upholstery elements are developed
- Experience prototyping of inflatable head support concepts

February

- Experience prototyping of the study protocol
- First user testing of chair No1

March

- Further user testing of chair
- User testing of chair 2
- First tests of the inflatable head support prototypes
- Update of the chair design
- Design of the overall system including floor elements, side panels and top cover

April- May

- Redesign of cover components
- Contacting manufacturers for the development of the final inflatable head support, chair components and panel elements

June- July

- CNC cutting of the chair seating pan, leg-rest, back-rest and metal components
- Fibreglassing of the chair and painting
- Upholstery elements are produced
- User testing of refined inflatable head support prototype with motion tracking
- Analysis of results
- Assembly of chair components

August

- Design and conceptualisation of the remote control
- Production of panel, floor and cover elements
- Start of the documentation on how to use the product

September

- User testing of updated head support prototype
- Analysis of user testing results
- First test prints of the remote control

October

- Assembly of the whole system
- Documentation of the system in photos and video
- Final technical documentation

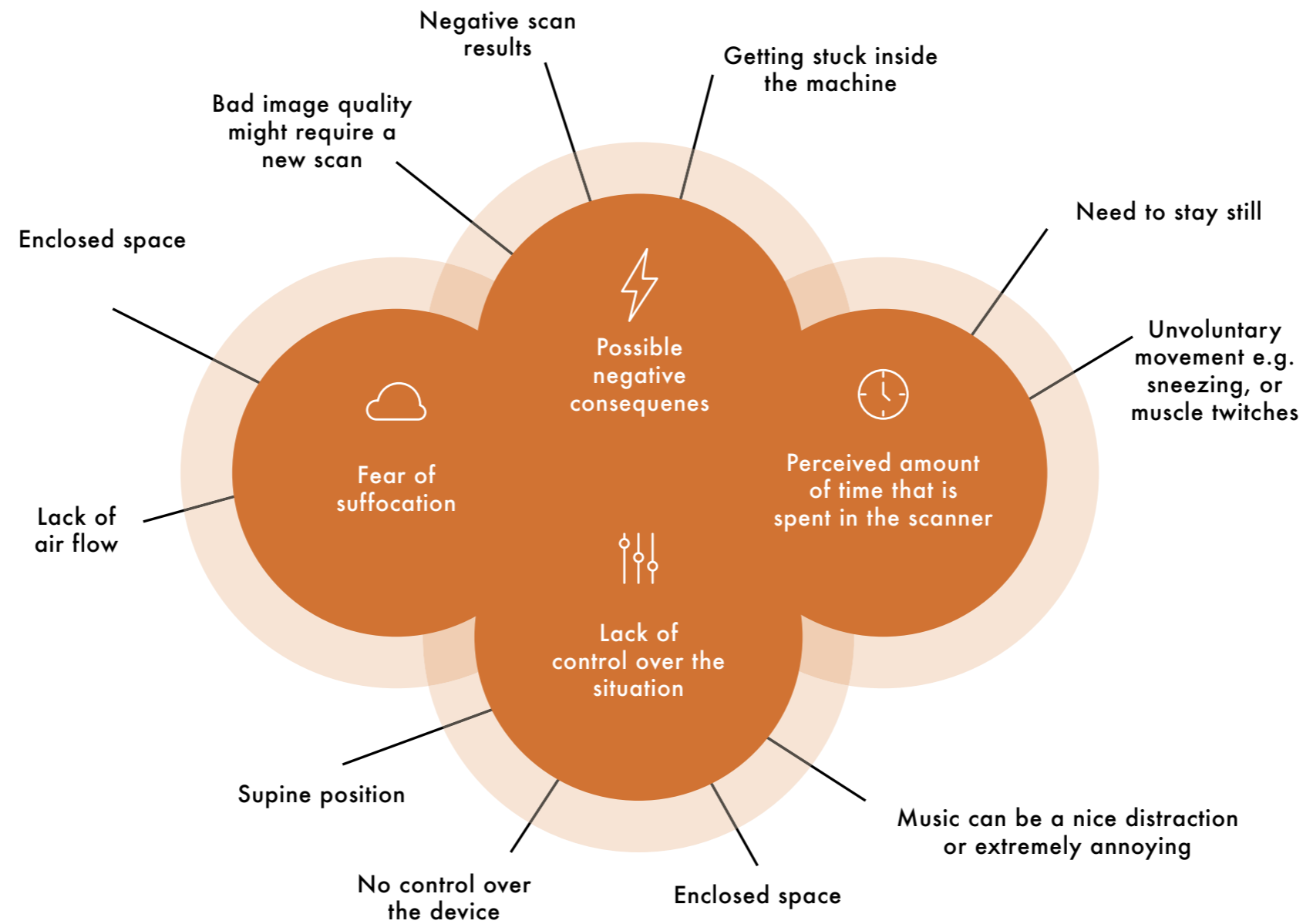
November

- Preparation for shipment

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PATIENT EXPERIENCE

We summarised the main negative points that affect the current MRI patient experience in four themes. Part of our system allows addressing the 'lack of control' and 'perceived suffocation'.

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Travels for the	The patient arrives at the clinic for the appointment	The patient waits	The previous experience might be recalled	Patient potentially directs his/her negative emotion directly toward the MRI scan room and its contents	The patient is informed about the procedure	The examination preparation starts	The MR contrast is administered	Mental strategies are used to cope with the situation	MRI scanner starts with the scanning procedure	Music is used as a form of distraction	The patient has to remain still	Postexamination thanks	MRI can be perceived as a gateway
by stand still think how I'll be still for MRI.		Now in MRI waiting room. It's just me, a lot of sick people. help me'	First #MRI since D/X in 2000, the memories I thought I had banished came flooding back!..	"hating this room" picture of MRI scan room door I'm having an mri scan on my heart done soon Wish me luck bc this is my only fear in the hospital i am so claustrophobic, I freak out'		The MRI tech caught me taking a selfie #ManCardRevoked' + self-portrait photograph wearing MRI gown		During my MRI today I kept calm by thinking up ways to legally frustrate & shame the stomp on the flag challengers.	Ugh having an MRI is like being inside of a pissed off fax machine I laughed through the whole MRI bc I was makin beats out of the noise it was making.	At least the loud machine gun noise of the MRI machine drowned out the terrible music on the headphones When you're getting an MRI and you have to be still and Uptown Funk comes on the radio	...another MRI of my brain tonight and I'm no joke looking forward to the time to relax		So much to be thankful for. No more MRI's until 2016. All clear... Bad news after all, found and ACL tear in my MRI. Surgery in two weeks
anticipation								<ul style="list-style-type: none"> mental distraction support from others rewards and/or bribes music 			<ul style="list-style-type: none"> Possibility to have a nap. Noise cancelling headphones are enablers 		
about injection phobia		<ul style="list-style-type: none"> being surrounded by "sick" people while waiting 								<ul style="list-style-type: none"> lack of control over the situation liking or not having any music at all 	<ul style="list-style-type: none"> inability to keep still claustrophobia pain twitching while sleeping perception of the amount of time spent having panic symptoms 	<ul style="list-style-type: none"> enforced nature of having to remain motionless desire to scratch an itch having panic symptoms thoughts about the (negative) consequences 	

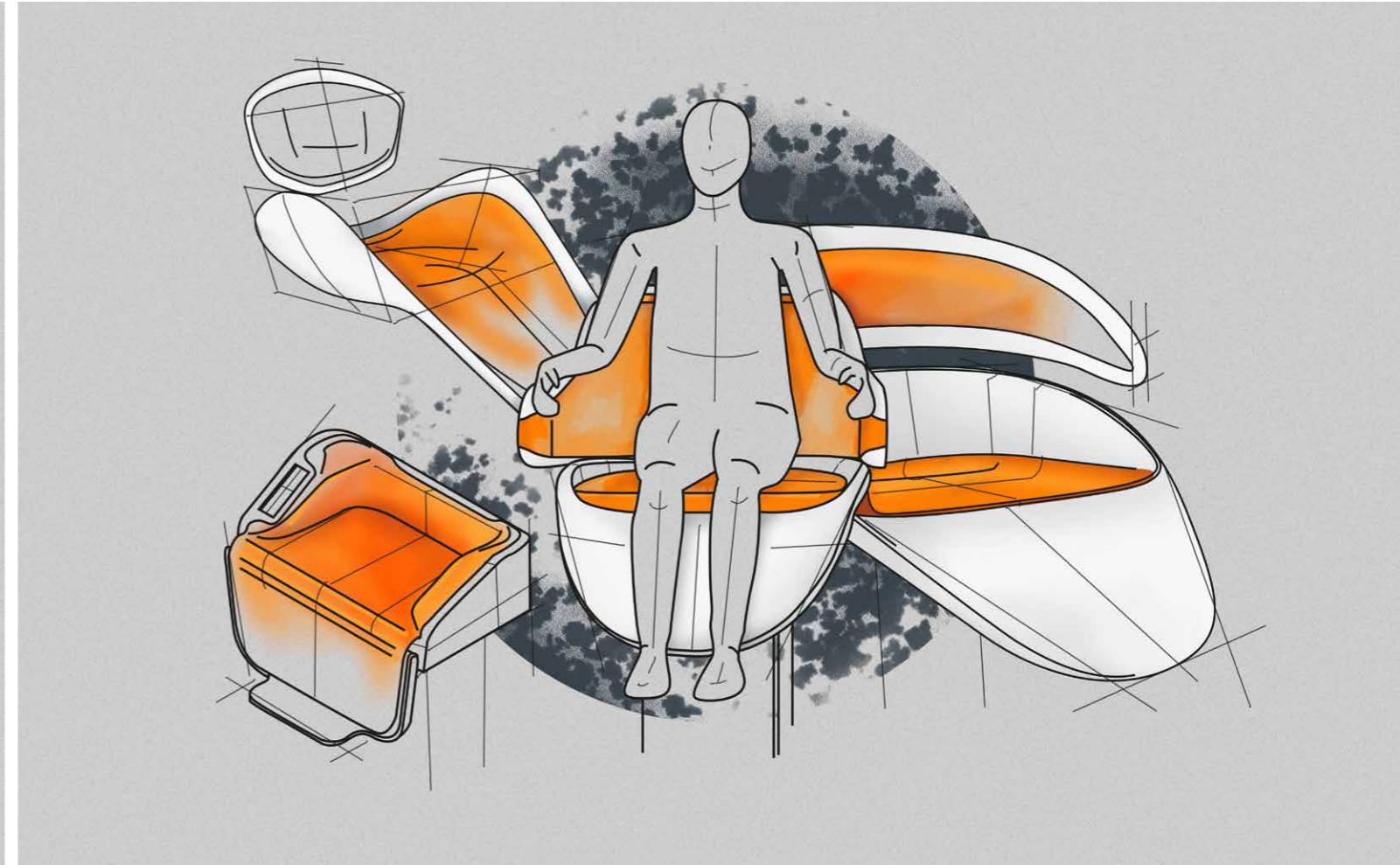
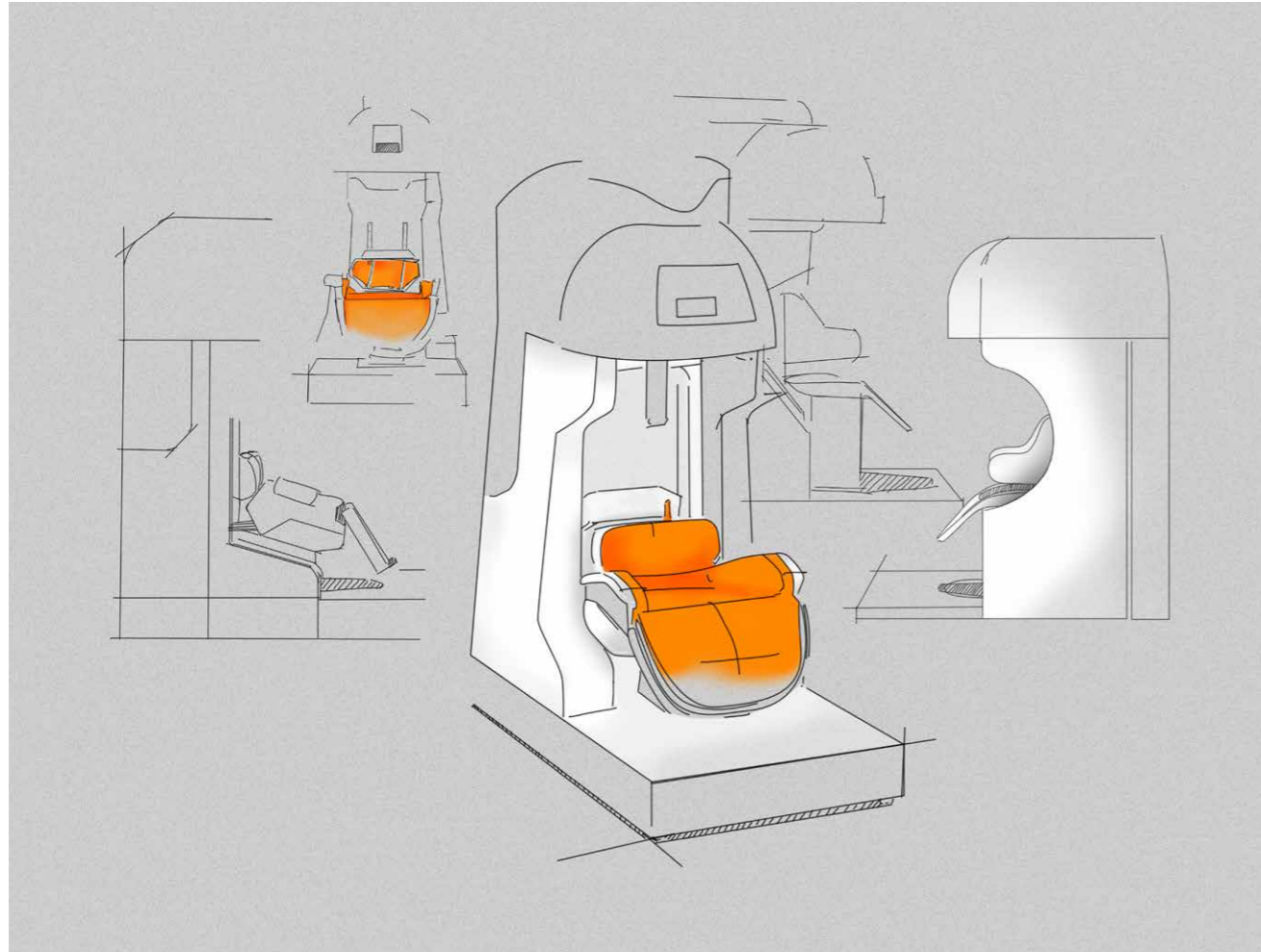
CUSTOMER JOURNEY

A customer journey helped in the process to gain a deeper understanding of the context of use and the patient experience that is involved in the context of this project. We focus in the project on the environment in the hospital that can be extremely confronting and challenging for the patient.

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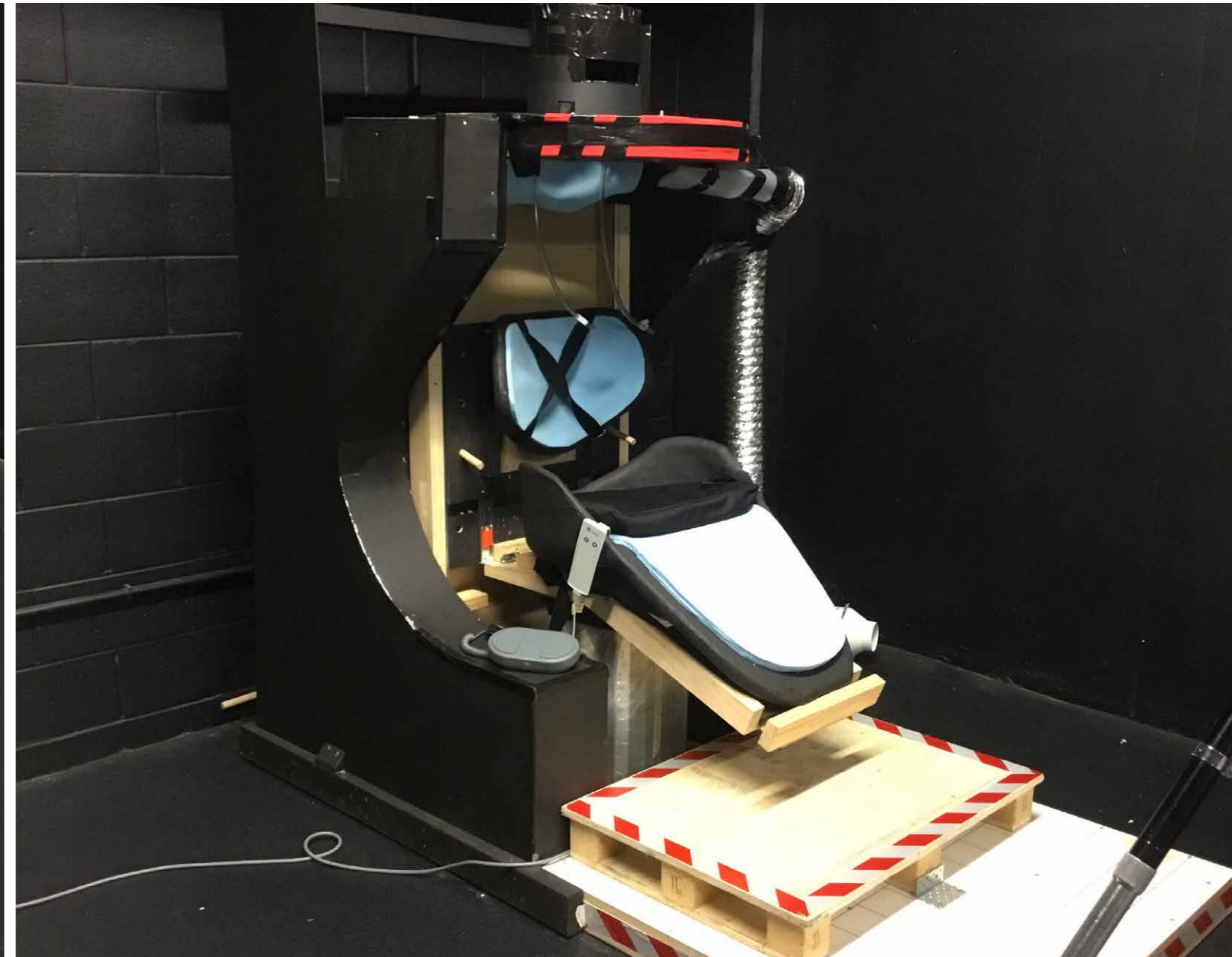
SKETCHES

We developed different
concepts to position the
patient inside the magnet
bore using sketches and
3D models.

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EXPERIENCE PROTOTYPING

We tested different concepts for the chair and head support before involving participants and refined the user testing protocol iteratively to secure a safe testing environment

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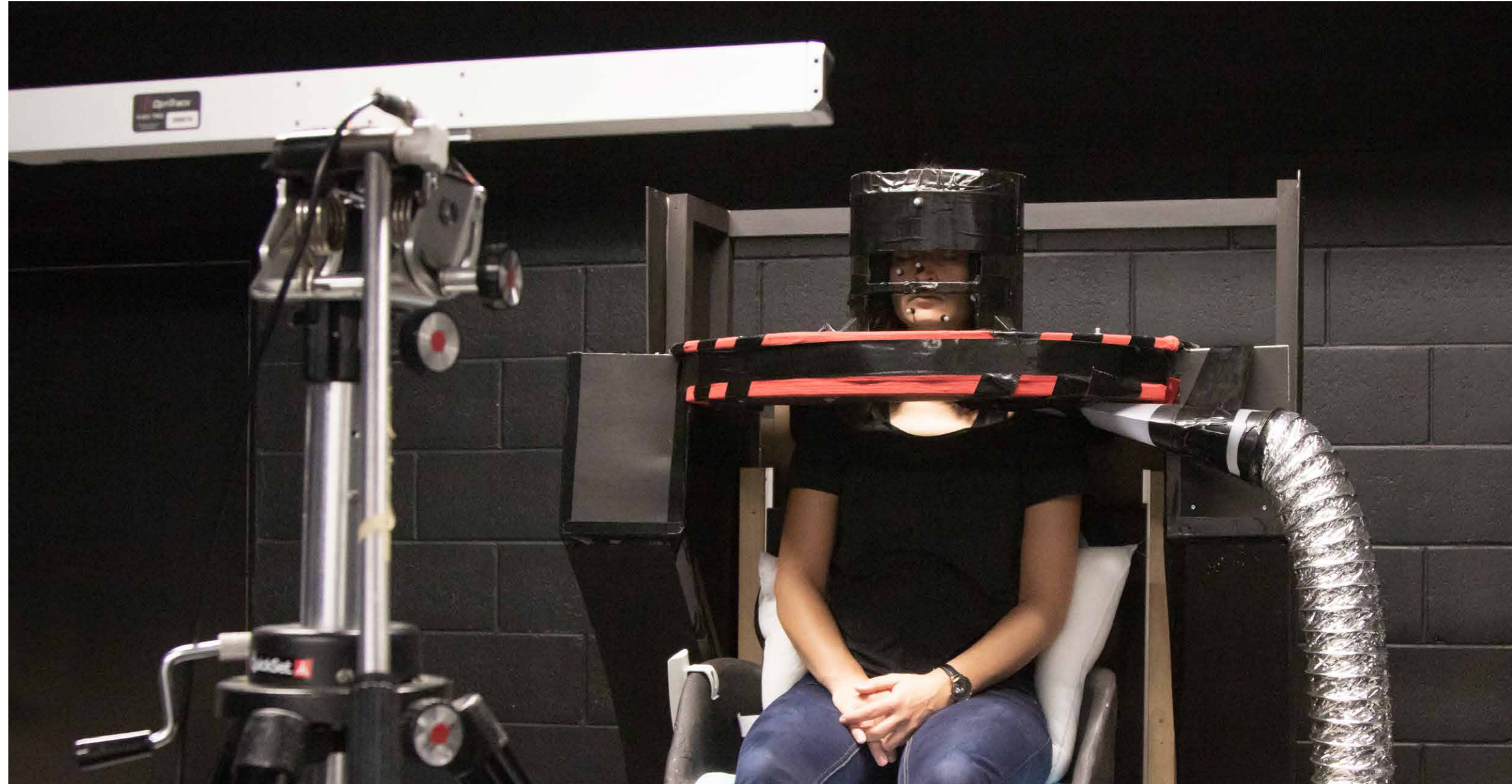
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USER TESTING AND MOTION RECORDING

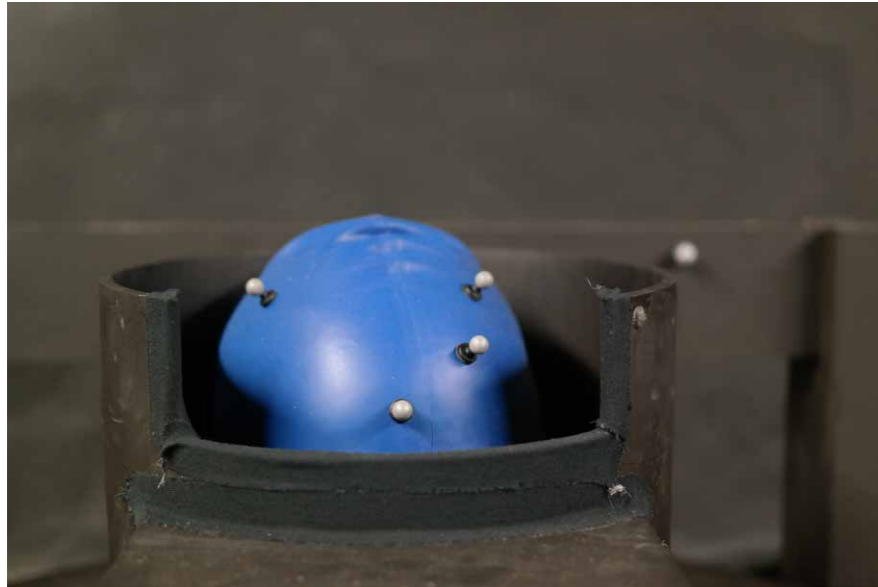
The chair and head support design were tested with a combination of qualitative and quantitative research methods. We used a motion tracking system to determine the amount of head movement which had to remain under 1mm in the x,y and z axes.



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DATA COLLECTION

We used a combination of quantitative and qualitative methods to assess and refine the system. We asked participants during the testing session to move the arms to determine how much the head support system can compensate for.

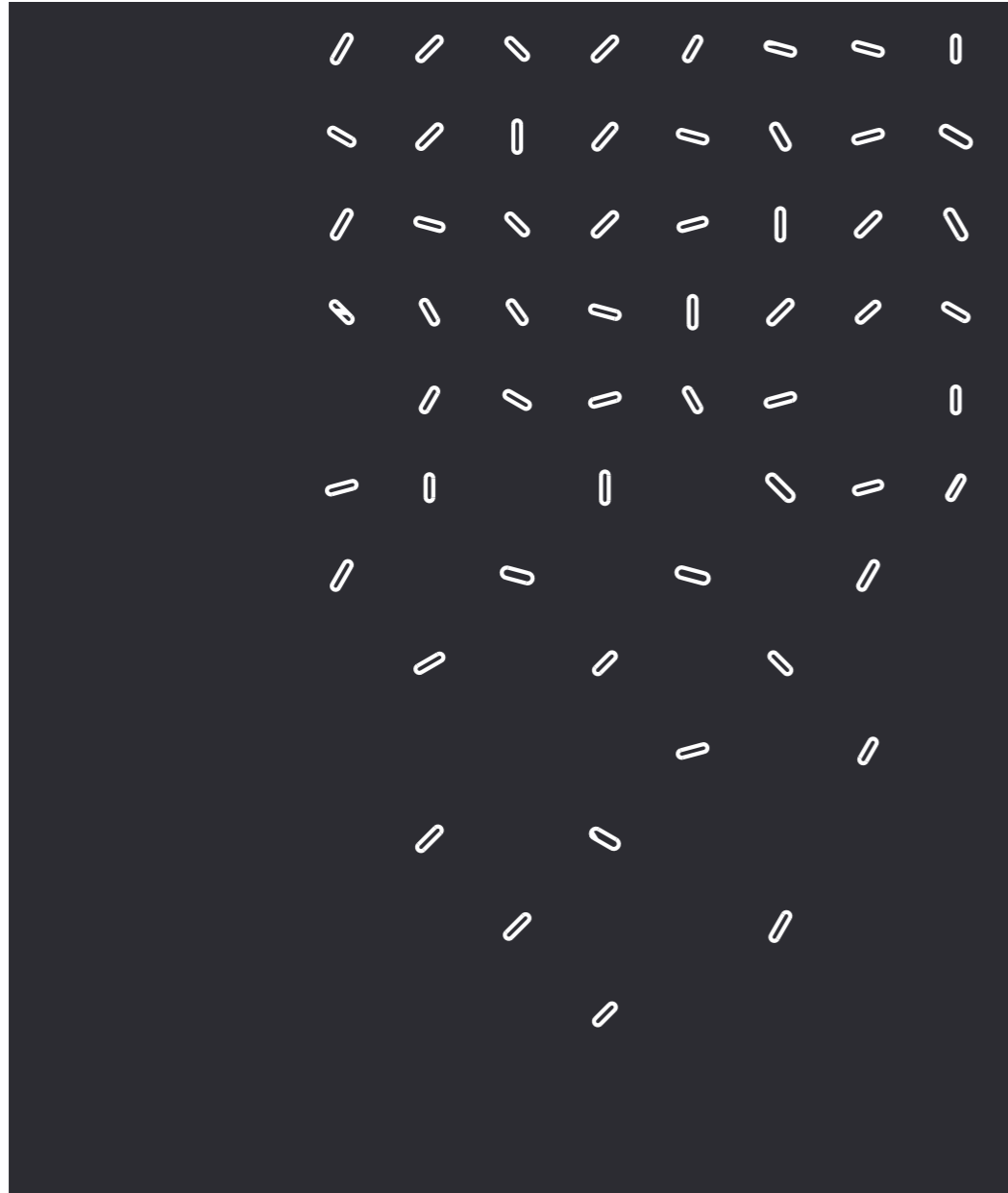
It felt harder to keep my head still when performing the hand movements. But apart from that, when I was just remaining still it was fine.

Participant 04
User testing of the inflatable head support prototype
July 2019

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NEW ZEALAND ORIGIN

We used a pattern element on the different parts of the system as a unifying element and reference to its development in New Zealand. The pattern is based on the way New Zealand flax grows which is an extremely durable and adaptive material spanning various applications and areas of everyday life. The pattern references at the same time the functionality of a magnet aligning atoms of a body.



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FOAM CORE

The chair was developed and designed in an iterative process. Two full-scale chairs were produced and tested prior to the design and production of the final system.

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TECHNICIAN CONTROLLER

The technician can control the height of the chair, angle of the leg rest, the light and airflow as well as the inflation and deflation of the head support device.



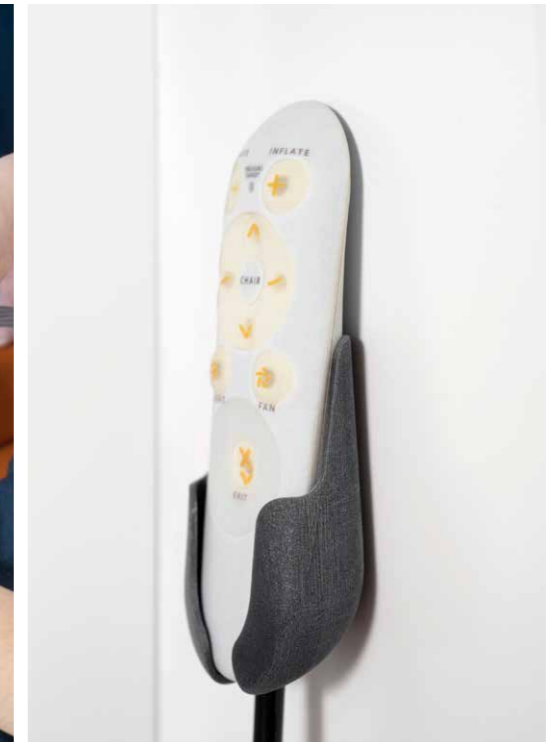
PATIENT CONTROLLER

We offer patients the unique possibility to control the chair themselves. They can control the elevation of the chair, angle of the leg rest and inflation as well as deflation of the head support device.

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PATIENT POSITIONING

An electric lift included in the chair allows to position the patient inside the magnet bore. The chair can be controlled by the patient or the MRI technician.

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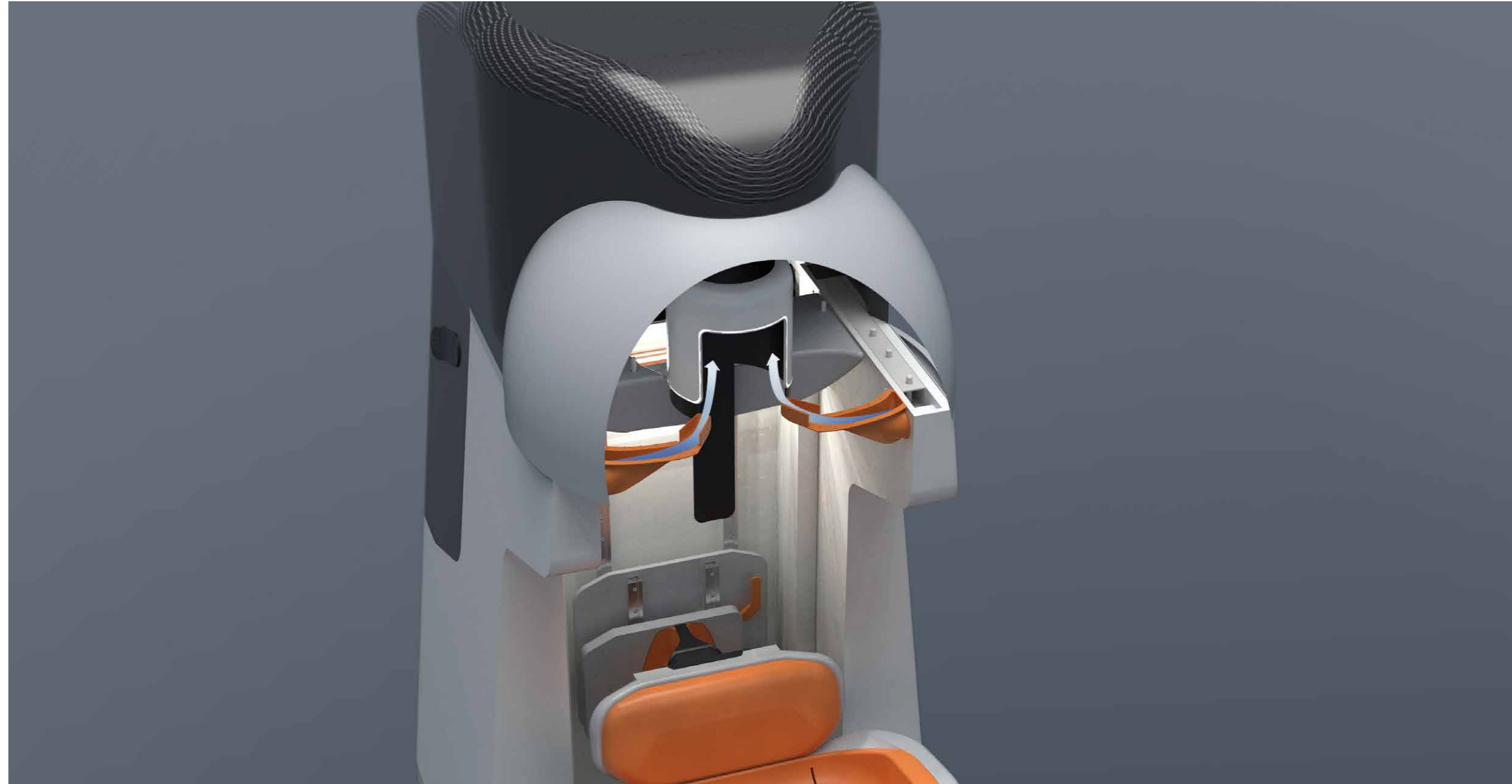
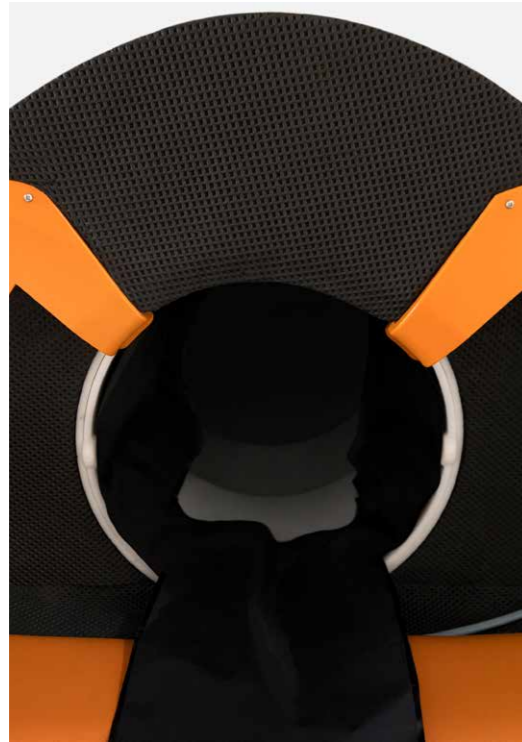
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AIRFLOW

Air is led into the inside
of the magnet bore to
decrease any feelings of
a lack of oxygen during
the scanning process.

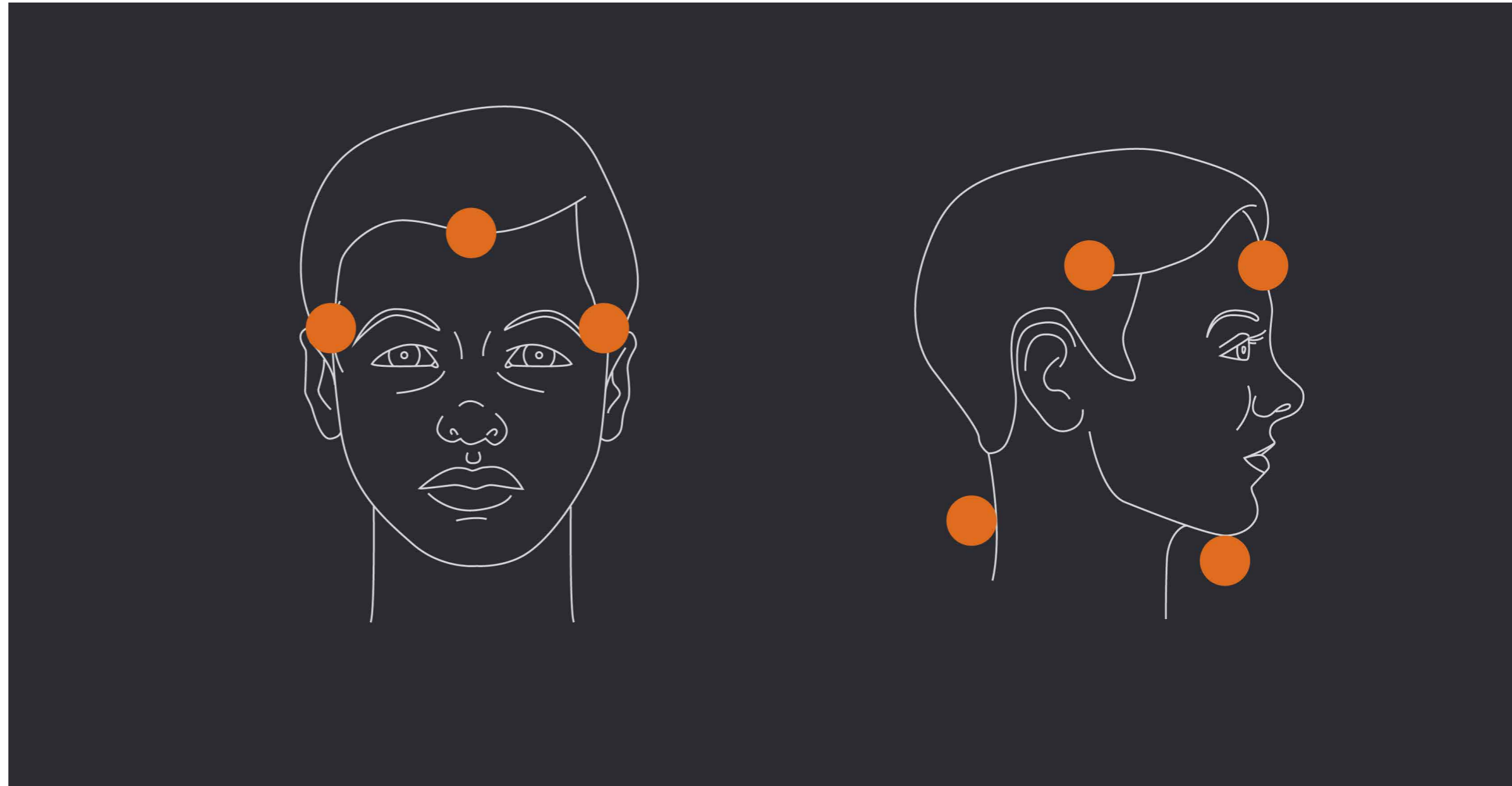
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SUPPORT POINTS

We used low fidelity prototypes to investigate points of support for the head that feel comfortable during a twenty minutes scanning process. Based on user feedback potential points are the sides of the head, forehead and back of the head.



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Solid head support prototypes and
competitor analysis



COMPETITOR ANALYSIS AND SOLID HEAD SUPPORT PROTOTYPES

We analysed medical devices that are used to restrain the movement of the head and developed a number of solid head support prototypes. We did find out during our user testing that the entering of the bore was quite difficult with a solid device.

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INFLATABLE HEAD SUPPORT

We decided to focus on an inflatable head support concept which allowed an easy entrance into the system and could fit users with different anthropomorphic features.

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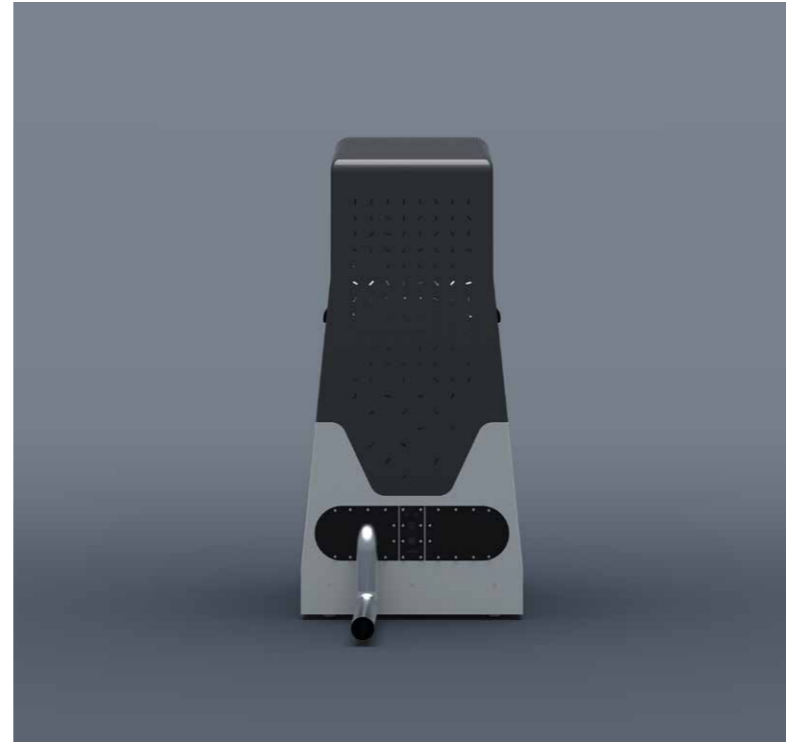
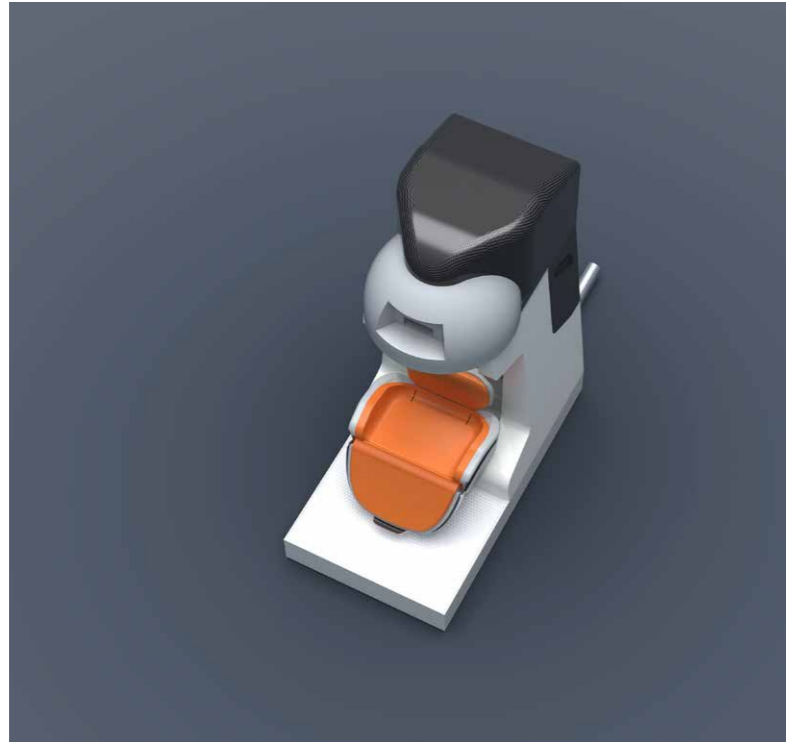
FINAL SYSTEM

The final head support consists of a carrier that can be placed inside the bore to secure a consistent position of the inflatable bladder. The bladder can be inflated and deflated from the back with an automated pump system based on the preference of the user.

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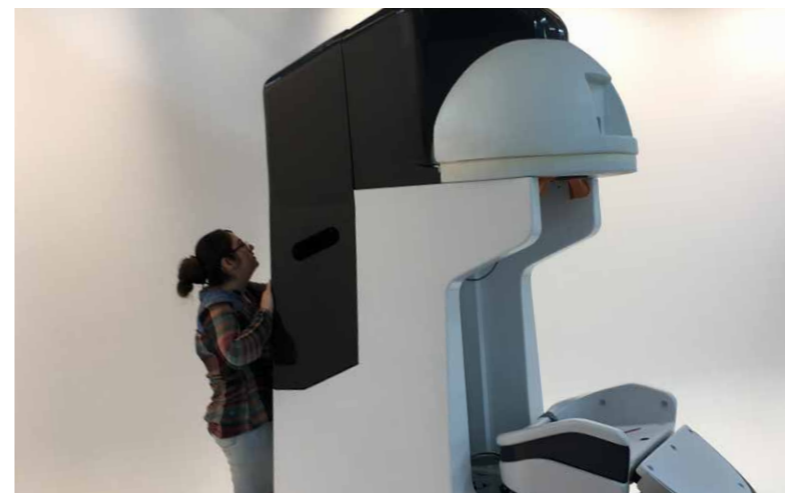
RENDERINGS

3D visualisations of the final system

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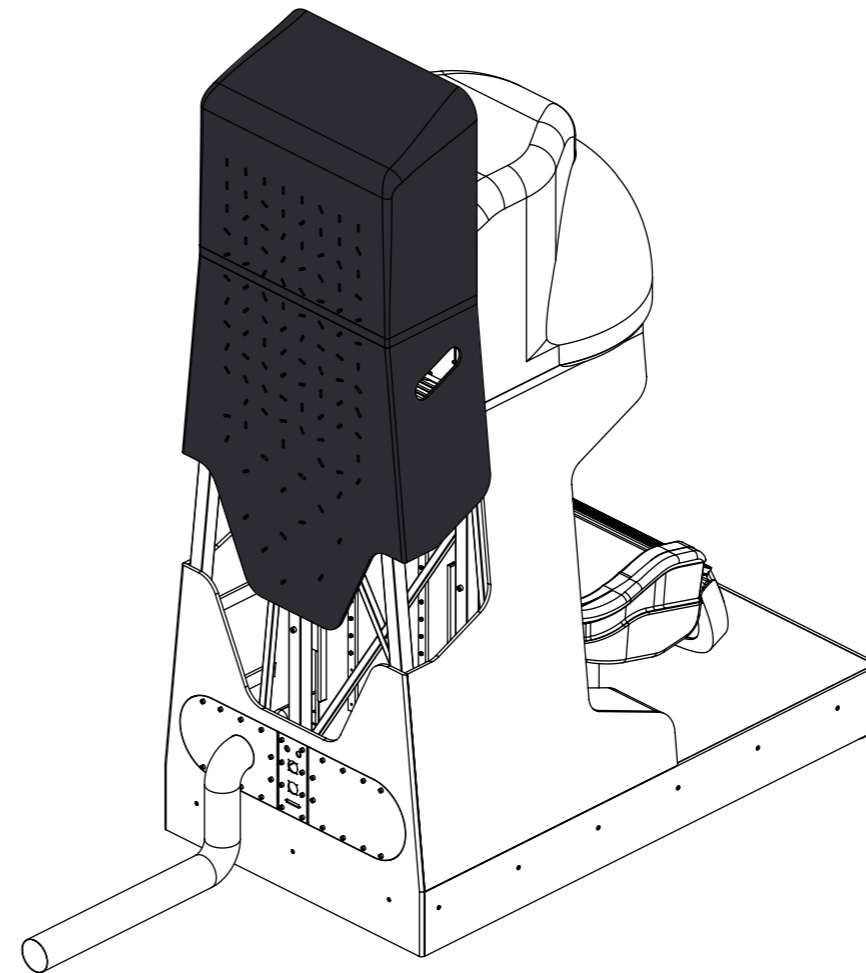
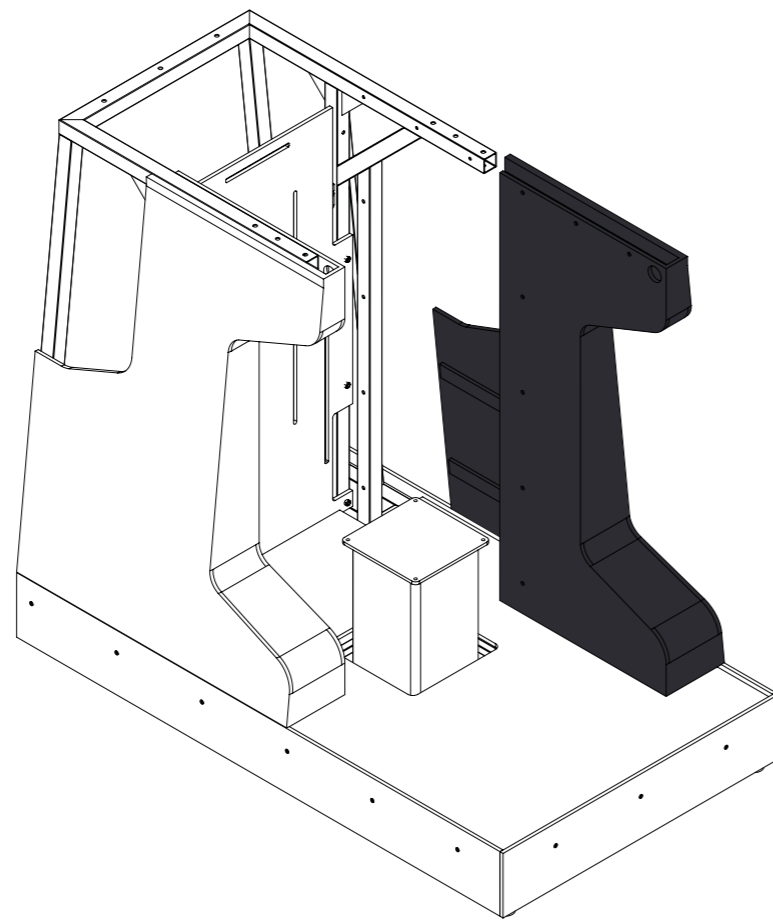
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ASSEMBLY AND TRANSPORTABILITY

The system is made in a way so it can be taken
completely apart and be transported in a shipping
container.

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FINAL PROTOTYPE

All the parts of the final prototype are labelled and can be assembled with a detailed instruction guide.

