Assisting Wheelchair and Mobility Scooter Users
to Independently Board and Alight Metro Trains

The Rhinos: Kinson H. Ben C.

Introduction

Wheelchair and Mobility Scooter Users (WMSU) are entitled to use trains according to Universal Design (UD) principles. This means they need not depend on others to complete their train journeys, and they should not, as far as possible, be left to feel they are different to other rail users. In NSW and other OECD countries , the present system requires station assistants to deploy a folding ramp for WMSU to board and alight trains. Although adequate, this system is not suited to peak hour nor multiple users, and is less than ideal when compared to UD principles. Clearly, a new automated system is both possible and desirable in these circumstances given the uses of big data within smart cities.

Martin Tomitsch, a contemporary researcher into smart city technologies found that, “Despite the promises of new user-interface paradigms, such as tangible computing and the internet of things, the user-experience design industry still focuses mostly on digital interfaces, such as websites and mobile apps.”, (Tomitsch , 2018b, p170)

A recent review of disability assistive technologies concluded, ”technology-based applications are still not used as generic enablers in the promotion of social inclusion for people with disabilities”, (Manzoor & Vimarlund, 2018, p377). According to another leading design commentator, “The best interface is no interface”, (Krishna in Tomitsch, 2018b, 32).

Given these findings from the current literature on how smart city and big data might assist disabled users, our approach has been to start with this concept and include only what was needed for the Auto-Ramp design to function optimally. Over the design process we did accommodate the design brief by adding some interactivity which may or may not be optimal in a real world design solution to the problem. Our view therefore, is that smart cities should and do have the ability to facilitate an automated system for assisting WMSU to board and alight from metro train services. An optimal/minimal strategy balances both simplicity of use and interactive requirements.

Several features of Auto-Ramp allows for minimal and optimal user interaction, which ensures an efficient, safe and engaging automatic transfer system for WMSU and the general public.

By conducting an interview with an experienced City of Sydney Town Planner we derived a key insight with regard to anything designed for disabled users, “Dignity is a top concern” (Wallace, 2019)

Through empathetic testing our research showed:

1) About 84% of respondents preferred to be self-sufficient when using trains

2) About 58% of respondents preferred an Auto-Ramp to needing assistance

An Auto-Ramp system which is deployed upon request removes the burden of needing a station assistant, or guard to assist, and additionally, it speeds up transfers when WMSU board and alight, especially with multiple users. The WMSU has dignity and autonomy, not relying on others to structure and accomplish their daily routine. Additionally, negotiating train journeys successfully reduces the impediment for WMSU to enter and stay in employment, adding to their engagement with the wider community, and achieve whole of life outcomes successfully

Our initial concept was very much to use big data and smart city thinking to automate the process of deploying a ramp.

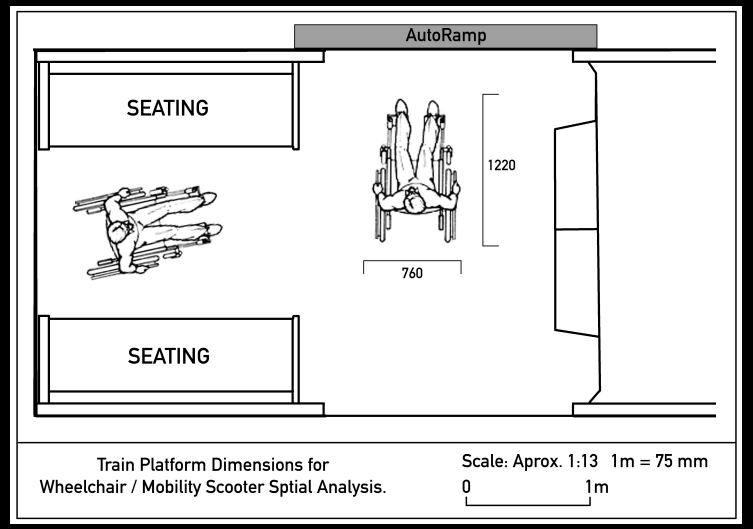
Initial literature review demonstrated that the use of AI and data was underutilized, with an overemphasis on web and app. designs. This is in part from the venture capital and profit motive, rather than the efficiency and user rewards that a city or a state body would see as a needed investment and community based return. Our category class C for the design brief of disabled users made it even more so applicable to emphasise a real world problem/solution. Following is an outline of the three main interactions we designed:

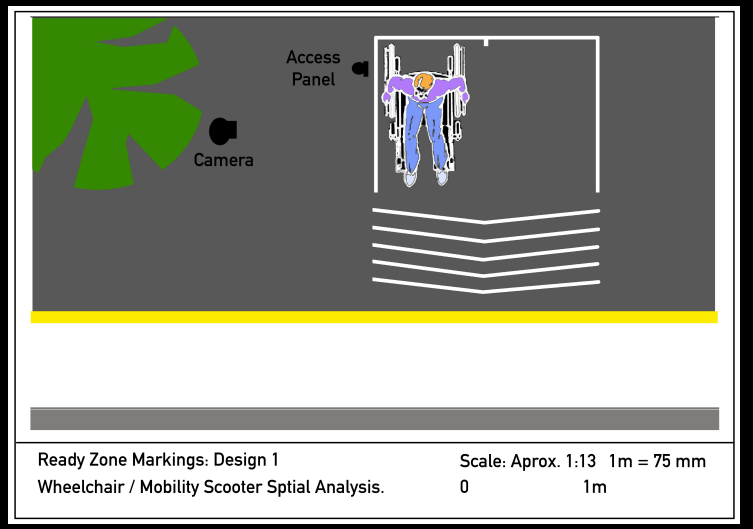
1) The Ready Zone and Movement Zone design

2) Requesting the Ramp

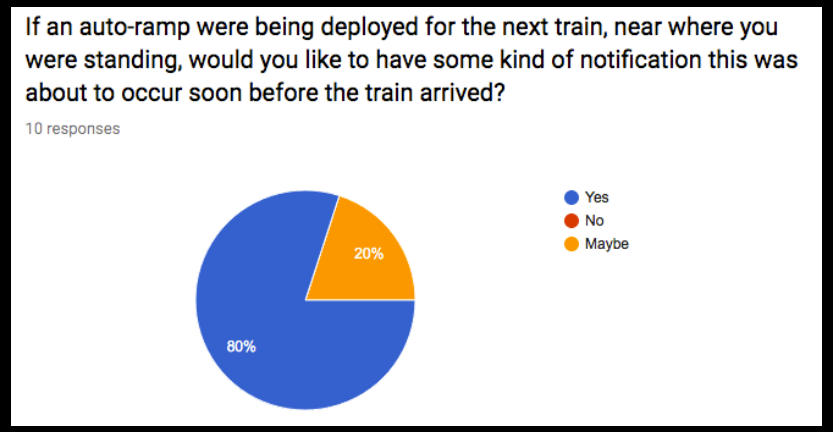
3) Screen interactions

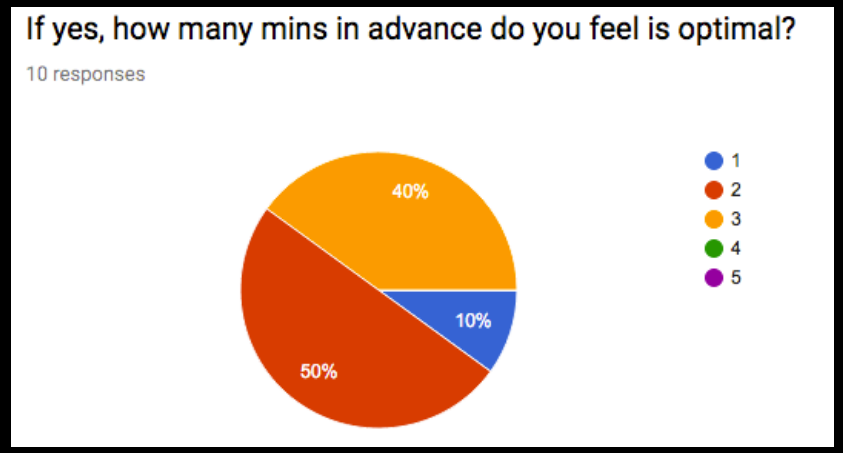
1) The Ready Zone and Movement Zone design came about from looking at existing literature and diagrams for ergonomic parameters for WMSU in public spaces.

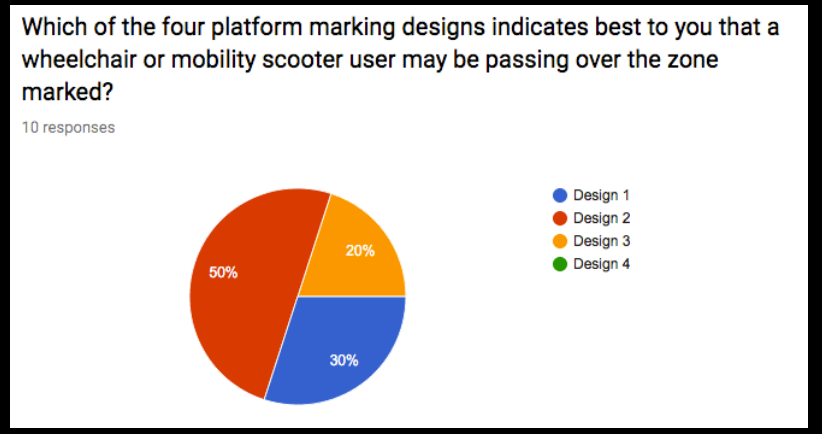


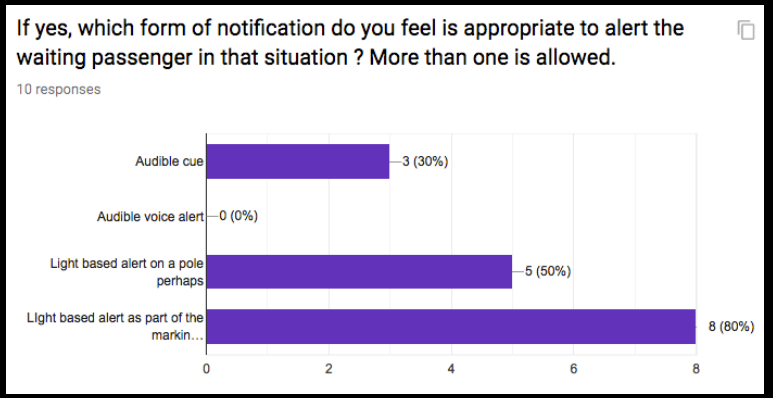


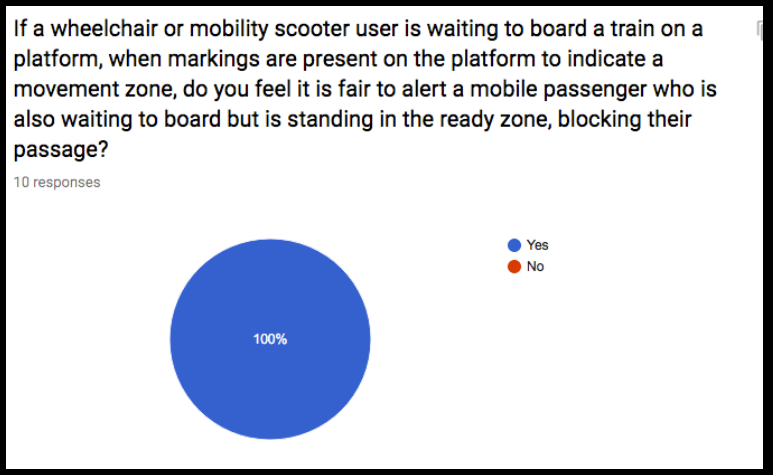
We derived over 25 different design patterns for the Movement Zone which is in front of the Ready Zone, (see Appendix 2). From this list we chose 4 to test in a google docs survey. The shallow arrow design (2) was chosen by 50% of the 10 respondents. 100% of respondents thought it was fine to alert a person blocking the WMSU path to the platform, and 80% felt a light based prompt was preferred. 50% agreed 2 mins was adequate for alerting the train is coming.









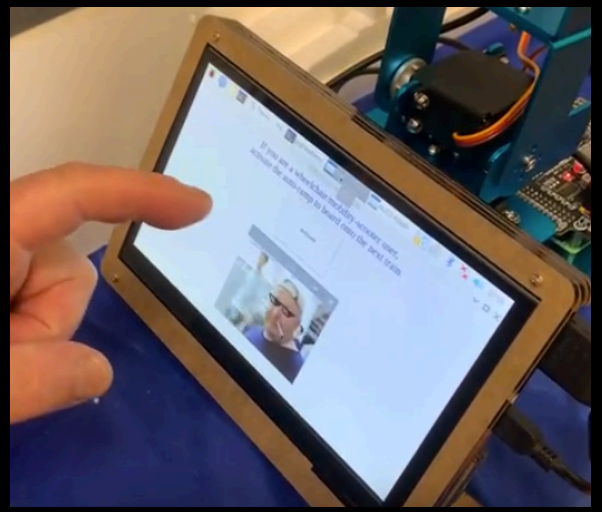


2) Requesting the Ramp required a step by step approach. The sequence is first to request the ramp, by touching the screen or access panel, then the camera and IA recognition software identifies the WMSU in the Ready Zone. The machine learning needed 300 images which were annotated ‘Wheelchair User’ IBM WATSON CLOUD machine learning service, at 500 Epochs, for a reliable accuracy of about 80-90%. For pedestrians we used YOLO pretrained model which has a 95-100% reliable accuracy. Both were necessary for recognizing a legitimate and non legitimate request for the ramp, designing out misadventure by deliberate mischief, and to recognise a pedestrian in the Movement Zone inside 2 mins. We also then linked the request outcome to the screen and access panel colour changes.

Examples of images of the type used to program the IBM WATSON CLOUD

A ‘Person’ and a ‘Wheelchair User’ recognised

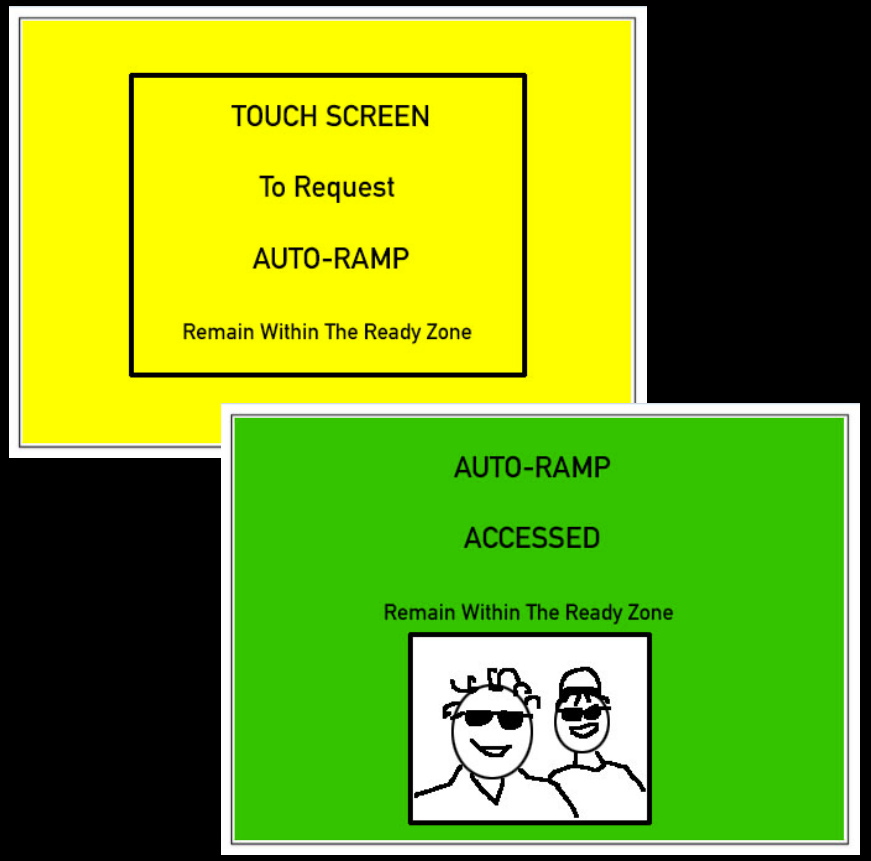
3) Screen interactions were initially button based, and through discussions with tutors we included a level of playful interactivity on the platform side with a screen replacing a the Access Panel. Sun-glasses appear overlaid on the face(s) captured by the camera, after the successful request for the ramp. This was a modified code segment using Pi-Motion from Shenzhen Yahboom Tech. Other options, although not sourced, could have been Bunny ears or Mouse Nose and Whiskers.



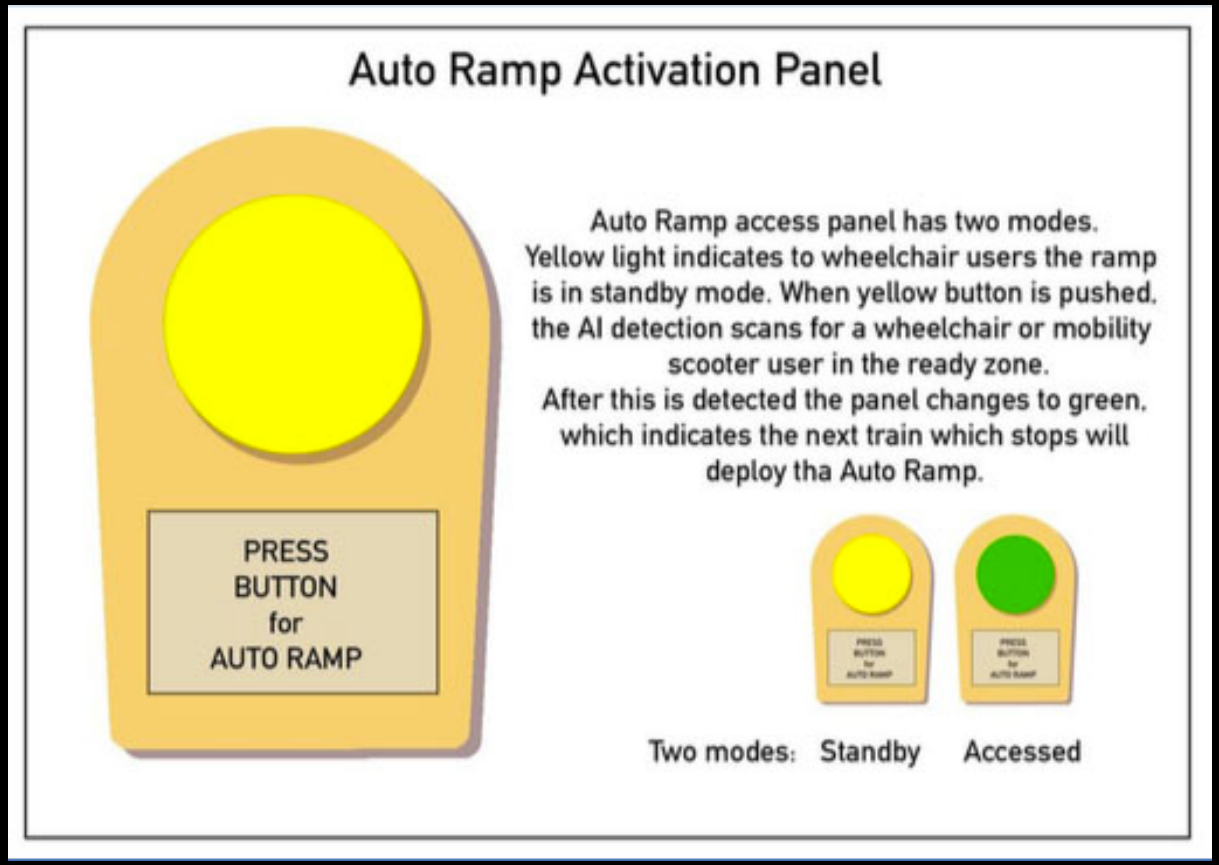
Core functionality

Auto-Ramp Features

1) a. On station or within a train Auto-Ramp can be requested using:

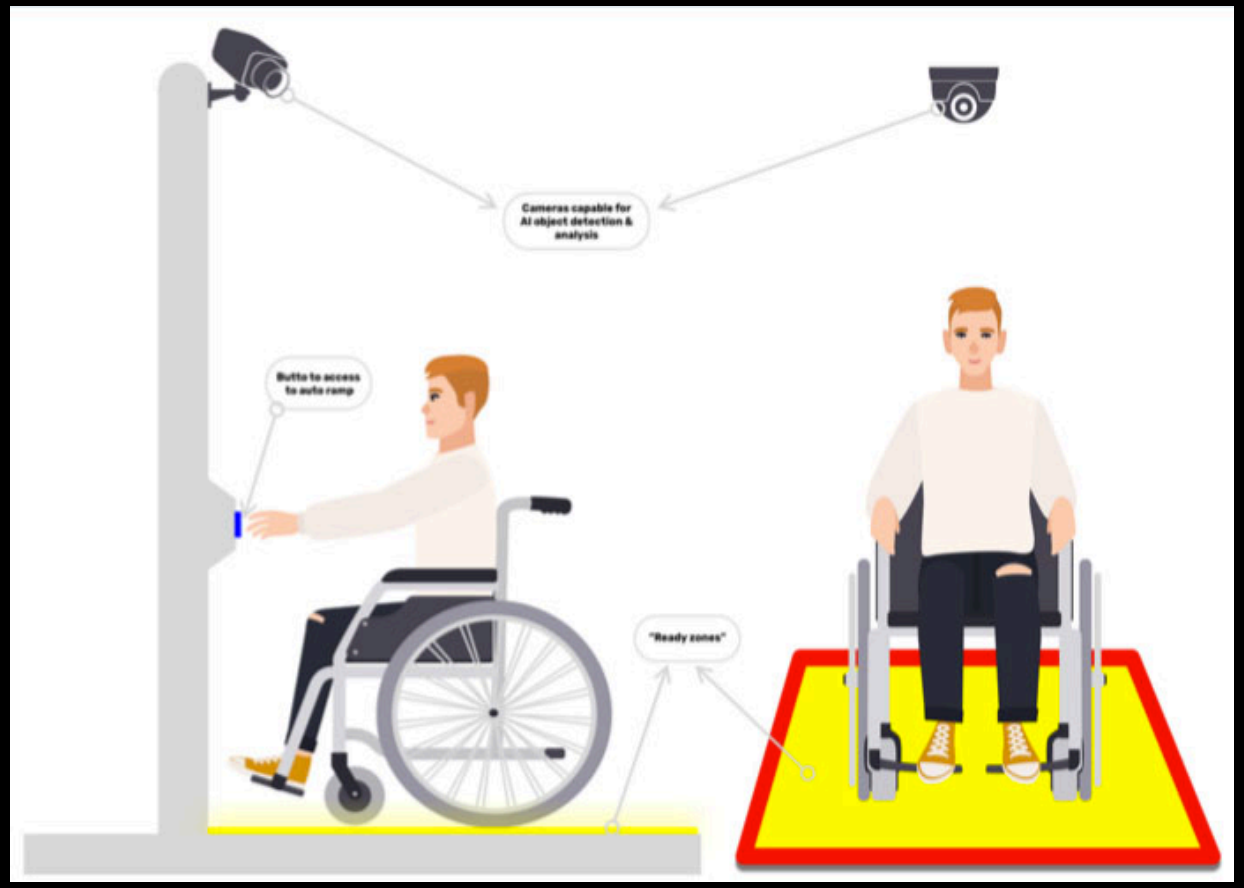


Touch Screen

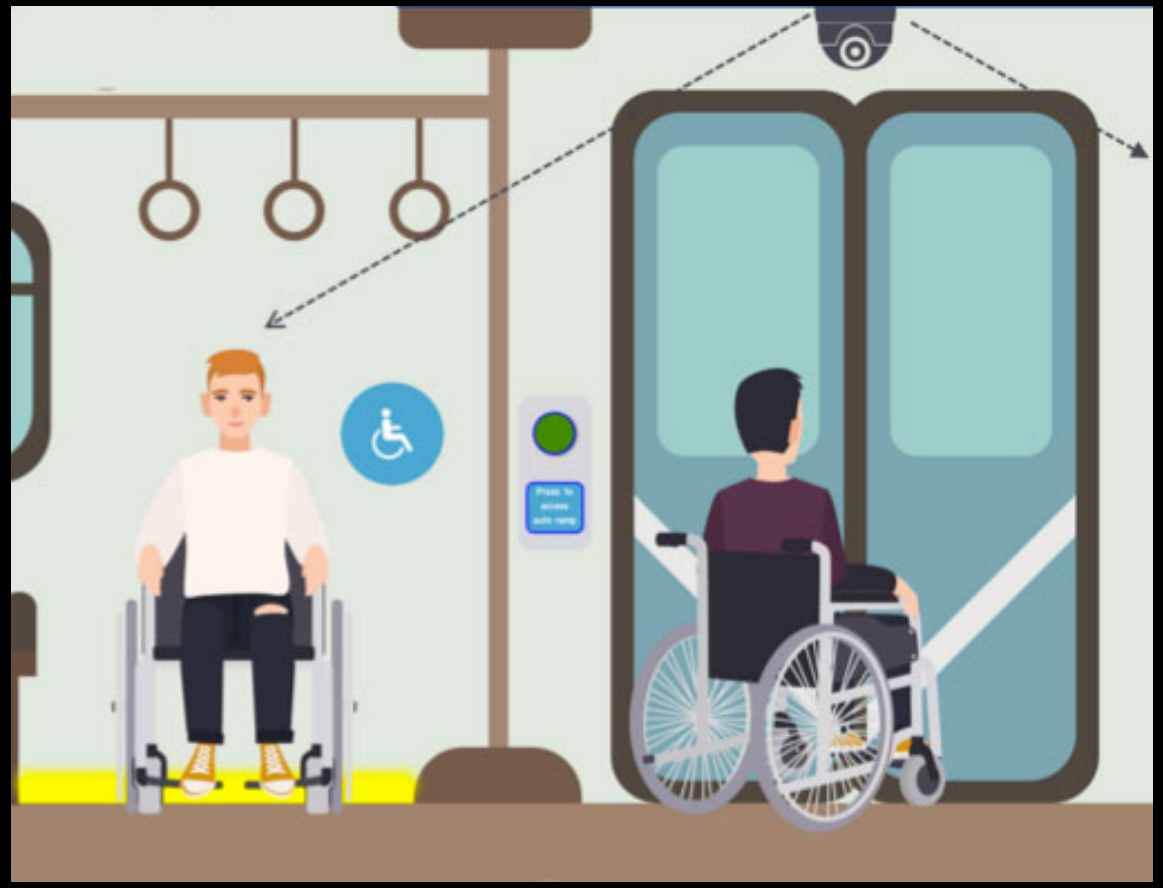


or Access Panel

b. Camera using AI and machine learning searches and recognises a WMSU:



in the Ready Zone on the platform



or in the vestibule on board the train.

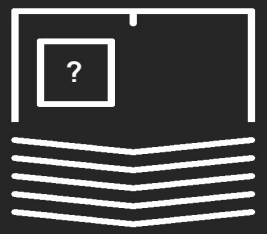
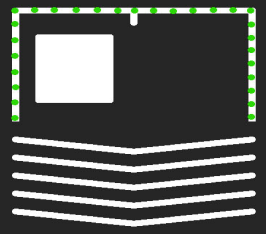
2) a. Green lighting surrounding the Ready Zone on the platform assures the WMSU that the ramp is activated, and alerts surrounding commuters. On board the train the Access Panel affords the same;

b. Green Lighting comes on in Movement Zone within 2 mins of the train arriving and;

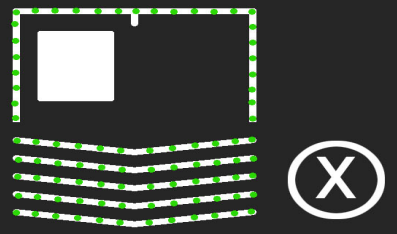
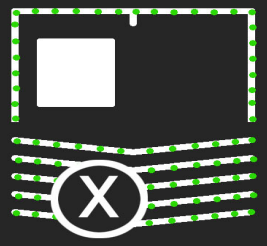
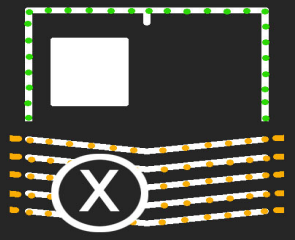
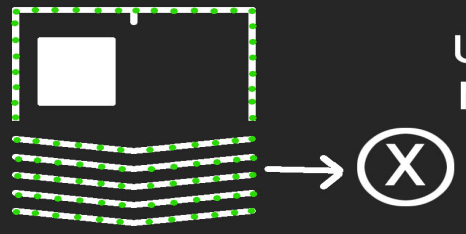
c. Flashes Orange If a pedestrian stands in the way.

3) Using data from motion capture a lightly humorous overlay onto the WMSU image is shown on the screen display while they wait. Several styles can activate at random: Sunglasses (used in this iteration), Bunny Ears, Whiskers, overlaying any face in the camera view.

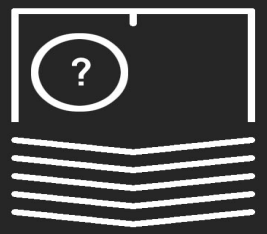
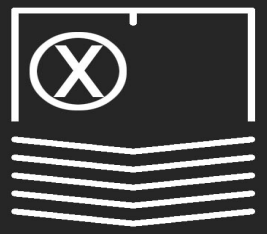
Auto-Ramp: Primary User Interactions 1 - Wheelchair/Mobility Scooter Request

Position		Action	Outcome
Ready Zone Unoccupied		Ready Zone is clear	Auto-Ramp not requested not deployed
Ready Zone Occupied Unverified		User moves into Ready Zone	Auto-Ramp not requested not deployed
Access Panel Screen		ORANGE Screen accessd by Touch	Camera Scanning and AI. search
Ready Zone Occupied Verified		Ready Zone Occupied	User Verified Auto-Ramp Requested for Next Stopping Train Ready Zone: GREEN Lights ON Movement Zone: Lights Off
Access Panel Screen		GREEN Screen Text Notofication	Auto-Ramp Deploys Next Stoppping Train

Auto-Ramp: Primary User Interactions 2 - Under 2 Minutes, Pedestrian Blocking

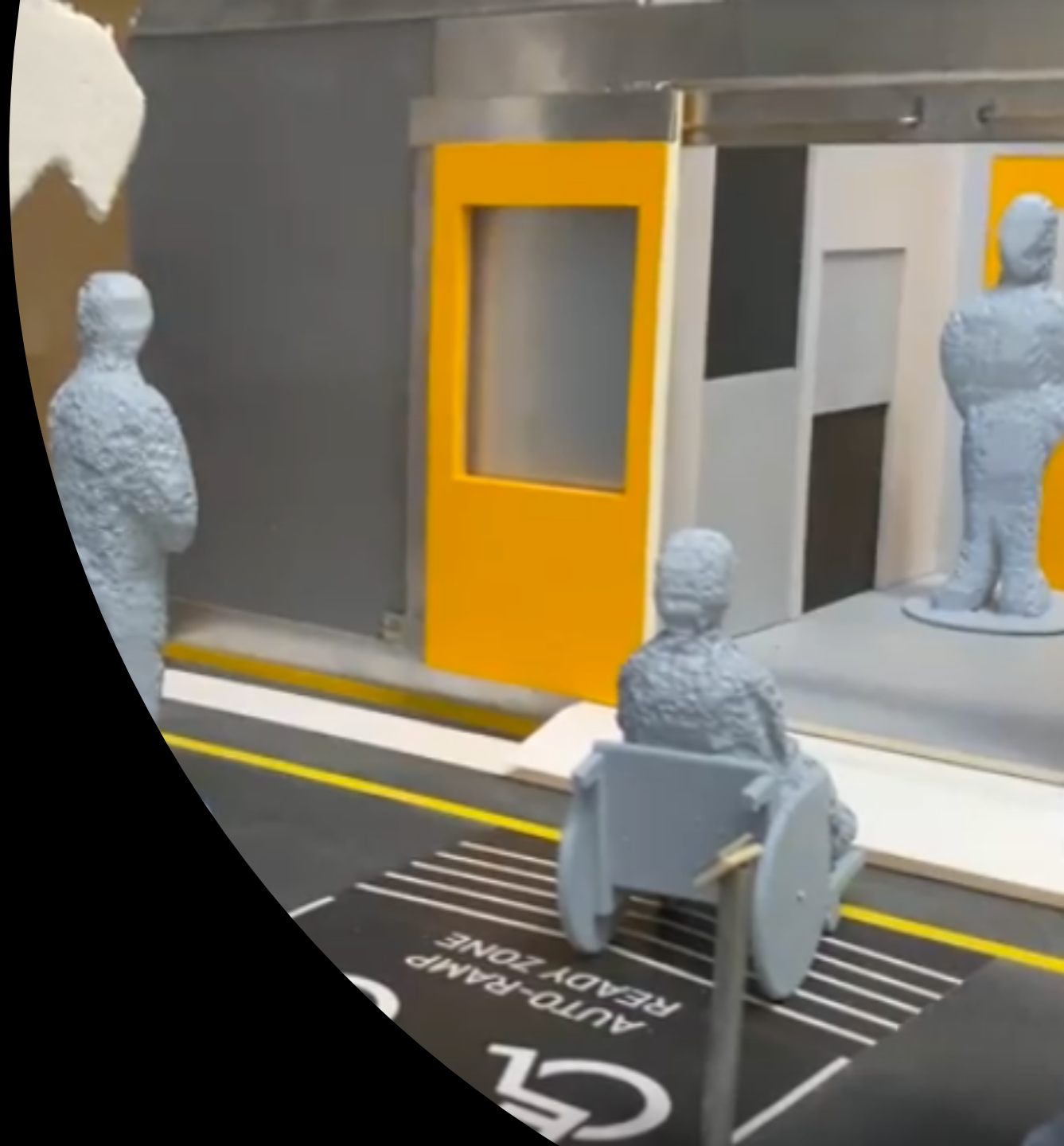
Position		Action	Outcome
Ready Zone Occupied Verified		Under 2 mins Ready Zone Occupied	User Verified Ramp Requested Ready Zone: GREEN Ready Lights ON Movement Zone: GREEN Ready Lights ON
Ready Zone Occupied Verified		Unknown User dwells in Movement Zone	Camera Scans and Detects Pedestrian User in Movement Zone
Ready Zone Occupied plus Verified Pedestrian		Under 2 Minutes Movement Zone Blocked	Ready Zone: GREEN Lights ON Movement Zone: ORANGE Lights ON Flashing
Ready Zone Occupied Verified Pedestrian Moves Clear		Under 2 Minutes Movement Zone Unblocked	Camera Scans and Detects Movement Zone is Clear Ready Zone: GREEN Ready Lights ON Movement Zone: GREEN Ready Lights ON

Auto-Ramp: Primary User Interactions 3- Pedestrian Request

Position		Action	Outcome
Ready Zone Unoccupied		Ready Zone is clear	Ramp not requested not deployed
Ready Zone Occupied Unverified		Unknown User moves into Ready Zone	Ramp not requested not deployed
Access Panel Screen		ORANGE Screen accessd by Touch	Camera Scanning and A.I. search 
Ready Zone Occupied Non-User		Ready Zone Occupied Unverified No Action	User Verified as Pedestrian Auto-Ramp not requested
Access Panel Screen		ORANGE Screen can be accessd by Touch	Screen returns to Read Mode

5) Train comes to a stop, the Auto-Ramp deploys, and then doors open.

6) WMSU boards or alights the train.



7) Doors close, Auto-Ramp retracts and train moves off.

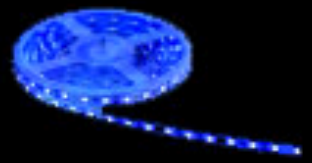
8) The train moving off resets the Auto-Ramp system.

Hardware/software requirements

Hardware

Raspberry Pi 4B computer

Yahboom Pi-motion AI Camera platform



programmable LED light strips

7" touch screen

Software

Google Cloud Vision API

Google Vision API

Open Computer Vison Python Library

Raspbian OS

Known Issues

1) The interaction between pedestrian rail uses and WMSU is always going to be a potentially hazardous one. It is not our belief that bad behavior can be designed out completely from human affairs. That said we decided to not proscribe a Ready Zone inside the vestibule on trains, even though this might look good. The reason was that they are often semi chaotic zones, and people are sometimes not concerned with the welfare of others – even disabled people. This is exacerbated during peak periods where people are in a hurry to make connections or move quickly. In accordance with some of our early observations, WMSU often wait briefly for walking people to go first, simply to avoid collisions. We did look carefully at the Ready Zone and Movement Zone on the platform however. For the same reason we retained an access panel on the train, whereas we altered it to a screen for the platform.
2) The Auto-Ramp poses a risk of misadventure and injury while deploying. If a passenger is too close to the ramp their feet could be crushed. This is outside the safe zone on NSW trains, but nevertheless, we recognize it is an issue. Apart from station assistants observing, which is in a way redundant to automation, and non-dependence for WMSU, we have not been able to design away that issue.
3) There is the potential for the WMSU, or a pedestrian user to slip and fall close to the junction of the ramp and door edge, if the ramp is exactly the same width as the door area. We considered a reasonable remedy was to extend the width of the ramp to be equal to the deployment distance outward so in all but an exceptional case the WMSU would be on the ramp when at the edge, and, pedestrians would be safe too.

Future work/versions

Auto-Ramp has a future in fully designed cities from scratch, but also in cities which are willing to repurpose infrastructure for a growing population. The main future improvements we see ahead for Auto-Ramp are widening it s application to users with mobility issues like elderly and walking frame or stick users. All these could be learned by the cloud recognition and made available.

We also see that Auto-Ramp could be a feature of every train doorway, and therefore, it would deploy at every stop. This would obviate the requirement for it to be called and it would conform to universal design. The added bonus is it would remove the possibility of anyone falling between the carriage and the track while boarding or alighting.

Looking closer into the light based interactions would lead to improvements perhaps, and possibly adding an audible cue when a person stands in the Movement Zone.

Improving the accuracy of the image recognition would be something to be expected as improvements advance the power of computing.

Bibliography

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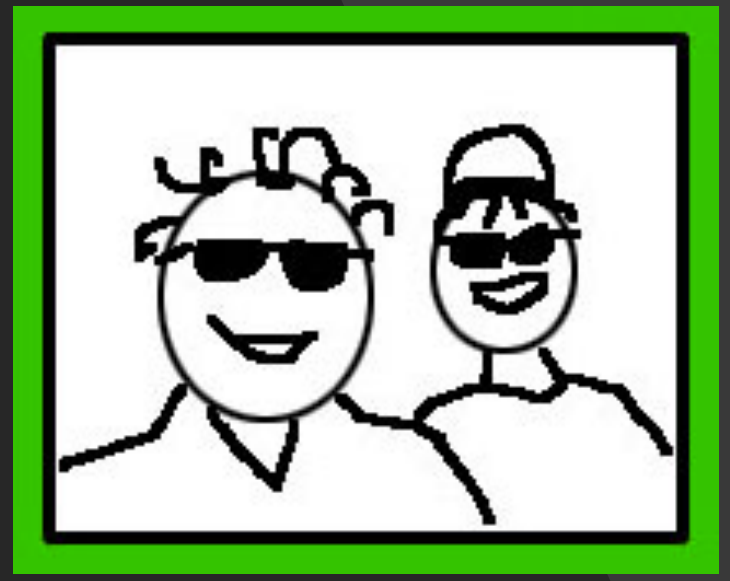
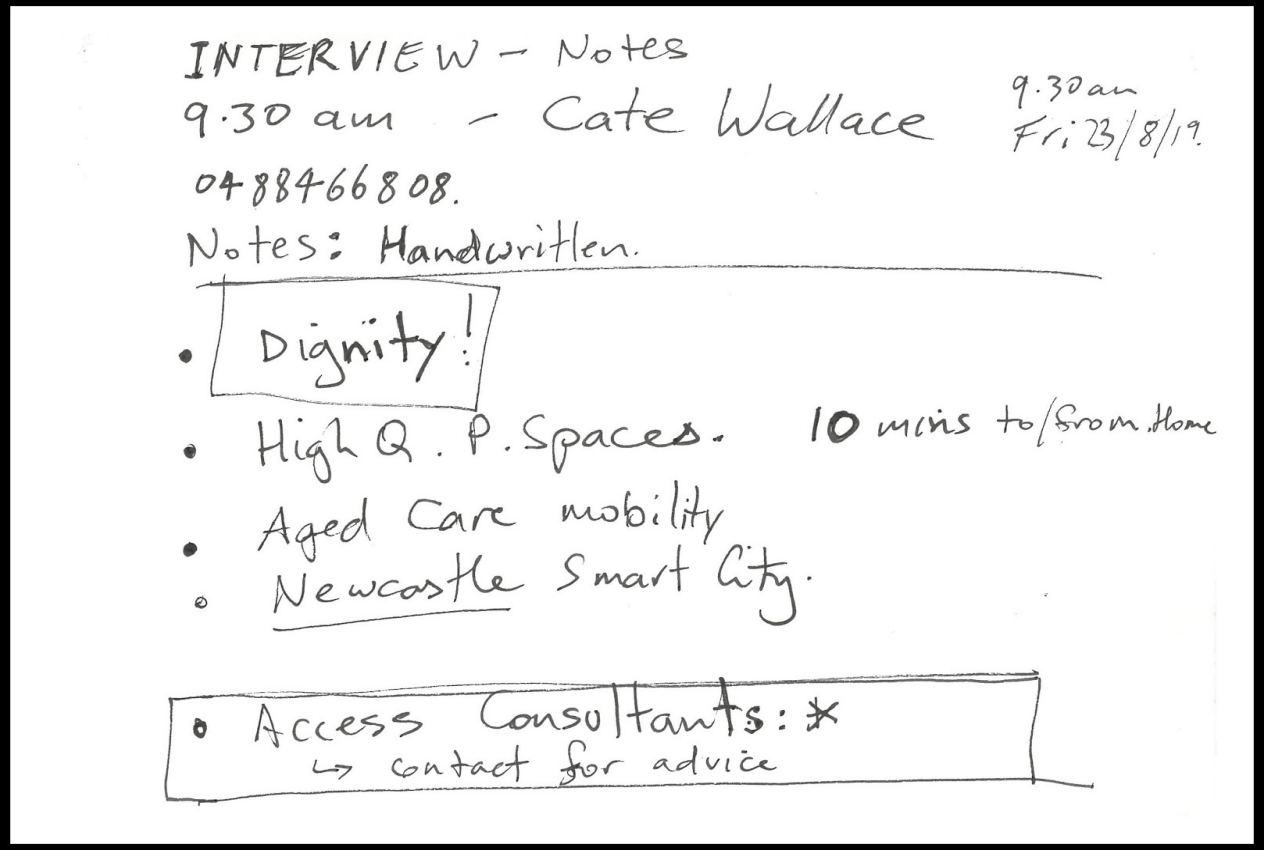


Appendix

1) Interview Notes with Cate Wallace, City of Sydney Town Planner



INTERVIEW – Notes
9.30 am – Cate Wallace
9.30 am
Fri 23/8/19.
0488466808.
Notes: Handwritten.

- Dignity!
- High Q. P. Spaces. 10 mins to/from Home
- Aged Care mobility
- Newcastle Smart City.

- Access Consultants: *
  ↳ contact for advice

Appendix

2) Movement Zone markings testing

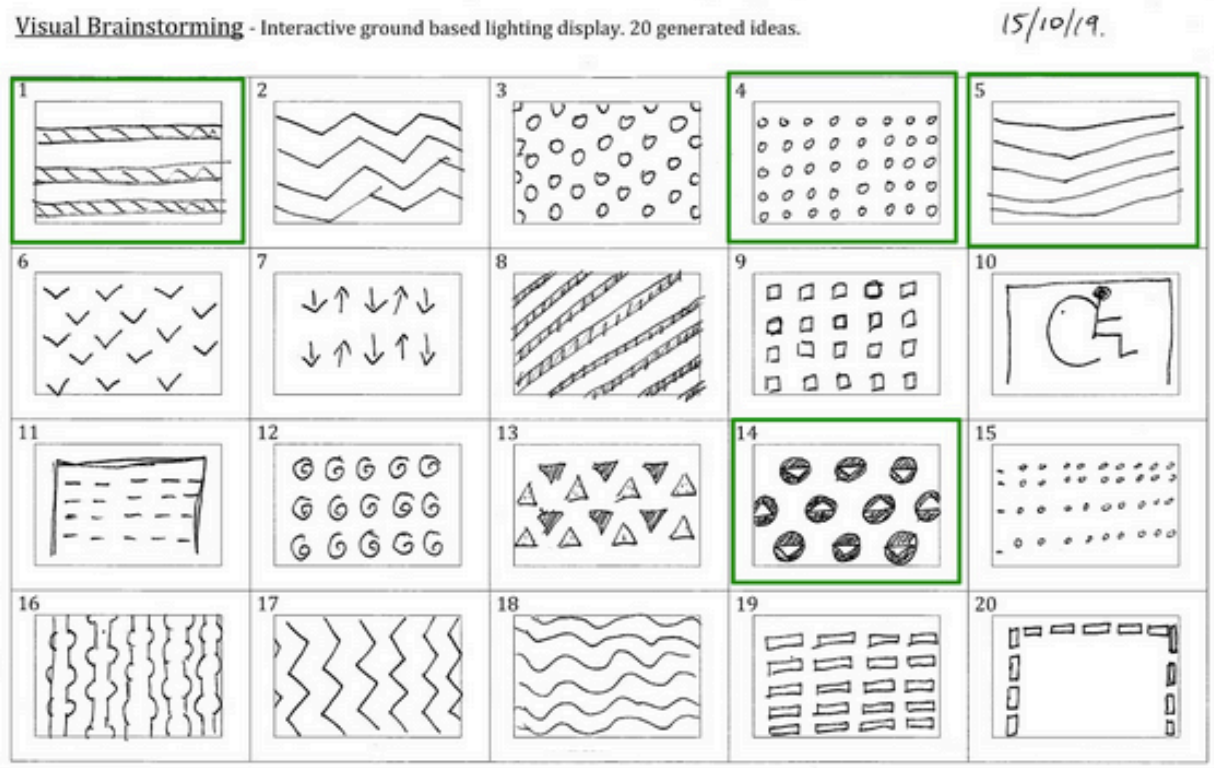


Figure 1.1: Annotated Ready Zone Platform Design Options.