New Workflows in the Automotive Design Process and their Potential Impact in Education and Practice

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Short Abstract: Future megatrends such as autonomous mobility, the shared economy, the aging of the human population, and new power train technologies will create opportunities for new vehicle configurations, vehicle interiors, and user mobility experiences.

The Transportation Design program at the University of Cincinnati has redefined its approach accordingly. A new studio space supporting collaborative work, 2D visualization, as well as a virtual reality and physical prototyping was created. VR 3D sketching tools are used in tandem with low-fidelity physical prototypes during the creative process. VR is also used to visualize high-fidelity interactive virtual prototypes.

Key words: future of mobility, future of education, transportation design, virtual reality, new design workflows

1- The Status Quo

We are about to enter a new industrial revolution [R1]. Jeremy Rifkin mentions that when there are simultaneous innovation in the realms of energy, communication, and mobility, the increase in productivity is such, that change in the human world accelerates dramatically. The pre and post 1st industrial revolution cities and societies show this, as coal energy, the steam engine, and trains transformed the world. The harnessing of electricity, oil, the internal combustion engine, and centralized telecommunications in the 20th century created the world we live in today. After World War two, the personally-owned automobile became aspirational and became a symbol of freedom and status. The paradigms that defined the urban environments we inhabit today were created around the car.

2- The Traditional Transportation Design Process

This is the moment when automotive design was born, as Harley Earl's work at GM produced design studios that created a model that, to a large extent, continues being the norm. Lewin and Borroff have defined automotive design as "… the aesthetic cultivation of every element of an automobile that is visible to the customer." [LB1] The term transportation design was born as an extension of this same definition to other types of vehicles beyond the car. Transportation designers have been focused, mainly but not exclusively, on creating the aesthetics of technical packages developed by the engineering department. This has been enabled by decades-old vehicle configurations afforded by the internal combustion engine (i.e. sedan, SUV, coupe, etc.). As automobiles are usually the second most expensive possession after the house, they are perceived as status symbols parked in owner's driveways. This has made the design of automotive exteriors the banner of automotive design studios. The interior, for a long time, has been viewed as a cockpit to operate a machine first, and then as a liveable space.

For vehicle interior and exterior design, the traditional transportation design process begins with the development of a technical packaging that responds to the market and user needs. The design studio performs research about the vehicle's future users and brand character in order to generate aesthetic concepts. These are explored first in 2D sketch form, and later in 3D physical and virtual models. The modelling process is iterative and switches from CAD to clay models and back, beginning small and then transitioning to full scale. Once the final design is developed, industry uses robust VR equipment to make the last reviews and green-light prototyping, product engineering, and manufacturing. Final design presentations usually consist of a poster explaining the vehicle concept, its design process, and final renderings, as well as high-fidelity physical models. These involve a high investment of time and cost, as well as requiring a very high skill level for their execution.

Transportation design design centers vary in their workflow and configuration, but usually have a series of studios focusing on vehicle exterior styling, interior design, clay modeling, digital modeling, color and trim, and graphic design, HMI, both for production models and advanced design. Traditional Transportation Design education focuses in exterior or interior design, with color and trim, HMI, and graphic design departments taking design professionals from other creative disciplines. [RN1]

3- The coming future and its implications for vehicles and their design process

The transportation design process has so far responded to the 2nd industrial revolution's internal combustion engine. However, Rifkin mentions that we are about to start a 3rd industrial revolution. Global megatrends that suggest this include the superinternet, cheap and renewable energies, and the new paradigms of autonomous and shared mobility. All of these megatrends present a shift in the way the vehicles of the future will be designed. The superinternet and 5G connectivity will make the car an extension of our digital selves. Cheap and renewable energies mean new powertrains and vehicle configurations, challenge the traditional internal combustion layout, creating new design opportunities. Shared mobility is expected account for 80% of vehicles in US urban areas by 2035, [CV1], disrupts the concept of the car as a driveway trophy, making the purchasing (or renting) decision based on the riding experience, increasing the importance of the vehicle's interior. 75% of the vehicles in US urban areas are expected to be autonomous [CV1]. People will no longer need a cockpit to operate a machine or keep their attention on the road for that matter, again increasing the importance of the interior. In addition, autonomous vehicles will need new ways to communicate with pedestrians, passengers, and other drivers. Designing new mobility options such as first-last mile vehicles, hyperloops, passenger drones, and personal rapid transit will become more important. These new mobility options will not follow a decades-old configuration. All of this means the transportation design process needs to evolve to address the upcoming status quo.

4- New workflows to tackle the coming future

Transportation Design program at the University of Cincinnati has been part of its renowned industrial design program since the year 2000, and until 2016, responded to the traditional transportation design paradigm. The goal was to prepare professionals to fill industry needs, by giving them the necessary hard skills to become specialists on generating attractive and provocative proposals. The approach to projects was individual and competitive, mainly focused on automotive exteriors. In 2016, the program saw a leadership change and Islas Munoz became Head of Transportation Design. By understanding the upcoming status quo and the impact that the global megatrends would have on transportation design, program was re-envisioned and reinvented.

The University of Cincinnati has a century-old Co-Op program in which students attend up to five internships during their academic experience. This allows us to be in the aware of the latest workflows and technology in industry. During the Fall of 2016, Raleigh Haire and Victor Fortmann, now accomplished transportation designers, returned from an internship at Ford Motor Company. There, they were tasked to try the then-new HTC Vive VR headsets and assess if they would be useful for the transportation design workflow. Haire and Fortmann were impressed with the technology and the program decided to acquire it.

The combination of our understanding of global megatrends, and the virtual reality was a potent combination that transformed the program at the University of Cincinnati. The new version of the program focuses on:

- Creating new land, water, and air vehicle concepts and configurations, from first-last mile, to the automotive space and mass transportation.
- Developing vehicle interiors as habitable spaces first, with positive user riding and driving experiences.
- Envisioning the future of autonomous vehicle's exteriors focusing on the new interaction requirements for pedestrians, passengers, and other drivers.

This new approach aims to envision the mobility experience of the future, through the application of a research-informed problem finding and solving approach, rather than an inspiration-based one. Projects in the program consider the urban environment not only consider the vehicles, but also their users, as well as the complexities of their physical context. The program, rather than creating individually competitive specialists in vehicle exteriors, aims to foster multidiscipline and collaboration, allowing students to develop their own pathways for specialization. Today, the program welcomes students interested in the how vehicles look (sketching, rendering, and CAD skills); how they feel (material, color, and finish skills); how they solve problems (user-centered design skills); how we physically interact with them (mock-up and making skills); and how we would experience them if they existed today (digital skills such as virtual reality and game engines).

4.1– The new Transportation Design studio at the University of Cincinnati

Figure 1 : The Transportation Design Studio at UC. The entire layout (top), the collaborative work space (bottom-left), and the 2D visualization bay (bottom-right).

In order to achieve this, the Transportation Design space at the University of Cincinnati was redesigned. Its previous layout included a classroom with large desks, each with a tablet for 2D digital work, and an area for clay or rapid-prototyped modeling area. Its current layout is divided in three main spaces: the collaborative work area, the 2D visualization bay, and the virtual and physical prototyping technology lab (Figure 1). The collaborative work space is composed by 16 desks, walls and furniture with pinnable surfaces, a tabloid-sized scanner, and a light table. It is separated from the 2D visualization bay by lockers, with pinnable sides. The 2D visualization bay has 16 desks with Cintiq 22HD tablets to facilitate digital sketching and rendering. The virtual and physical prototyping technology lab consists of four virtual reality booths big enough to fit a virtual full-sized car, and a corresponding area for physical mock-ups and interior bucks.

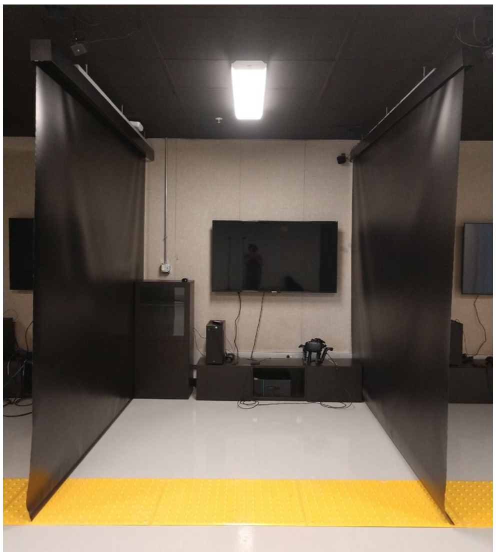

Figure 2 : Virtual reality booth

Each VR booth is equipped by a virtual reality headset, a 65 inch monitor, tactile surfacing on the floor for spatial awareness, and a VR ready computer. It is equipped with immersive sketching software Gravity Sketch for early creative work, Autodesk Maya and Fusion 360 for CAD modelling of the final idea, and Autodesk VRed for its high-fidelity visualization (Figure 2). The VR booths are separated by roll-down dividers that can fit differently sized vehicles, from first-last mile to buses or plane interiors (Figure 3). Each VR booth has a corresponding physical prototyping space (Figure 3) in order to correlate and validate the high-fidelity virtual model with low-fidelity physical mock-ups (Figure 4). To achieve this, a modular aluminium system will be used to easily create bucks. It will work with real automotive seats and allow for custom-made add-ons (Figure 4).

4.2– Project output using the new space and workflows

The use of the new tools and workflows has proven to be very powerful, as seen in the student projects in the Transportation Design 1 course during the Spring semester of 2019. This was the first time this group of students faced a transportation design project, which has a steep and challenging learning curve. This usually shows in the execution of the student work. However, under the new workflows student projects exceeded the usual output quality at the Transportation Design 1 level. For the project, students were able to select from a variety of challenges that included the design of passenger drones, semi-autonomous walking aids, and interior designs of hyperloops and autonomous vehicles for the aging population. Once a vehicle was selected, students focused on a dimension of the vehicle between the design of the physical interior, CMF, or user experience.

Figure 3 : Virtual and physical prototyping space with dividers down (top), and up (bottom). Markings on the floor define the space for each interior buck.

Figure 4 : Vehicle interior buck rendering

Students Hunter Elmore and Matt Whitby took on the same vehicle challenge with different dimensions to focus on (Figure 5). Elmore worked on the physical design of the vehicle, while Whitby focused on what the most intuitive way to fly it would be. Both students used low-fidelity physical mock-ups to develop the most ergonomic posture possible while still recreating an adventurous “superhero” flight experience. Once the hard points were identified and the posture recreated in Gravity Sketch, Elmore developed close to 200 iterations of the exterior and interior design of the vehicle which were then explored further in 2D sketching. The Gravity Sketch file was used as an underlay for the final CAD model for rendering and VR, as well as Photoshop finishing for 2D renderings. Whitby, on the other hand, used the physical prototype, an HTC Vive tracker, and the Unity game engine to develop, test, and refine the intuitiveness of the flight experience.

Figure 5 : Transportation Design 1 projects: Hunter Elmore's high-fidelity CAD model (top and mid-left), and low-fidelity physical mock-up (bottom-left). Matt Whitby's playable simulation (mid-right), and physical mock-up (bottom-right).

Students in this class did not present their final projects with the traditional poster and physical high-fidelity scale model, but rather with screen-based slide shows and VR immersive experiences. The project critics were able to sit in, experience demos, and even operate the vehicles. The conversation during the final critique was not, as it usually is at this level, about the quality of the imagery produced by the students to explain the concepts but about the content of the concepts themselves.

Figure 6 : Parth Kashikar presenting his final Hyperloop project in a slideshow and VR (top). Guest critic during an immersive demonstration of the quadcopter project.

4- Industry's reactions

While there was concern that challenging traditional transportation design workflows would have a negative impact in the eyes of our industry partners, the interest has actually increased. Since the change in approach, the program has had sponsored projects with Crown Lift Trucks (Fall of 2016), Fiat-Chrysler Automobiles (Fall of 2017), and General Motors (Spring of 2018). These sponsorships, in addition to university funding, have made the studio renovations possible. Since then, the program has become an excellence center for Gravity Sketch. The university is an Autodesk Strategic Partner as well. Yuki Fukunaga, an automotive designer from a Tier-1 vehicle interior supplier company in Japan, was sent by his company for a two-year residency in order to learn from new workflows. He mentions:

"The Transportation Studio at the University of Cincinnati is an ideal place to design and review the next generation of mobility with a 2D sketch workspace, VR equipment and full-scale mock-ups. In the studio, students are developing various mobility designs while flexibly using 2D sketches, CAD, and Gravity Sketch depending on the situation. Design reviews are conducted by combining VR and full-scale mock-ups created by students, to create high-level output in limited time. If design development methods implemented at the University of Cincinnati 's Transportation Design Studio become widespread in the automotive industry, designers will be able to produce higher quality outputs in a short time. Designers will be able to see their ideas not only in sketches (2D) but also in 3D from the early stages of design development, and will be able to create a wide range of ideas while accurately grasping the three-dimensional configuration and design requirements. In addition, if high quality CAD data can be shared with related departments from the early stages of design development, early detection of issues for production and reduction of the number of design surface fixes at the end of the design development phase can be expected."

5- Conclusions

While the traditional vehicle architectures still exist and thus traditional Transportation Design workflows continue to be relevant in industry, global megatrends indicate that other types of vehicles and new dimensions in the design process should be addressed by future design teams. The Transportation Design program at the University of Cincinnati is focusing on creating the designer of this fast-coming new status quo. The benefits of the flexible use of 2D visualization, the use of VR in early concept development final proposal visualization, in tandem with low-fidelity physical validations mean: faster design processes, higher quality output, more impactful presentations, and a reduced need for high-fidelity physical prototypes (which means lower development costs). It is only a matter of time for industry to understand these benefits and produce a substantial new paradigm of what the design studio of the future and its workflows should be.

6- References

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