## 8 FULL INTERVIEWS

Five professional designers who participated in the user study were interviewed about their backgrounds, challenges they experienced in previous projects that involved designing articulated objects, and what they liked and disliked about using our system. Note that the interviews are translated and edited for clarity.

### 8.1 P1

**Q1. What field were you trained in?**
Transportation design.
**Q2. What is your work experience?**
Worked for 11 years as a professional car designer in car design studios.
**Q3. What software do you primarily use?**
Autodesk Alias.
**Q4. How long did it take to learn the software?**
Over one year, with one lecture per week.
**Q5. What articulated objects did you work on in the past?**
As part of a future mobility exploration project, a one-seater flying car concept was designed where the drive module and the cabin module could be separated, and a quadrotor module could be mounted on the top of the cabin module. When not in use, the quadrotor module could be folded up for storage.
**Q6. How long did the project take?**
Five people worked for a total of 12.5 weeks. Two weeks for 2D sketching, one week for design decision-making, one and a half weeks for fluid dynamics simulation, four weeks for surface modeling, and four weeks for video production.
**Q7. What were the challenges of the project?**
A lot of time and effort was spent on making sure parts that moved along trajectories did not pose a hazard. In particular, all moving parts had to work well together without any interference in all the different combinations that the parts could be assembled.
Moreover, tools used for surface modeling, such as Autodesk Alias, had almost nonexistent support for moving parts. However, special tools for animation, such as Autodesk 3ds Max or Autodesk Maya, could not be used because of cost and because NURBS surfaces would need to be downgraded to polygonal mesh, which made it difficult to return to the original tool for iteration.
**Q8. What did you like about our new tool?**
The exploded view made it easy to see the entire structure at a glance. Adjusting the pacing of the animation through a hand movement was intuitive.
**Q9. What did you dislike about our new tool?**
It was difficult to manipulate parts when they were too small. Due to repetition, the rigging took too long compared to the sketching, even though many parts were symmetrical.
**Q10. What value could our new tool bring to your work?**
The bigger the project and the more people involved, the more important it is to communicate accurately. Inaccurate communication will cause the project to fall apart. Therefore, even if it was labor intensive, ideas were 3D modeled and different poses were manually captured to be made into presentation slides. Such a process would have taken seven to eight hours for P1-A, four to five hours for P1-B, and seven to eight hours for P1-C.

On the other hand, the concept created with the new tool consists of key curves, expresses rough but important features regarding the form and movement, and would be enough for establishing a shared vision: "Let's make something that looks like this and moves like that." At this point, there is no need to think about the exact mechanisms or further refine the sketch because it is not a work of art itself, but a means of communication. More importantly, the earlier the direction can be set and shared, the more time would be saved in subsequent steps.
The new tool makes folding easier, so there is a higher chance that folding will be considered in the design at all. In other words, the scope of the designer's thinking would be broadened. In existing tools and processes, products that fold multiple times are very difficult to deal with. If the new tool could be used for the past project, a more cohesive folding design could be produced. The designers would have the ability to fine-tune the motion instead of barely getting the basic form and functional structure right. The new tool would be great for early exploration and quick visual prototyping.

### 8.2 P2

**Q1. What field were you trained in?**
Transportation design.
**Q2. What is your work experience?**
Worked for eight years as a professional car designer in car design studios.
**Q3. What software do you primarily use?**
Autodesk Alias.
**Q4. How long did it take to learn the software?**
Three months is enough to learn the basic skills, but to become fluent enough for professional work, one and a half to two years. Designers who have logical minds tend to learn more quickly.
**Q5. What articulated objects did you work on in the past?**
Three types of futuristic, autonomous vehicles commissioned by a heavy equipment manufacturer, including autonomous excavator, autonomous loader, and autonomous dump truck.
**Q6. How long did the project take?**
Three people worked on it for three months.
**Q7. What were the challenges of the project?**
Personally, it was the first time designing products that underwent a lot of transformation. The body of the autonomous excavator could rotate, and each caterpillar could swivel so that the height of the excavator could be adjusted, but these separate parts would often break the overall visual flow or would collide with one another. Since Autodesk Alias did not support movements, parts were manually copied and pasted into some predefined poses. Due to this limiting way of working, it was not possible to produce fully satisfactory results. Compromises had to be made regarding the range of motion for the sake of the appearance, so the autonomous excavator could not maneuver as freely as an ordinary excavator.
There were as many as three or four feedback cycles per day. When changes were necessary, two or three alternative models were sent for review. When in a hurry, sketches drawn on top of screen captures of models were sent. Overall, some 20 intermediate models were built. The form could be communicated relatively accurately this way. However, communications regarding movements ended

up being much more abstract because there was no practical way to visualize movements until later stages when the modeling had completed and the video production had begun. As a result, the form could not be iterated based on the movements it produced.

**Q8. What did you like about our new tool?**

Compared to Autodesk Alias, the new tool was much more intuitive and easy to understand. It was impressive that moving concepts could be produced with only a few multi-touch gestures, in addition to some perspective drawing. Manipulating by hand was enjoyable. It would be ideal for making short, rough, and punchy 3D clips. It was definitely a very memorable way of working.

**Q9. What did you dislike about our new tool?**

There were times when the screen was too crowded around the area of interest and operability was poor. In particular, there were times when it was difficult to touch two points. Even with symmetrical parts, rigging had to be done repetitively and took a long time. It would be better if mechanical components like gears and closed loops of linkages were introduced.

**Q10. What value could our new tool bring to your work?**

With Autodesk Alias, going back and forth between different poses causes too much hassle, so iteration is kept at a minimum. It is also a pain to export/import data across different software. Compromises are somewhat unavoidable. On the other hand, the new tool makes it easy to move different parts and check how the object will appear from certain angles. Static shapes can be managed one way or another, but the kind of quick animation that this new tool enables is otherwise impossible. The ability to add movement is essential for 3D sketching.

It allows designers to see ahead of time what can only be seen when the work has progressed considerably. A designer's greatest fear is having to go all the way back to the beginning and change the design because a problem is discovered much further down the road. Compared to existing workflows, this new tool could let designers check the viability of their designs approximately 1-2 weeks earlier compared to existing workflows.

### 8.3 P3

**Q1. What field were you trained in?**

Product design.

**Q2. What is your work experience?**

Worked for two years as an in-house artist at a creativity support software company.

**Q3. What software do you primarily use?**

Adobe Photoshop, Rhinoceros 3D, Blender.

**Q4. How long did it take to learn the software?**

It takes a month to learn basic functions of Adobe Photoshop, but a full college education is required to learn all the perspective and rendering techniques; Rhinoceros 3D takes about a semester to learn but years to become proficient; Blender takes less time than that.

**Q5. What articulated objects did you work on in the past?**

A sci-fi alien weapon was designed as part of a personal portfolio submitted to a world-renowned VFX studio.

**Q6. How long did the project take?**

Three months. One month in 2D drawing, and two months in 3D modeling.

**Q7. What were the challenges of the project?**

It was difficult to design something that, as a whole, maintains a consistent visual flow while also retaining functionality and realism to the extent even the internal parts can almost be manufactured. It was not easy to determine the range of motion of the moving parts, such as the sniper scope and bipods, while also predicting the shape before and after parts were attached, detached, or posed. In order to overcome this and as a part of an exploratory study, various shapes were made out of paper and moved around as if they were actually being used.

More than 100 side views were drawn with 2D sketches, but the 3D modeling took a long time because there were no drawings from other viewpoints. After doing some rough modeling, more sketches had to be drawn and incorporated into the model repeatedly. Copying multiple parts and manually positioning them along the expected trajectories to simulate movements in Rhinoceros 3D was labor intensive.

**Q8. What did you like about our new tool?**

The moving function is essential for 3D sketching. Visualizing the range of motion with a trail and the exploded view were pleasant and useful. It was easy to switch between different poses.

**Q9. What did you dislike about our new tool?**

Spatial curves are needed, in addition to planar curves. It was difficult to accurately set the range of motion with only hand movements, especially with curved sliders and ball joints. Once a joint is created, the designer should have the ability to fine-tune its position and orientation.

**Q10. What value could our new tool bring to your work?**

When developing characters or props, 2D production art is an essential medium by which ideas are communicated. The key is to put as much actionable information as possible in the picture. Some production arts lack multiple views, have many occlusions, are asymmetrical or vague, or do not make sense. They are prone to causing problems when translating to 3D models. If there are too many problems, the 2D production art itself might need to be redone, even if an art director previously approved it. Currently, there are not that many tools and processes that can help with this; the burden is on the designers to make things work. However, when it is too much work to consider all poses, designers tend to make compromises and fake it in some places.

This new tool will be able to resolve the frustration for designers during this process. Not only can they effectively convey 3D ideas without having to draw from multiple angles, they can also convey movement as well. Using this tool, designers could communicate more information in the same period of time, or communicate the same information in a shorter period of time. A recent project's productivity could have been doubled had this tool been available. A good tool helps designers push their limits.

### 8.4 P4

**Q1. What field were you trained in?**

Transportation design.

**Q2. What is your work experience?**

Worked for three years as an in-house artist at a creativity support software company.

**Q3. What software do you primarily use?**
Autodesk Alias, Blender.
**Q4. How long did it take to learn the software?**
Autodesk Alias takes about four months to learn the basics and two years to become fully accustomed while Blender takes about six months. Compared to Autodesk Alias, Blender is less concerned with strictness, so designers can work faster and more flexibly unless they need precise surfacing.
**Q5. What articulated objects did you work on in the past?**
A flying laboratory that terraformed exoplanets by dropping genetically modified plant seeds was designed and won an award in an online concept art contest. Two flying wing structures were layered on top of each other and were connected by several thin pillars. Flaps on the upper surface could be opened to reveal cargo spaces in the wings.
**Q6. How long did the project take?**
Two months, at a leisurely pace. One month for sketching and one month for modeling.
**Q7. What were the challenges of the project?**
Converting a 2D sketch into a 3D model was difficult because there were many parts that could not be expressed by the three views of an orthographic drawing. It was difficult to depict the part covered by the wings or the internal structures. This project required much time and effort so that the angles of the opened flaps and the angles of the pillars between the wings would match harmoniously. While it is important for these kinds of concepts to look nice standing still, when they move or transform, they should be designed to make the most impact.
**Q8. What did you like about our new tool?**
The rigging and posing process was more convenient and intuitive than existing software, so more complex joint structures could be tried in a surprisingly natural way. Movements could be expressed even before the forms had been completed.
**Q9. What did you dislike about our new tool?**
It was inconvenient not being able to copy 3D curves, some of which considerable time was invested in. It was also difficult to manipulate small parts, so separate manipulation handles that protruded to the outside had to be drawn. Something similar is often used by 3D modeling communities who create, share, or sell rigged 3D assets.
**Q10. What value could our new tool bring to your work?**
Even complex forms that are difficult to imagine in 2D can be boldly tried with 3D sketching. Compared to orthographic drawings, 3D sketches could substantially accelerate 3D modeling. Until now, it was the designer's job to fill in information gaps that occur when translating an idea from 2D to 3D. In the future, 3D sketches could replace 2D sketches, especially elaborate ones intended for more technical communication. Instead, more abstract 2D sketches could focus on experimenting with the overall look and feel.

This new tool is great for immediately checking movements that could only be visualized after 3D modeling and rigging had completed, even during the sketching phase. The act of moving parts around could be helpful in and of itself . For example, when creating a structure where several parts are connected in a chain, such as the spine, bending it and trying different poses can inspire new and more concrete design ideas. A more impactful design requires a more thoughtful consideration of what actually makes sense in reality. In addition, the faster the overall speed, the more attempts can be made. The ability to create moving sketches will be dearly missed at the workplace.

### 8.5 P5

**Q1. What field were you trained in?**
Product design.
**Q2. What is your work experience?**
Worked for seven years as a designer of toys based on robot animations.
**Q3. What software do you primarily use?**
Rhinoceros 3D, Blender.
**Q4. How long did it take to learn the software?**
After college education, it takes about three weeks to learn the basics and about six months to become proficient.
**Q5. What articulated objects did you work on in the past?**
Almost all previous projects had some articulated parts. Recently worked on a humanoid toy robot based on a famous Japanese robot animation.
**Q6. How long did the project take?**
About eight months. After completing the basic modeling in two months, the director of the original animation inspected it for six months.
**Q7. What were the challenges of the project?**
The most difficult part was envisioning the overall structure, e.g., when designing an airplane toy that transforms into a humanoid robot, two to three weeks may be spent just thinking about how to connect the appearances before and after the transformation. After the initial conceptualization, it is verified by modeling. The solution is found after hundreds of iterations, each of which involves modifying the segmentation or the joint positions and orientations, until no more interference occurs. Once the large lumps are figured out, the details are added.

Toy owners tend to be happiest when the transformation takes place over several intermediate steps, so this should be factored into the design. Even the molds, draft angles, and manufacturing tolerances are considered when dividing the entire form into parts. Extra care is necessary for parts that may break easily or paint jobs that may peel off easily. Finally, the price rises whenever the number of parts, colors, or the overall size increases.

The director who inspected the 3D model of the toy based on his original 2D animation could not handle 3D modeling software. Therefore, the 3D model was orthographically projected to 2D images and sent for review. The director marked some 2D curves over those images, which had to be remodeled back into 3D. In some cases, the 2D drawings from the front and side views would contradict one another, so a model based on one view was chosen over the other, otherwise compromises between the two had to be made. Each feedback cycle took one to two weeks. Sometimes more than 10 revisions were made before approval because the director was very picky.
**Q8. What did you like about our new tool?**
It was fun to use. It was great getting to the animations quickly and easily.

**Q9. What did you dislike about our new tool?**

Everything was visible at all times since the model was entirely made up of curves and there were no surfaces to block out the opposite side. As a result, it was visually crowded, which made it difficult to specify a curve. The new tool is not suitable for creating simple extruded volumes. It would be nice to be able to define a local coordinate system for each part by moving the grid. For designing toys, it should be able to check for interference.

**Q10. What value could our new tool bring to your work?**

The process of drawing a 2D sketch and then converting it to 3D will become easier. After using the tool to envision a structure made of large lumps, designers should be able to import the 3D curves into the surface modeling software and use them as references. Creating NURBS surfaces can be easier with these references. In a project with tight deadlines, communication would be much faster if there were movable 3D sketches to send and receive. In particular, it would be great if decision makers who cannot use existing 3D modeling software and are only accustomed to 2D drawing would send the feedback as a 3D sketch.

If it could be used on a portable device, such as an iPad, it would be great for casual sketching focused on idea generation. If the color or line thickness of the curves could be adjusted, a 3D sketch could be presented as an artistic rendition. The sense of bulk that can be felt when holding a toy in the hands is important for design, but currently 3D printing is required. Using AR or VR with 3D sketching would be helpful when quickly checking the sense of scale.