TPED Flat Ride Design Report and Documentation
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Conceptual Design

The goals of this project were to create a flat ride design with six arms that horizontally spin around the base, with ride vehicles attached that rotate with a “hamster wheel” motion on the arm’s axis. This project gives students in the UF Theme Park Engineering Design club (TPED) experience with creating a functional ride that could be theoretically built in a theme park.

The primary teams of the TPED Ride Design Team are the Controls Team, the Arms & Base Team, and the Ride Vehicle Team. The Controls Team is in charge of the electronic components and controls of the ride. The Arms & Base Team is responsible for the creation of the base and the arms that will attach to the base. These arms will also be attached to each vehicle to guide it throughout the ride. Finally, The Ride Vehicle Team’s purpose is to design the ride vehicle that riders will sit in throughout the duration of the ride. The ride vehicle team is expressly responsible for the motors that control rotation, associated ASTM safety standards, and accessibility of the ride vehicle.

To begin, the ride vehicle team completed a “design sprint.” The goal of this collaborative experience was to volunteer ideas for the ride vehicle and work together to decide what was the best final design. For the restraints, the ideas that were brought up were to include over the shoulder restraints, exclude lap restraints, do not have Comfort Collars restraints, and to design the restraints to include handles for riders to grip. The ideas that were brought up for the ride vehicle were to include a throttle that would spin the rider, a magnetic piece underneath the seat that would slow down the ride and stop the spinning at the end, weights that would help to swing the riders back into place after they spin, having a split experience where one rider would face one way while the other one would face the opposite way, and including a round shaped vehicle. General ride ideas included having interactive elements rather than making the ride extremely fast and allowing the feet of the riders to hang off of the vehicle.

For the restraints, it was decided that there would be over-the-shoulder restraints, similar to the vest restraint of the Jurassic World VelociCoaster in Universal Studios in Orlando, FL. In terms of the ride vehicle itself, it was determined that the best design would be a bottom heavy, round ride vehicle. There would be weights that would allow for the vehicle to swing back into place after it does its “hamster wheel” spin. Additionally, it was decided that the ride vehicle would be designed so that riders’ feet would hang off of the vehicle. Figures 1 and 2 show the concept sketches of the ride vehicle created after the design sprint.

Figure 1: *Ride Vehicle concept sketches*

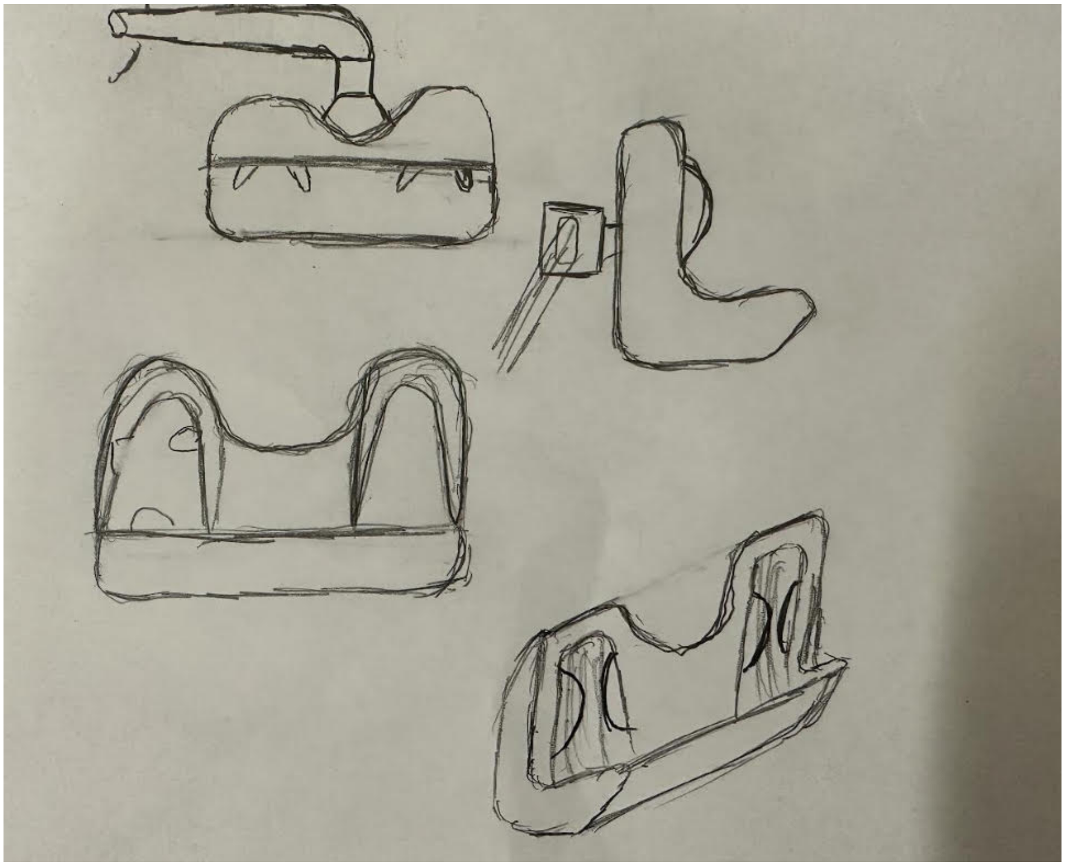
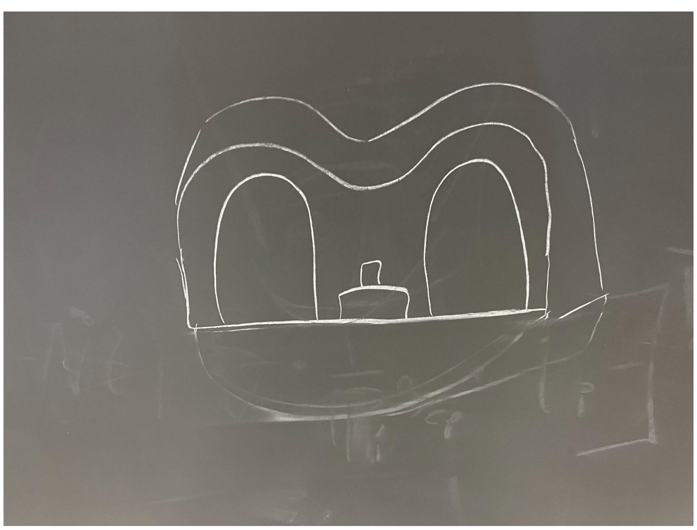


Figure 2: *Ride vehicle CAD concept sketch*



ASTM Standards Considerations

Arms and Base Hydraulic Motor

A hydraulic motor system is required to operate the arms and base. There are several standards that specify design and maintenance of hydraulics.

The maintenance of the hydraulic motors must comply with ISO Standard 4413:1998(E) [1], which details steps to avoid potential hazards related to hydraulic fluid power systems. Additionally, in compliance with ASTM Standard F2291-22a [2], the locations of indicators, fill points, drains, and any components or subassemblies that require regular maintenance should be provided to the purchaser.

The hydraulic fluid type should be in compliance with ISO Standard 4413:1998(E) [1]. The fluid should be shielded to prevent fire hazard. Additionally the fluid must be shielded from riders and observers if it is above 110 degrees Fahrenheit. No fluid can leak externally from the machine, as recommended by ASTM Standard F2291-22a [2]. Additionally, the temperature of the fluid must be measured and indicated [2].

The pressure at which the fluid is kept at is recommended by ISO Standard 4413:1998(E) [1]. The system is protected from overpressure because elements are required to operate at pressures below pump overpressure device settings, and if components are overpressured, they are regulated to an acceptable pressure.

The fluid reservoir is designed in accordance with ISO Standard 4413:1998(E) [1]. They should provide for conditioning of the fluid, provide time for air to release, and have filtration devices. Environmental and fluid temperatures and circuit holding volumes must be considered [1].

Ride Vehicle Restraints

The rider restraints of the ride vehicle were designed in accordance with section 6 of ASTM Standard F2291-22a [2]. The restraints system will be securely fastened to the ride vehicle body. Also, restraints will be designed so that there is a minimal possibility of hands and feet being trapped when the restraints are fastened and unfastened.

An analysis of the ride design revealed that the forward rotation motion of the vehicle calls for a passenger safety restraint, since passengers could fall from their seats. Due to the high intensity of the ride motion, it is best to use a Class 5 restraint [2]. This type of restraint has a locking system that only the operator can lock and unlock, with redundancy built in. The restraint will have both a primary and secondary restraint that lock and unlock independently of each other.

The design of the restraints will be over-shoulder restraints with lap bars similar to the *Banshee* roller coaster at King's Island in Mason, Ohio [3]. Each restraint will hold an individual person. The shoulder restraint and lap bar ensure that the rider moves minimally while the ride is in motion. The shoulder restraint is especially important because the ride may cause the rider to be upside down during some points in the ride. The centrifugal force of the forward rotation should keep a rider in their seat, but if the ride ever failed, the over the shoulder restraint would prevent the rider from falling. This hazard is also why the Class 5 restraint is necessary. The patron must not be able to unlock their restraint, and there must be multiple independent restraints to ensure their safety if one restraint fails.

Additionally, the restraint will be designed with a patron clearance envelope in mind [2]. This is an area of space that protects the rider from other objects they may encounter during the ride. An empty "envelope" of space ensures that the rider will not hit any protruding parts while on the ride.

Materials

<u>Arms and Base</u>

The base material will be a steel frame. There are many standards applicable to the use of steel. One standard that specifies the process of welding steel is AWS D1 .1/D1 .1 M:2020 [2]. Additionally, a standard that describes the stress that steel can withstand is AISC 316, while AISC M015 discusses the load that steel can handle [2].

The foundation material of the arms and base will be concrete. For concrete, standards ACI-301 and ACI-318 should be abided by. Another standard that the arms and base should be in compliance with is BS 4500-10 [2].

<u>Ride Vehicle</u>

The ride vehicle will also have a steel frame. This frame should also follow the standards for steel mentioned above for the arms and base steel frame.

Ride Dimensions

The ride structure takes up a 52 by 52 foot area, totaling 2704 square feet. The height of the structure is 20 feet.

The motion of the vehicle includes the ascending and descending movement of the arms and the rotation of the ride vehicle. The maximum vertical displacement from the movement of the arms, from the bottom positioning as 0, is 17 feet, or 204 inches. The average velocity of the vertical motion is 2.125 feet/second. The minimum time of the ride base rotation is 12 seconds. The minimum time it takes for the ride vehicle to flip is 2 seconds (high) and 4 seconds (low).

The materials and components of the ride are described below. The actuator type of the motion of the ride system is hydraulics, as used in Disneyland's *Dumbo* ride [4, 5]. The actuator material is steel, and the foundation material is concrete. The base material will be a steel frame, while the arm material will be a steel beam, bar, or round. The material of the shell of the ride vehicle will be a steel frame with a fiberglass shell and seat. The lights that will be wrapped around the structure and arms will be T5.5 Turbo Light Bulbs, which are popular at amusement parks and carnivals [6].

The maintenance schedule of the ride will be similar to Zamperla's *Mini Jet* Dumbo ride build [5, 7]. This schedule details when parts like the vehicle support, tie-rod pin, arm pin, tie-rod, arm, cylinder-arm pin, cylinder-center pin, rotating center, and base frame should be replaced, and what to check for with maintenance. Checking for cracks, corrosion, and weld strength ensures that the ride is safe and regularly maintained to be in working order.

The 3D printed model of the flat ride is scaled down to a 20th of the structure's actual size. In the actual flat ride, spinning of the ride vehicle won't be controlled, but in the model the ride vehicle will automatically spin the vehicle.

Arms and Base Process

Background Info

The steps our team took while designing the arms and base of the flat ride are (i) Design Sprint, (ii) CAD modeling, (iii) Scaling to real life. These steps were taken in this order to maximize the limited time our team has.

Design Sprint

To develop ideas for the arms and base design, a Design Sprint was conducted. The Design Sprint consisted of all Theme Park and Engineering Design Club (TPED) members drawing or describing 8 designs in 2 minute intervals. This process allowed each TPED member to contribute multiple ideas quickly.

After the initial idea activity, each TPED member cut down their 8 design ideas to 3. Each TPED member was given 3 flashcards to go more in-depth on 3 of their ideas. Afterwards, everyone voted on their favorite ideas.

The last step of the Design Sprint for base and arms base deciding upon a finalized concept. Once a concept for the base and arms was chosen, a draft sketch was created.

CAD Modeling of Base and Arms

After the design sprint, the arms and base team began working on creating the CAD for the miniature model of the flat ride. The model would be based on a 1:20 scale. Each team member worked together creating the CAD models, and documenting the results.

Figure 3: *CAD MODEL: ARM*

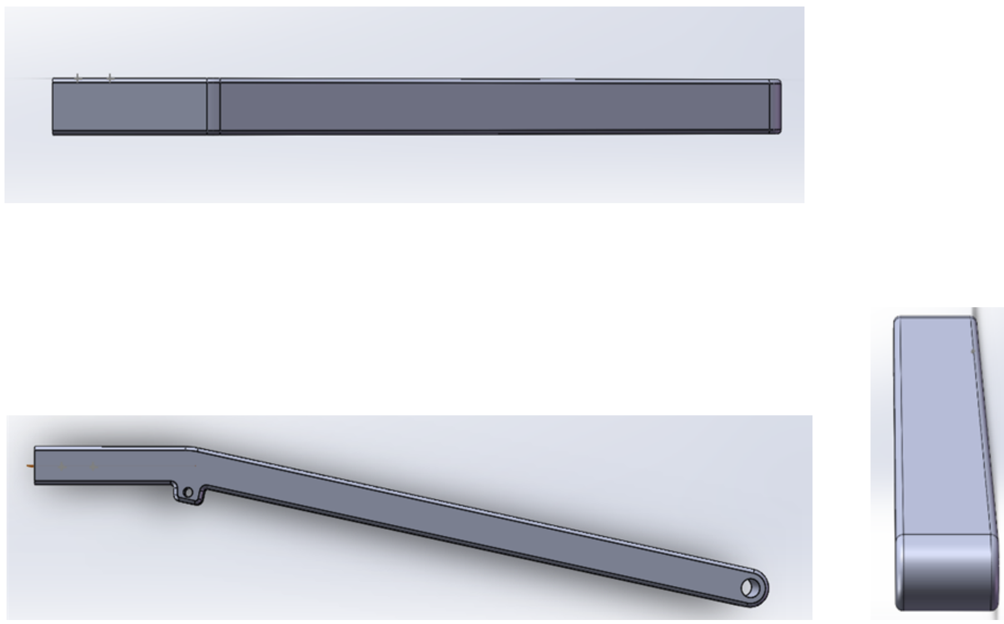


Figure 4: *CAD MODEL: BASE*

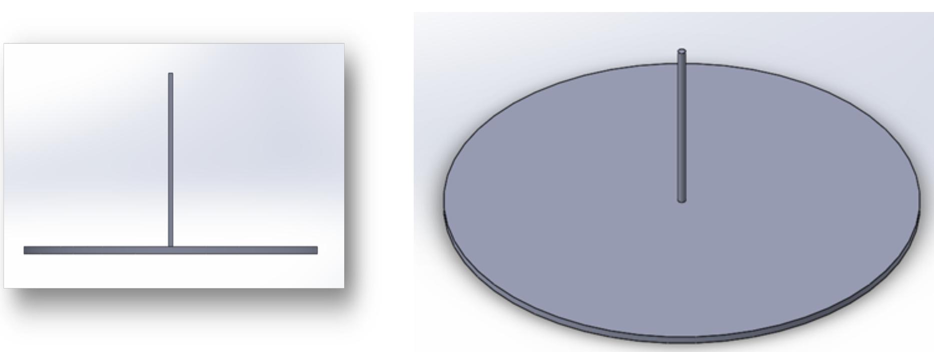
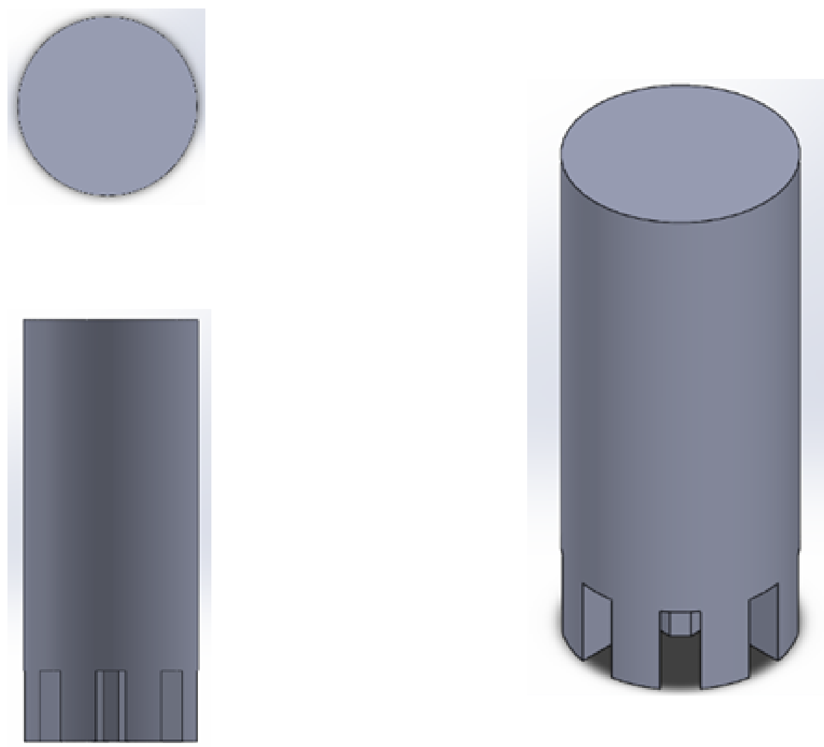


Figure 5: *CAD MODEL: ROTATING BASE*



Scaling of Base and Arms

<u>Scaling Basics</u>

Our scale for converting our miniature model is 1:20. The base material is a steel frame. The foundation material is concrete. The arms material is a steel beam, bar, or round. The lighting on the arms will consist of T5.5 Turbo Light Bars.

<u>Arm and Base Scaled Sizes</u>

The actual area for the ride is 52ft x 52ft (2704 ft^2). The arm length is 19ft (total), 15.5ft (Actuator to RV), and 3.5ft (Actuator to Counterweight). The Counterweight on an arm will have an equilibrium of 3100lbs. The height of the base is 20ft. The maximum displacement of the arms is 17ft.

Making the Miniature Model

<u>3D Printing the Parts</u>

The miniature model of the arms and base was created by designing 3D printed parts in CAD. The skeleton of the model was created through 3D printed parts. These 3d printed parts are designed to be able to attach and work alongside other parts.

<u>Main Motor</u>

For our model's main motor, we decided on using a servo motor [Fig 6]. The brand of the motor is the MG90S-4Pcs. The stall torque is 2.0kg/cm (4.8V). The operating speed is 0.11s/ 60 degrees (4.8V). The structural material of the motor is aluminum metal for the teeth, a coreless motor, and a double ball bearing.

Figure 6: *Servo Motor*

<u>Mini Motor</u>

For our model, we decided to use a small dc motor [Fig 7] to power our vehicle's arms. The brand of the dc motor is AUTOTOOLHOME. This motor can reach a speed of 35000 RPM. The voltage is 6 volts, 12 volts. The horsepower is 18000 watts. The material of this motor is metal, and it weighs 0.09 kilograms.

Figure 7: *DC motor*

Ride Vehicle Process

Background Info

The steps our team took while designing the ride vehicle of the flat ride are (i) Design Sprint, (ii) CAD modeling, (iii) Scaling to real life. These steps were taken in this order to maximize the limited time our team has.

Design Sprint

To develop ideas for the ride vehicle design, a Design Sprint was conducted. The Design Sprint consisted of all Theme Park and Engineering Design Club (TPED) members drawing or describing 8 designs in 2 minute intervals. This process allowed each TPED member to contribute multiple ideas quickly.

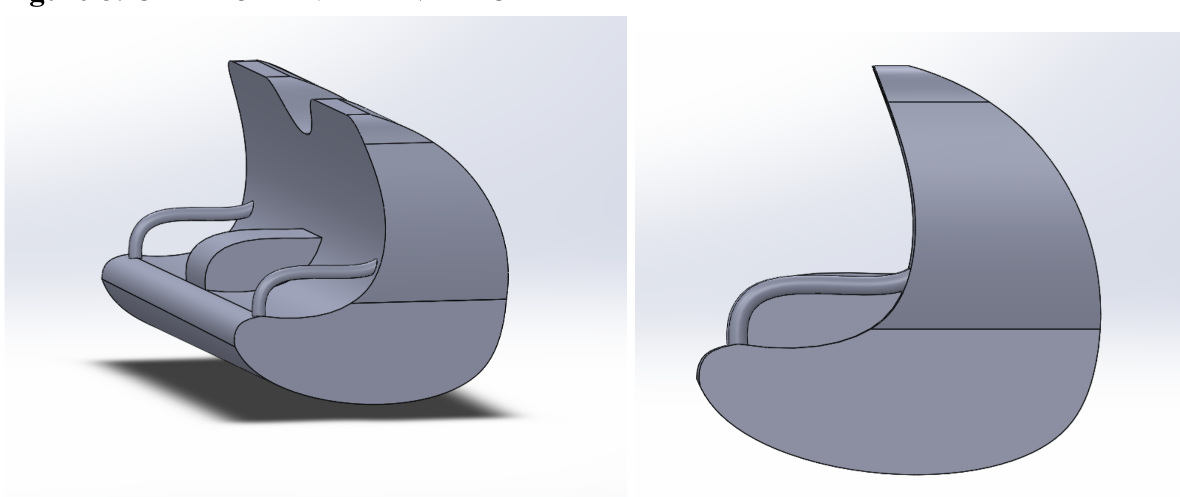
After the initial idea activity, each TPED member cut down their 8 design ideas to 3. Each TPED member was given 3 flashcards to go more in-depth on 3 of their ideas. Afterwards, everyone voted on their favorite ideas.

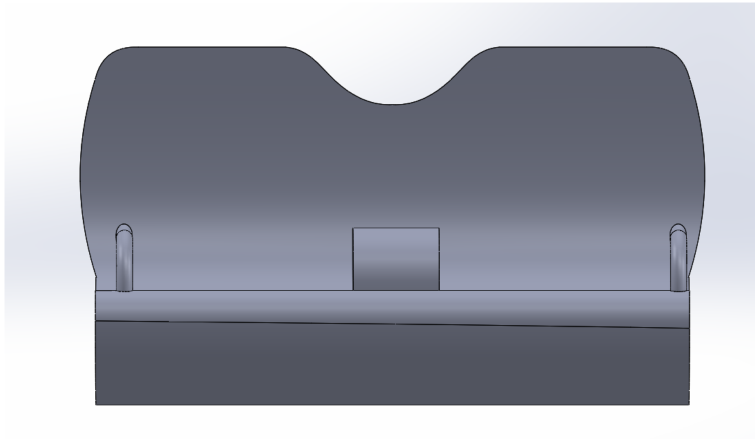
The last step of the Design Sprint for the ride vehicle was deciding upon a finalized concept. Once a concept for the ride vehicle was chosen, draft sketches were created, as shown in Figures 1 and 2.

CAD Modeling of Base and Arms

After the design sprint, the ride vehicle team began working on creating the CAD for the miniature model of the flat ride. The model is based on a 1:20 scale. Each team member worked together creating the CAD models, and documenting the results.

Figure 8: *CAD MODEL: RIDE VEHICLE*





Scaling of Ride Vehicle

<u>Scaling Basics</u>

Our scale for converting our miniature model is 1:20. The ride vehicle materials consist of a steel frame with a fiberglass material for the vehicle shell and seats. The lighting on the vehicle will consist of T5.5 Turbo Light Bars.

<u>Ride Vehicle Scaled Sizes</u>

The ride vehicle will be 7ft x 4ft, with a seating box of 2.6ft x 2.1 ft. The ride vehicle will weigh approximately 500-700lbs. The minimum time for the ride vehicle to rotate and flip is 2 seconds (high) and 4 seconds (low).

Making the Miniature Model

<u>3D Printing the Parts</u>

The miniature model of the ride vehicle was created by designing 3D printed parts in CAD. The skeleton of the model was created through 3D printed parts. These 3d printed parts are designed to be able to attach and work alongside other parts.

References

[1] *Hydraulic fluid power - General Rules relating to systems*, 4413:1998(E), ISO, Switzerland, 1998, [Online]. Available: https://www.iso.org/standard/21935.html

[2] *Standard Practice for Design of Amusement Rides and Devices,* F2291-22a, ASTM, Pennsylvania, 2022, [Online]. Available: https://compass.astm.org/document/?contentCode=ASTM%7CF2291-22A%7Cen-US

[3] King's Island Staff, "Banshee," VisitKingsIsland.com, https://www.visitkingsisland.com/rides-experiences/banshee (accessed Apr. 19, 2023).

[4] Arrow Development Staff, "Dumbo Under the Hood," ArrowDevelopment.blogspot.com, http://arrowdevelopment.blogspot.com/2014/07/dumbo-under-hood.html (accessed Apr. 19, 2023).

[5] Zamperla Staff, "Aero Top Jet," Zamperla.com, https://www.zamperla.com/products/aero-top-jet/ (accessed Apr. 19, 2023).

[6] National Supply Staff, "VSV 090 Series Cabochon," NationalSupplyOnline.com, https://www.nationalsupplyonline.com/VSV_Cabochon.html (accessed Apr. 19, 2023).

[7] Zamperla Staff, "Service Bulletin No. 2019 MJ01," RidesDatabase.org, https://ridesdatabase.org/wp-content/uploads/2020/01/zamperla-2019-mj01-1804.pdf (accessed Apr. 19, 2023).