User and Product Manual Instructions

GNG2101

Design Project User and Product Manual

FAST Rails

Submitted by:

FAST Rails (Group F1.3)

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Table 1. Acronyms

Acronym	Definition
OMS	Ontario Medical Supply
PLA	Polylactic acid
FEA	Finite element analysis

1 Introduction

The significance of sleep for both physical and mental well-being is widely acknowledged, constituting a cornerstone of human survival. It is imperative that individuals attain adequate sleep to maintain optimal health. However, numerous obstacles may hinder this, including insufficient support for individuals with disabilities.

Within Ontario Medical Supplies (OMS), the dedicated team behind FAST (Fully Accessible System for Travel) Rails is committed to the development of secure, lightweight bed rail tailored for travel purposes while ensuring safety and comfort. Compliant with governmental regulations concerning medical assistive apparatus, the FAST Rail initiative has successfully positioned its travel bed rails as indispensable medical aid accessible to individuals across diverse socioeconomic backgrounds. While this product has yet to be approved as a medical device, it is assumed that the travel rails would be approved as a medical supportive device. Furthermore, it is assumed that the rails will be primarily used by medical caretakers tasked with helping their patients. Although they are also intended for anyone who may require bed rails for permanent or temporary circumstances.

This document is intended to support potential users as well as inform future innovators on the design process applied during the development of the travel bed rails. Topics that will be covered include an overview problem, the design considerations, how to use the rails and then finally troubleshooting as well as product support.

2 Overview

Figure 1: Final prototype

The main user of this product is a 7-year-old girl with a type of cerebral palsy who has low muscle tone and control. It affects her mobility as it hinders their ability to sit unassisted, crawl or make controlled neck movement. However, this does not limit her body movements in bed, and thus she can roll over to the sides of the bed while asleep. Therefore, the main dangers are her rolling over into a suffocating position (with her mouth and face compressed to the safety rail) and her flailing her limbs onto the bed rail.

For a child with cerebral palsy, fall protection during sleep is critical to prevent accidents and ensure restful sleep. Traveling adds another layer of complexity, as standard bed rails may not be portable or breathable enough, limiting options for safe sleeping arrangements. This means there is a significant gap in the market for compact travel bed rails suited for their needs.

The fundamental needs of the user are:

- **Safety**: The primary concern is preventing falls during sleep, ensuring the child's physical well-being.
- **Breathability**: Due to the child's condition, proper airflow is crucial to prevent discomfort or complications during sleep.
- **Portability**: The bed rails must be lightweight and compact, facilitating easy transportation during travel.
- **Cleanability**: Easy cleaning and maintenance are essential for hygiene and to prevent the buildup of bacteria or allergens, ensuring a healthy sleeping environment for the child.
- **Affordability**: The bed rail should be accessible and affordable for families, ensuring that financial constraints do not limit access to essential safety equipment for their child.

2.1 Conventions

Since the rods used in the bed rails are measured in imperial units, numbers mentioned in this document are in inches unless otherwise specified.

2.2 Cautions & Warnings

For potential users, this project poses no direct threats. However, for those seeking to build upon the work established by the FAST Rails team, it is strongly recommended to possess either proficiency in machining or enlist the guidance of a seasoned mentor well-versed in machining practices. The prototyping phase entailed the utilization of several potentially hazardous machining tools, including a drill press and a table saw. Thus, proper protective equipment and training is

required for further developments. Although this risk can be mitigated by outsourcing the prototype manufacturing.

3 Getting started

The system comes in a custom travel bag, which should be used for storage every time the system is disassembled. The system can be put together in under 5 minutes and can just as easily be stored in the same amount of time. The pipes and fittings are labeled from 1-22 as seen in Figure 2, with arrows to indicate the proper orientation.

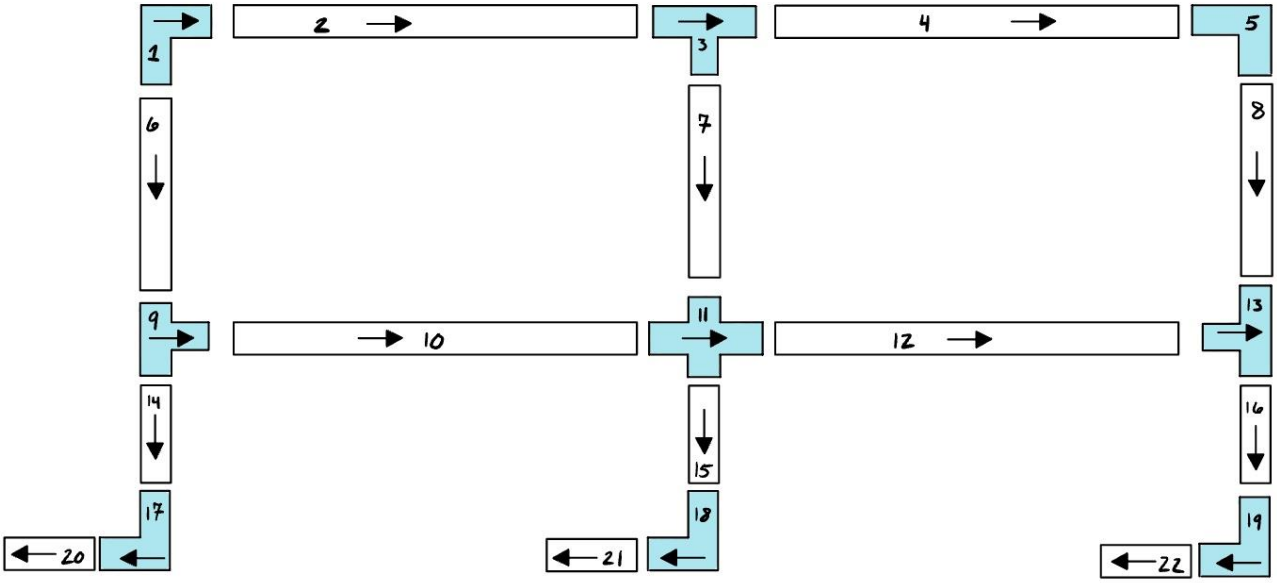

Figure 2: Labeling of prototype

The locations of the pins are easily identifiable through the holes found on the pipes and fittings.

3.1 Configuration Considerations

Due to the client's specification, there were many factors to consider when starting this project. For instance, the size of the mattress, the thickness of the mattress along with whether the bed has a headboard or box string. Understanding the geometry of the bed is the basis of this design. If the travel bed rails are unable to span the length of the bed, the client's child would still be in danger of falling during the night. Similarly, if the rails are not high enough, she could simply roll over the bed rails, thus defeating the purpose of rails.

3.2 User Access Considerations

The main users of the travel rail are those requiring fall protection while sleeping at night. The FAST rail system provides a portable solution to users while traveling. Other users of interest include parents with small children looking for ease of mind at night. The main restriction placed on accessibility is the user needs to have a caretaker install the bed rail as it isn't an accessibility friendly installation.

3.3 Accessing/setting up the System

1. Arrange the pipes and fittings using the arrangement shown in Figure 2, ensuring that the arrows match the directions indicated in the drawing. Ensure that the holes for the pins line up on both the rails and the fittings. Once the arrangement is complete, the foam coverings can be added, as seen in Figure 3.

Figure 3: Assembly of the pipes and fittings

2. Next, the pins should be installed, ensuring that the cotter pin is secured to prevent it from falling out. There are 11 pins; the user should confirm that all 11 pins are installed before moving onto the next step.
3. Slide the assembled rails under the mattress. Ensure that the rails are secure, and pushed in as far as possible, like shown in Figure 4.

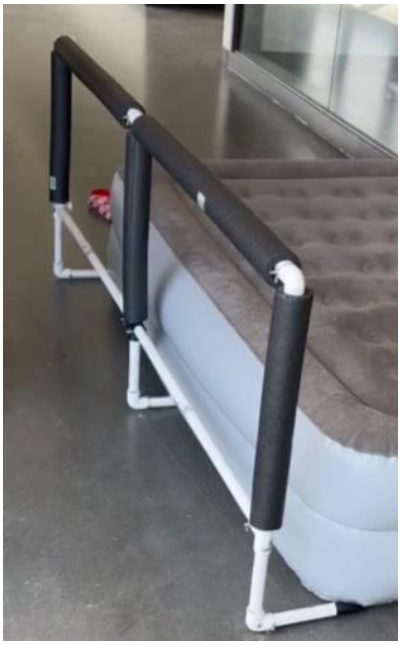

Figure 4: Travel rail installed under mattress

4. Next, place the mesh over the rail, as seen in Figure 5. The mesh is meant to stretch – this ensures that tension will be maintained during use to form a more rigid barrier for the user. Once the mesh is properly placed, zip up both zippers located on the bottom side. Ensure that the hole in the mesh is aligned with the opening on the pipe fitting on the top right corner.

Figure 5: Mesh covering assembled

5. The final product will have 2 travel rails, connected by 1 adjustable middle rod. However, due to budget limitations, only 1 rail was built. If the user is assembling the final product, steps 1-5 should be repeated with the second rail.
6. The final step is the place the rod in the rails. The rod can be adjusted based on bed width, using the screw mechanism. The holes are spaced 5 inches apart to ensure maximum adjustability.

Figure 6: Adjustment mechanism

7. Once the rod is adjusted to the appropriate width, it can be secured in the corresponding fittings (#5 and #13 as seen in Figure 2) on each side of the travel rails.

Only 1 adjustment mechanism was purchased due to budget limitations, however the final prototype would have 2.

3.4 System Organization & Navigation

As seen above, the system is comprised of two main features, the rail parts, and the mesh. All rails are connected to one another using pipe fittings and secured with clevis pins. The mesh is added by simply sliding the fabric over the assembled rails and zipping the bottom to secure the mesh.

3.5 Exiting the System

Once the system is no longer required, it can be easily disassembled by removing the middle rod and the mesh. Next, the pins can be removed, and finally the rails be separated. Once the disassembly is complete, everything can easily be stored in the provided travel bag.

4 Using the System

When using the system, no additional steps are required by the user. The rails are made to be static and not give to movements or forces below 30bf. However, a load bearing capacity test will be effectuated to confirm this speculation. Therefore, when using the system, it is important to be within the acceptable weight range as the rails could be unsafe.

5 Troubleshooting & Support

Possible error conditions include incorrectly installing the rails. To troubleshoot, please refer to the labelling diagram to find the missing part or the incorrectly installed one. If a piece is lost,

please contact Support to replace the part. Furthermore, if a piece is broken, the same approach should be taken.

5.1 Error Messages or Behaviors

Behavior indicating failure would be parts misaligning, missing, or broken. Causes could be due to applying too much force on rails during installation or incorrectly following installation instructions. Please follow troubleshooting recommendation or contact Support.

5.2 Maintenance

Maintenance of the rails is relatively low. It simply requires storing the rails in the provided bag, in a cool, dry location. If the mesh gets dirty, remove it and wash it on cold, low spin settings.

5.3 Support

FAST Rails Call Support Team is available 8am-4pm from Monday to Friday with reduced hours on Saturday ranging from 11am to 2pm. During off-hours, support can still be provided by sending an email to the Help Desk Support email, response may take up to 3 business days.

Contact Support Information	
Help Desk Support	Email: support@fastrails.com Phone Number: 1-800-432-2222
Help Chat	Fastrails.com

6 Product Documentation

6.1 Subsystem 1 of prototype: Bed Rails

6.1.1 BOM (Bill of Materials)

Item #	Item Name	Item Description	Price per unit($)	Quantity	Price(Total)	Link
1	Pvc Tubing	PVC tubing (10ft)	18.98	1	18.98	Link

6.1.2 Equipment list

- Drill press
- Hand saw
- Vernier calipers
- Tape measure

6.1.3 Instructions

To build the bed rails, a drill, drill press, vernier caliper and tape measure were used. First, the desired length of the pipe was measured and marked. Next, a hand saw was used to cut the material. Following this, the vernier caliper was used to measure a 1'' distance from the edge of the tube, on each end. A drill press was then used to drill a hole through the material. This process was repeated until all the pipes were prepared. Please refer to Table 2 for the respective tube lengths required. Note that some adjustments to the length may be required depending on the pipe fitting

tolerances. Although PVC was used for this subsystem, the final goal was to use a more robust material such as aluminum or carbon fibre to provide more strength.

Table 2: Pipe lengths (See Figure 2 for pipe numbers)

Pipe number	Length (in)
1, 2, 10, 12	35
6, 7, 8	18
14, 15, 16	7
20, 21, 22	6

6.2 Subsystem 2 of prototype: mesh

6.2.1 BOM (Bill of Materials)

Item #	Item Name	Item Description	Price per unit($)	Quantity	Price (Total)	Link
1	Mesh	Mesh cover for rails (sold by yard)	7$/m	2.5	17.50	Link
2	Zipper	2 30'' zippers	13.99	1	13.99	Link

6.2.2 Equipment list

- Sewing machine
- Measuring tape
- Sewing thread

6.2.3 Instructions

To build the mesh, the fabric was folded over the rails and measured. Scrap fabric was glued to the edges of the fabric to allow for better grip of the thread to the fabric. Both edges of the fabric were sewn wrong sides facing out to create a bag. Next, the bag was folded so the seams were inward, and both zippers were sewn onto the open ends of the bag, ensuring that there was room in the middle to allow for the middle PVC rail. Due to a lack of time, there are no pictures of the process used to create the mesh. Furthermore, no set measurements were used to create this subsystem – everything was measured by eye. Should this subsystem need to be built again, please contact Annabelle Many (amany062@uottawa.ca) for further guidance.

6.3 Subsystem 3 of prototype: 3D printed fittings

6.3.1 BOM (Bill of Materials)

Item #	Item Name	Item Description	Price per unit($)	Quantity	Price(Total)	Link
1	PLA	PLA filament	0	N/A	0	

6.3.2 Equipment list

- 3D printer
- Drill press
- PVC cement

6.3.3 Instructions

The 3D printed fittings were made using the 3D printers in the MakerSpace. For the final product, these would be made of a more resistant material such as a 3D printing material reinforced with carbon fibre. The relevant files can be found in the MakerRepo page for this project. The parts were printed with 60% infill, using supports. Once the supports were removed, the fittings were placed onto their respective PVC pipe, and a drill press was used to create a hole through both the 3D printed part and the pipe to ensure proper alignment. The holes were drilled between parts 1 and 2, 2 and 3, 3 and 4, 4 and 5, 9 and 10, 10 and 11, 11 and 12, 12 and 13, 17 and 20, 18 and 21, and finally, 19 and 22. The remaining parts were permanently joined using PVC glue following the instructions shown on the glue container. Refer to Table 3 for the number of each kind of 3D printed fittings required for the prototype.

Table 3: 3D printed pipe parts

Fitting type	Number (see Figure 2)	Quantity required
4-way fitting	11	1
XYZ fitting	5	1

Modified T fitting	13	1
Wedge	Inserted in pipes 20, 21 and 22	3

6.4 Subsystem 4 of prototype: adjustment mechanism

6.4.1 BOM (Bill of Materials)

Item #	Item Name	Item Description	Price per unit($)	Quantity	Price(Total)	Link
1	Curtain rod	Curtain rod	35.98	1	35.98	Link

6.4.2 Equipment list

- Drill press

6.4.3 Instructions

To build the adjustment rod, the ends were removed by sliding them off, to reveal the curtain rod tube with a 1-inch nominal diameter. One end collar and screw were kept, to be used for the adjustments (see Figure 7). Next, using the drill press, holes were drilled in 5-inch increments along the inner tube. The drill bit used was one with a nominal diameter slightly larger than the curtain rod screw. This was determined by inspection. Next, a hole was drilled in the outer tube, near the edge. To adjust the width, the screw and collar are kept in the outer tube's hole, and the inner tube slides inside the outer one to shorten/extend it. Once the appropriate width is attained, the screw is

screwed into the corresponding inner tube's hole to lock it in place (refer to Figure 6 for hole locations).

Figure 7: End collar and screw

6.5 Testing & Validation

The FAST Rails Team established 3 different prototypes prior to the final prototype, these initial prototypes were used to validate the final design. Each prototype designed to test for a specific result. The first prototype (see Figure 8: 3D Model of Prototype 2) was an analytical prototype which involved modeling a rail using the CAD software SolidWorks. This prototype was used to visualize the initial concept. It also provided the opportunity to reflect on the design and ensure that it included all the necessary components and requirements.

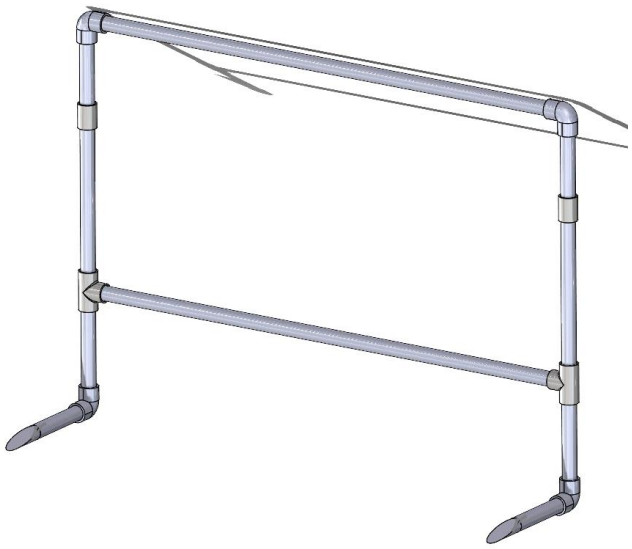

Figure 8: 3D Model of Prototype 2

The next prototype was physical and comprehensive small-scale 3D-printed of one of rail. The model was a proof of concept 20% scale model of the final design and was made from polylactic acid (PLA). This prototype was used to test the real-life usability of the rails.

Figure 9: 3D Printed Prototype

The next prototype was low fidelity and was used to test whether the rails met the target specifications surrounding weight bearing. This prototype included performing finite element analysis (FEA) and performing deflection calculations. FEA uses simulations and advance computations to model stress and strains on an object of interest, whereas the deflection calculation was used to understand how a part will bend or buckling when a static load is applied.

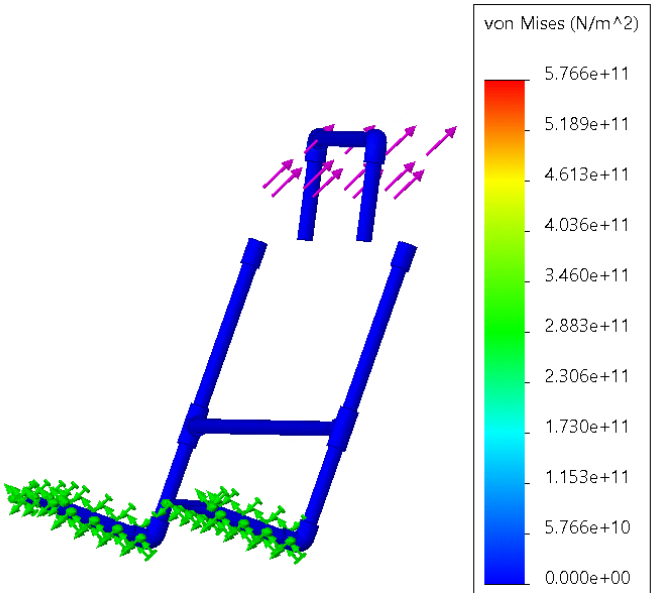

Figure 10: FEA Model with a 40 lbs Statically and Evenly Distributed Load Applied to the Top of the Rails.

Although the FEA was inconclusive (see **Figure 10**), the weight calculation showed that the middle rail would support enough weight. If this product is to be further developed, it is recommended that a proper FEA analysis be conducted using the appropriate material before the product is tested for weight bearing with a user.

With each prototype, all the tests validated the final design concepts but there were several areas of growth and iteration done throughout the validation process. The FAST Rails teams learned from these processes and used them to improve the design and strived to adapt to results from each of the tests.

7 Conclusions and Recommendations for Future Work

In conclusion, this project has taught the design team at FAST Rails the importance of thinking outside the box. Going back to the conceptual design and knowing when to improve on the design was another key feature learned. The most productive avenue for future work is to rework the extendable rail design and come up with better ways to be a portable, compact design while accommodating as many bed types as possible. Another avenue is to work on manufacturing aluminium rails to improve sturdiness.

If there had been more time, the team would have implemented the ideas discussed previously in future work avenues. Numerous ideas were abandoned mostly due to lack of time and budget. One of the main future recommendations is the use of a more rigid material for the bed rails, including pipes made of aluminum or carbon fibre. These materials will require more advanced manufacturing techniques, as well as custom pipe fittings.

APPENDICES

8 APPENDIX I: Design Files

Table 4. Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
MakerRepo page	https://makerepo.com/katrinelabonte/1997.fast-rails	April 2024