Operator’s Manual

Bed Railing Device (BRD)

Team #4
Randy Corriveau
Eric Nastuk
Ian Wallis

Client Contact: Sean Stenglein, Brenda Stenglein
Phone: 860-429-1059
34 East Howey Road
Ashford, CT
brenda.stenglein@gmail.com
Important Safety Instructions

General Warnings

- Do not operate BRD if anything is impeding the path of the rail’s movement.
- Activating the toggle switch from “up” to “down” without stopping at the center position will destroy the motor.
- Do not operate if anything is lodged in a hinge joint or motor connection area.
- Should only be operated by an adult or a properly trained individual.
- Secure all bedding articles before operating the BRD.
- Do not operate if any wiring is visibly loose or dislodged from its connection point.
- Failure to maintain a minimum operating distance of three feet may result in serious injury.
- The BRD is designed to be operated indoors and should never been operated outside.
- The electrical components should never be handled in a way they were not intended for.
- Do not attempt to service the device when the power supply is plugged into the wall outlet.
- Do not attempt to rewire the BRD while the power supply is connected in order to prevent electric shock.
- Do not attempt to solder any wiring of the BRD while the power supply is connected.
- While operating the BRD constant monitoring of the entire system should be done in order to stop failure as soon as they occur.
- Do not allow the motor to continue to rotate in event the push button fails to kill the power to the motor.
- Activating the toggle switch before the BRD has deployed or retracted to the full position will prevent the it from making a full movement.
- Engage emergency power switch in the event of motor failure.
- Engage emergency power switch in the event of electrical spark, fire, or explosion.
- The rail should not be used in the presence of a “clicking” noise when the rail is activated.
- Do not operate in the presence of any liquids.
- Maintain careful watch of all working parts while the BRD is in motion.
- Check all the hinges and connections pieces every time before operation the BRD.
- Check the motor housing unit before operating the BRD.
Parts and Accessories: quantity expressed in ().

**BRD frame**

**BRD horizontal rail (2)**
BRD vertical rail (4)

BRD eight hole inside corner bracket (4)
BRD bolt assembly for corner brackets (32)

BRD Frame 5 hole T joining plate (6)
BRD bolt assembly for joining plate (30)

Flanged Button Head Socket Cap Screw (FBHSCS)

80/20 1020 end caps (3)
BRD Hinges (5)

Hinge bolt assembly (20)

Style #1

Flanged Button Head Socket Cap Screw (FBHSCS)
**BRD Support System**

**Horizontal support piece (1)**

**Vertical support piece (3)**
Six hole inside bracket (3)

bolt assembly for BRD support corner brackets (36)
80/20 1020 end caps (5)

Support system anchoring pieces (3)
Support system connecting pieces to anchoring pieces (3): 18 bolt assemblies

80/20 1010 end caps (3)
**BRD Motor Mount**

DC gear motor (1)

**BRD Electronics**

BRD Emergency power toggle switch to shut off power (1)
BRD rail direction Toggle switch (1)

BRD push buttons (2)
Features

- BRD frame
- BRD support frame
- Protective foam
- Vinyl covering
- Netting
- Motor direction toggle switches
- Push buttons
- AC to DC converter power supply
- Emergency power toggle switch
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1. Introduction

1.1 General Overview

The BRD consists of three main components: the rail, the support system and the motor mount/ electronics. We will start with the frame of the BRD and go over the key components. The horizontal and vertical supports of the railing frame skeleton will be made from part number 1020 from the erector set company 80/20 Inc. Part number 1020 is a one inch by two inch T-slotted profile made out of clear anodized 6105-T5 Aluminum. This allows for easy assembly and ensures a sturdy rail design for Sean’s BRD.

The railing consists of six structural components: two horizontal supports that will run the length of the frame and four vertical supports that will support the frame and give it its structure. Horizontal supports will be 60 inches in length and two inches in width. Hinges will be attached to the bottom horizontal railing support and connected to the rail support system to ensure 180 degree folding when the frame is raised and lowered. Hinges will also be purchased from 80/20 Inc as part 2086 to ensure proper compatibility with the 1020 horizontal supports and T-slotted extrusions. When assembly all 80/20 plates, one can use an 1/8” allen wrench to screw the bolt assemblies into the plates, hinges and brackets.

A bolt kit is needed for every hinge, and each kit consists of 4 assemblies of 80/20 part number 3386. The assemblies consists of a Flanged Button Head Socket Cap Screw (FBHSCS) and a slide-in economy T nut. The FBHSCS has a black zinc finish, is 3/8” in length and has a thread count of 1/4-20 (one quarter inch in length with 20 threads). The slide-in economy T nut is part number 3785 in the 80/20 catalog and was used in the bolt assemblies for the inside corner bracket and the five hole joining plate.

Figure 1. The slide-in economy T nut and the FBHSCS used for the bolt assemblies.
Four vertical supports will be placed in between the two horizontal rails to properly support the frame. Two supports will be on the end of the horizontal pieces and two will be evenly spaced out within the frame. All supports will be 11 inches long and have the profile of the 1020 aluminum. In order to connect the two end vertical supports with the horizontal supports the team will use part 4114 from 80/20 to ensure that the frame does not experience torsion and is structurally sound. Part number is 4114 is a eight hole corner inside corner bracket that allows bolt kits to firmly place the bracket in the T-slots of the 1020 profiled supports. Approximately four inside corner brackets will be used to support the BRD.
In order to mount the inside corners to the frame the team will use 32 bolt assemblies, with eight assemblies for each frame. The bolt assemblies from 80/20 Inc are denoted by part number 3393 and consists of a Button Head Socket Cap Screw (BHSCS) and a slide-in economy T nut. The BHSCS has a black zinc finish, is $\frac{1}{2}$” in length and has a thread count of $\frac{1}{4}$-20 (one quarter inch in length with 20 threads). The slide-in economy T nut is part number 3785 in the 80/20 catalog, has a centered $\frac{1}{4}$-20 thread count and also has a black zinc finish. The synchronized thread count ensures the bolt assemblies will work and be successful in mounting the inside corner brackets to the frame.

The two inside vertical supports will be connected to the horizontal supports by a 5 hole tee joining plate on both sides of the horizontal rail. The part number for the 5 hole tee joining plate is 4140 in the 80/20 catalog. Joining plates width and height are three inches (denoted by A in the drawing) and the ends that go over the one inch horizontal profile view of the 1020 supports are one inch in width (denoted by B in the drawing). Six joining plates will be used in the assembly of the BRD.
In order to mount the joining plates to connect the supports the team will use 30 bolt assemblies, with five assemblies for each plate and eight plates on the frame. The bolt assemblies from 80/20 Inc are denoted by part number 3321 and consists of a Flanged Button Head Socket Cap Screw (FBHSCS) and a slide-in economy T nut. The FBHSCS has a black zinc finish, is one half inch in length and has a thread count of ¼-20 (one quarter inch in length with 20 threads). The slide-in economy T nut is part number 3785 in the 80/20 catalog and was used in the bolt assemblies for the inside corner bracket.

In order to protect the ends of the BRD frame the team will use part number 2025 from 80/20 Inc. Part number 2025 is a one inch by two inch end cap that is one-eighth of an inch thick and can fit the extruded profile of the 1020 frame. The bed rail has six of these end caps to ensure that the frame’s rough edges are not exposed, thus preventing Sean from any potential harm. All end caps come with the necessary fasteners to ensure a clean fit with the 1020 profile.
The railing support system will also be made of clear anodized 6105-T5 Aluminum and the upper support uses the same 1020 extruded profile as the BRD frame. The horizontal support piece will be the same length as the BRD frame (60 inches) and will have the same 2025 end caps. Hinges will also be mounted to the horizontal support piece and allow for 180 degrees of folding motion. All hinge bolt assemblies that were used in the frame is used in the BRD railing support system.

Figure 7. Total assembly of the BRD support system.

The three vertical supports have the dimensions of the 1020 extruded aluminum and all are approximately six and one quarter inches tall. All vertical supports are connected to the horizontal support by an 6 Hole Inside Corner Bracket, 80/20 part number 4175. Bolt assembly part number 3393 will be used as the plate fastener and 6 bolt assemblies are used for every plate. The design of the BRD support system will use 3 Inside Corner Brackets to keep the pieces together.
The lower portion of the vertical support will be fit against the bed railing of the bed frame and on top of a piece of plywood that runs across the trusses of Sean’s bed. The vertical support is connected to a 46 inch base mounting piece that is made out of the 1010 extruded profile. The ends of the 1010 base mounting piece is covered with an 80/20 end cap, part number 2015. A 3 Hole Inside Corner Bracket, 80/20 part number 4176 is used to keep the 3 base mounting pieces firmly secured to the plywood base. A Bolt assembly, Part number 3393 in the 80/20 catalog, is used to secure the brackets for the BRD support system.
The vertical support is connected to the base mounting piece by a 6 Hole Center Inside Corner Bracket, part number 4111 in the 80/20 catalog. Six bolt assemblies, part number 3393, are used for every mounting corner piece, with three corner pieces needed to connect all the mounting pieces to the vertical rails. The center inside corner bracket ensures that the BRD will have a sturdy base for optimal performance.
1.2 Operation Steps

1.2.1 Installation

The BRD comes already built, so there is no assembly required for this device. In order to install the BRD, the bed where the BRD will be inserted should have its mattress removed. At this time the BRD’s support pieces can be placed on the mattress less bed. Then a wooden panel is placed on top of the support pieces in order to secure the BRD firmly to the bed. Any wood panel can be used as long as it height is not greater than one inch and its length is able to cover the distance between the first and last support pieces. Now the mattress can be placed on top of the wooden panel, and the BRD is ready for operation.

1.2.2 Preparation

Once the BRD has been installed the the bed properly the following steps and diagrams can be followed to safely operate the device. In order to operate the BRD the first step is to ensure that the wires coming from the power supply running to the motor are secured, with no loose visible wires, before plugging the power cable into the wall outlet. Also ensure that the user toggle switch is in the center position, it should not be directed towards either the “down” direction or the “up” direction before plugging the power cable into the wall.
1.2.3 Applying power

The next step is to plug the power cable into the wall outlet, which can be seen below. After that the system has power and is nearly ready to be used.

1.2.4 Controlling the BRD

The next steps are related to preparing Sean to enter his bed. When Sean is ready to transfer from the center of the room to his bed ensure there is a minimum three foot distance between the top of the rail and any individuals standing in the path of the deploying rail. This will ensure the rail does not cause any injury when it is deployed.
The BRD is now ready to prepare Sean for entering bed. The next step is to throw the toggle switch from the center position to the side indicating “down.” It should be noted that during this step all bed sheets, blankets, pillows, or any other objects should be kept away from the motor-to-frame connection, as well as the hinge joints, areas prior to activating the switch.
Figure 13. A clear motor-frame integration area

Once the frame deploying area and the motor-frame connection areas are clear, the switch indicating “down” is thrown, and the BRD will retract into the downward position. At this time Sean can be situated and moved into this bed. When transferring Sean into this bed the deployed rail may cause injury if Sean accidentally knocks into the BRD motor mount, so it is important to guide Sean as best as possible in getting into bed from the intended direction. The intended entrance side is the end of the BRD furthest away from the motor.

Figure 14. Entrance side of BRD

After Sean is safely in bed the operator should again clear the minimum three foot distance from the now retracting path of the BRD’s frame. Again at this time the motor connection area, as well as the hinge areas should be cleared of any objects. The next step is to move the toggle switch from the “down” position into the center position.
At this time it is important for the user to follow the following steps, once the switch has been moved from “down” to the center position. Check to see if Sean is ready for the rail to be deployed; thus securing him in his bed, then disable the power controlling push button by removing the track above the push button, which will release the pressure applied to the button by the rail.

The user switch should now center position into the “up” position; while maintaining a safe operating distance and ensuring there is nothing obstructing the path or connecting joint areas of the BRD.
Once this is done the rail will retract upwards until it comes into contact with the upper push button. The upper push button should be disengaged once the BRD is in the full upright position. Sean will now be secured in bed until it is desired to assist him out of bed. The steps above should then be followed in order to get Sean out of bed; the same steps are followed the only difference being Sean is getting out of bed rather than into it.

1.2.5 Manual Operation

The BRD also is equipped to operate under the event that power is not available to the system, which could be the resultant case in a power outage. The BRD’s motor can be disconnected to the frame in the event physical operation is required. In order to do this a 5/64” allen wrench can be used to remove the keyhole pin which secures the motor spindle to the rest of the frame.
The pin can be removed and the motor housing unit can slide along its support tract; removing the spindle from the motor mount connector piece, which connects the motor to the frame. The track can now be simply pulled away from the bed once the pin has been removed and the black 80/20 connector pieces have been loosened. Now the BRD is ready for manual operation and deployment.

The operator should be comfortable in applying a minimum load of 20 pounds in order to manually operate the BRD. Once the operator is comfortable with performing this task, two hands should be placed on the top corner of the BRD, as shown below.
Once the operators hands are in the correct position the rail can easily be deployed into the downward position. It should be noted not to allow the rail to slam the support frame on the way down; the rail should be gently place on the lower support frame when the contact is made between the frame and the support piece.

![Figure 19. BRD manually rotated downward](image)

Now that the BRD is in the down position it can be manually retracted into the “up” position. It should be noted that the steps above for clearing the path of the rain as well as clearing the joint areas should be followed. In order to manually retract the BRD a significant amount of more force will be needed. The operator should place his or her hands in the same position as before and again carefully move the BRD into the “up” position. Once physical operation is no longer desired the motor housing unit can be moved back and placed into the aluminum block spindle hole. The pin should be re-inserted and tightened with the appropriate Allen wrench.

If for any reason the BRD is not operating as it normally does the user controlled power switch should immediately be thrown. The switch should be immediately thrown in order to prevent any further damage that could be being caused to by the motor. The following are reasons to throw the power switch during operation: and object enters the path of the BRD or connecting areas, if the frame is jerking or not moving in a continuous motion upon deployment or retraction, if there is no response by the BRD when the switch is thrown “up” or “down.”
2 Maintenance

2.1 Maintenance - Mechanical

2.1.1 Frame

There are several aspects of mechanical maintenance that will ensure the BRD will be operating at top performance. Following the mechanical maintenance instructions will also extend the operational life of the BRD. The hinges where the BRD’s frame meets the supporting piece should be kept clean and free of objects during operation. This will ensure the hinge does not become deformed or damaged during operation. If the hinge were to become damaged 80/20 Inc. supplies replacement hinge pieces in the event that a hinge becomes damaged.

2.1.2 Motor Unit

The BRD’s frame has black connector pieces that can be tightened and realigned if any pieces, like the motor housing unit, become loose during the device’s lifetime. If the motor housing unit becomes loose over time, or when during manual operation the motor housing unit is not secured back into its position, the black connector pieces should be tightened to secure the housing unit in place.

During operation it may appear that the motor housing unit and the aluminum block are shaking. If the shaking is noticeably different from the previous operation the motor spindle may not be aligned properly into the aluminum block spindle hole. If this is the case loosen the tracks of the housing unit and pull back the housing unit. Now re-insert the motor spindle into the block spindle hole; being sure to observe the orientation of the motor spindle upon entering the block’s hole. The motor spindle should be entering the hole straight on; the angle of the motor spindle upon entry should be observed while facing the BRD. Also to assist in achieving a straight on entry the minute gap between the edge of the block hole and the motor spindle should be even over the entire hole.
circumference. This will ensure steady operation of the motor and frame. This will also have an effect on reducing any unwanted noise that can be associated with an increase in the shaking of the motor housing unit.

2.1.3 Vinyl

Maintenance of the vinyl will be important in prolonging the overall life of the device. Weekly cleaning of the vinyl and netting will maintain a bacteria-free environment, and will also maintain the overall appearance of the vinyl. The vinyl can be cleaned only with warm water and soap. A soft bristle brush should be used to scrub the vinyl, using anything to abrasive will destroy the vinyl. Then rinse the cleaned areas with water. It should be noted that extra care should be taken when cleaning vinyl that is in close proximity to the motor housing unit and user switches. No soap or water should come into contact with any of the wires, motor housing unit, or the user switch mount. If for any reason these component do become wet one week should be allocated to drying of the circuitry, and the manual operation will have to be used until all of these components are dry. Also in order to prolong the life and maintain the look of the vinyl a protectant can be used to treat the vinyl; giving it added protective characteristics. The protectant 303 Aerospace Protectant has been approved to use with this vinyl, and have been reviewed positively for its ability to protect the vinyl.

If the vinyl and foam padding underneath become ripped or torn in any way steps can be taken to fix the rip. Vinyl adhesive can be purchased for small rips of approximately one and a half inches in length. In order to repair the vinyl it is important to ensure that the starting surface is as dry as possible before applying the adhesive. For small rips simply place a small amount of vinyl adhesive on one side of the rip and then stretch the other side over the top of the side with the applied glue, and apply force to the newly conjoined vinyl for approximately 30 seconds. For larger vinyl rips, greater than approximately one and a half inches, a vinyl repair specialist should be employed to ensure proper alignment of the underlying foam.

The vinyl should also be kept as dry as possible. This will prevent the formation of bacteria and also it will maintain the overall appearance of the vinyl as to the water exposure will cause the vinyl to have a weathered appearance.

2.1.4 Netting

During operation of the BRD the netting may become dislodged or ripped. In the event that a piece of the netting becomes dislodged from the frame in one area the netting can be pulled to meet the spot in which it it came from and stapled or nailed to the underlying wood panel. In the event that the netting is torn to a point in which it cannot be placed back where it came from, for example if the netting developed a hole, the BRD should be taken to a vinyl specialist for proper netting alignment and fixation.

2.2 Maintenance - Electrical

2.2.1 Motor

If for any reason the motor does not perform as it normally does the power switch should be immediately used in order to prevent any unwanted damage to the motor. The motor’s performance is based on the motor-block alignment as well as the voltage and current supplied to the motor.
2.2.2 Wiring

It will be important to maintain the electrical components of the BRD if the frame is to remain in full working order. All objects should be kept away from the power supply cable to wall outlet joint. Any objects near this location could increase the risk of electric shock if an object were to fall onto the power supply cable. Also there should not be any objects on the wire running from the wall outlet up to the BRD motor and user switch mount. Unwanted objects applying pressure to the wiring could displace a wire from its correct place, rendering the BRD inactive.

In maintaining the electrical components it is most important to ensure the operating environment remains free of water and excess moisture. All of the wire connections areas should also be secured in order to uphold a working condition of the BRD. The prongs that enter the wall socket should be kept away from other objects in order to prevent them from becoming bent, which would prohibit a steady amount of voltage from being applied to the motor.

2.2.3 Push buttons

The connection between the power supply and the push button is the most important aspect of the control design. If the push button is not connected properly the motor will not stop rotating once it reaches the end of its path. In order to maintain the push buttons they should be cleaned with an air spray in order to prevent an accumulation of particles in between the push button and what it is supported on. It may be necessary to replace the lower push button due to overuse. This can be done by removing the old push button and re-soldering the wire leads onto a newly purchased push button.

2.2.4 Toggle Switches

The user controlled toggle switches responsible for the BRD’s movement direction and power to the circuit must be kept in working order if the BRD is going to operate over a long period of time. Any debris or particulars should be air sprayed and removed from the switch. Cleaning the switches with water should never be done, for any reason. If either of the switches become dislodged from their housing unit, or get wet, the system could fail to operate. If any of the wiring should become loose from the toggle switch, solder the loose wire back to the appropriate pin of the toggle switch.

2.3 Maintenance - Environmental

The BRD is meant to be operated in an indoor environment. Its intended operational environment is a dry, 70 degree Fahrenheit, or room temperature environment. If the operational environment status is changed, for example in the event of a flood, the entire room should be dried entirely before the BRD can be operated via the toggle switches and the motor. In the event that the environment becomes inadequate to operate the BRD; the user should use the manual operation until a safe operating environment can be reestablished.
3 Technical Description

3.1 Frame

The is able to function through the use of two different control methods, both mentioned in the above operational steps. The main degree of control is through a DC motor which is hard mounted to the BRD’s frame. When the motor rotates in a counterclockwise direction the attached BRD frame will deploy and rotate from the “up” position to the “down” position. When the motor rotates in the opposite direction the frame will travel from the “down” position to the “up” position. The hinges and the motor spindle are aligned so that all turning components share the same axis of rotation.

![Figure 21. Hinge Schematic](image)

The frame is able to pivot over the support frame through the rotational axis shared with five hinge joints. The hinge joints are made to be connected to the 80/20 frame easily. The hinges allow the top part of the frame to rotate a full 180 degrees. The frame can also function mechanically as a secondary method to raise and lower itself. This secondary method is a precaution in case the motor ever gave out or the power went out. In order to operate the BRD mechanically, one must follow a series of steps. The first thing that needs to be done is to take a 5/64” allen wrench to loosen the compressive set screw. The set screw ensures the motor spindle stays in the BRD connecting piece. Once the set screw is removed, then the BRD motor can slide back along the grooves in the motor mount, leaving the spindle interface free from obstructions.

3.2 Motor and Motor Housing Unit

The motor is connected via a pin and keyhole that was drilled into the aluminum block and fits through hole already on the end of the motor spindle. The aluminum block is directly connected to the base of the frame. The specific running voltage of the BRD’s motor is 4V and supplied with a
The motor chosen was selected because it can supplied the needed amount of torque to overcome the load of the BRD. The required torque to move the frame was calculated to be 10 foot pounds of force needed to rotate the 40 pound BRD. This torque values was calculated by multiplying the lever arm times the force in the y direction, or the force due to gravity of the frame. Testing of the required torque was also the verified through use of a force gauge and the calculated value was accurate. A full current supply of 6.5A is required to move the load and a lower current will be not be able to displace the BRD.

The desired operating voltage of 4V was found through experimental testing. The testing involved monitoring the rate at which the motor spindle rotated at varying voltages. The goal was to obtain a voltage that caused the motor spindle to rotate 180 degrees in approximately three to five seconds. Supplying a voltage of 4V to the motor achieved 180 degrees of rotation is approximately five seconds, which was desired.

3.3 User toggle switches

The user controlled toggle switches allow for control of the power supply as well as control over the direction the motor is rotating. When the toggle switch is to the “up” direction the wiring from the power supply can be seen in the figure, and when the toggle switch is to the “down” position the wiring from the power supply is reversed when compared to the “up” direction. This enables a change in the polarity because the positive and negative terminals for the “down” position on the toggle switch has be reversed. This circuit construction enables for the switch to act as the medium by which the polarity is reversed on its way to the motor.

There is also an emergency power switch that is responsible for maintaining the power from the power supply to the BRD’s motor. This switch was incorporated to add an extra safety feature, and a way to quickly disable the motor without reversing the polarity quickly, which may damage the motor. This switch also has a built in LED that illuminates when the power is on to the circuit. This is an added feature to assist the operator in determining if the power supply is still connected or whether the power supply has been short circuited.

The power supply supplies a constant voltage of 4V and a max current of 6.5A. The switches are all rated well above these values in their ability to turn on or off these values. This ensures that the switches are capable of cutting the power to the motor and power supply. The push buttons are also rated for these values.

3.4 Push buttons

The push buttons are activated when the rail come to either full deployment or full retraction. Pressure is applied to the surface of the push button when the rail is at the full “up” or “down” position. The purpose of the push buttons is to kill the power to the motor when the motor has reached its final position. This was implemented in order to protect the motor as well as the frame from being damaged in the event the operator did not return the user toggle switch to the center position. These push buttons ensure that the system remains functional and operating for an extended period of time. The user will have to operate a small piece aluminum that acts at the meeting spot between the push button and BRD’s frame. The small piece is removed, which restores
power back to the motor.

3.5 Power Supply

The power supply used is able to convert the wall socket AC voltage and current to a specified voltage and current. The specified current and voltage was determined to be 4V and 6.5A. The power supply is able to take the AC voltage and convert it from 120VAC to the desired 4V and 6.5A. The power supply is fire and shock resistant, which is necessary for the BRD to be safely operating indoors.

4 Troubleshooting

For given issues that could arise during operating or storing the BRD the following steps and directions can be taken in an attempt to restore the BRD into full working order. Troubleshooting can be divided into troubleshooting different aspects of the BRD’s design. Troubleshooting can be split into two categories one for troubleshooting the frame and the other for troubleshooting the motor.

4.1 Frame

There are several aspects of the frame that could be faulty during the use of the BRD. For example if any of the frame pieces became bent or disfigured steps can be taken to replace the damaged piece. If any of the long vertical pieces or support pieces become damaged to a point where they can no longer give adequate support to the frame they will need to be replaced. Such a fault can be spotted if the frame seems to unevenly deploy and retract while being operated. With use of an Allen key each piece of the BRD’s frame can be removed from the piece it is connected to by loosening the black connector pieces.
Other pieces of the frame that are not the long supporting pieces or vertical pieces may also have to be replaced. In the event that an object becomes lodged in the area where a hinge is, or in the area between two long 80/20 pieces, the object can cause the hinge to become faulty or the frame could no longer fit together tightly. If this is the case replace the hinge or other 80/20 piece that has been damaged in a similar fashion as to replacing the larger 80/20 pieces. A faulty hinge can be identified if the frame refuses to deploy or retract or if there is an uneven movement by the frame.

Figure 22. BRD 80/20 connecting pieces
The motor housing unit may become loose or dislodged during constant use of the BRD or in the event that the BRD is not properly connected when changing from the motor controlled operation to the manual controlled operation. In order to fix this issue tighten all of the connectors that secure the motor unit to the motor support structure. This error can be seen when the BRD is deployed or retracted accompanied by a violent shaking of the motor unit.

It should be noted that if any excess vibration that be witnessed during operation are all unwanted vibrations. In order to reduce the overall vibrations occurring over the frame as a whole; tighten each connector piece as tight as it can go. This should correct the unwanted vibrations.

If violent shaking is occurring during operation it may be necessary to realign the motor spindle with the aluminum block hole. To do this use an allen wrench to remove the pin from the
keyhole that connects the motor spindle to the aluminum block. Next loosen the motor housing unit connector pieces and slide it along the tracks away from the motor spindle. Then proceed to realign the motor spindle into the hole by sliding the motor unit back toward the frame and the aluminum block. Now observe from a straight on view the angle that the motor spindle is trying to enter the block hole and ensure that the motor spindle is parallel with the floor. The straight on angle of the motor spindle can be assured by assessing the distance between the motor spindle and the edge of the block’s hole. The distance between the motor spindle and the edge of the block’s hole should be uniform throughout the entire circumference of the hole. If the distance is not uniform over the entire circumference attempt to realign the spindle until the distance is uniform.

Figure 24. Lining up the motor spindle

4.2 Motor

There are several aspects of the motor that should be evaluated in an attempt to troubleshoot the BRD in event that it cannot deploy or retract. The first step in troubleshooting the motor is to ensure the power supply is firmly connected into the wall socket. Once this is ensured, trace the wires from the power supply to the motor and verify that there is no loose wire going from the power supply to the motor. If a loose wire is found solder the loose wire to the area by which it came loose
Soldering instruction can be found online and should be closely followed in order to prevent damage to any of the electrical components.

The motor should be getting supplied a voltage of four volts and current of six amperes. If the motor were operating at a speed higher than three seconds for the BRD to deploy or retract there is an incorrect amount of voltage being applied to the motor. To access the actual voltage being supplied to the motor; first ensure the power supply is not plugged into the wall outlet. Next remove the motor unit from the frame, following the directions above. Now reconnect the power supply and use the toggle switch to choose a direction of travel. Then while the motor is rotating, or is not rotating, take the positive and negative leads of a voltmeter and applying one to each of the motor’s terminals, or where the wires connect to the motor. The reading should indicate that approximately four volts is being sent from the power supply to the motor. If this is not the case the power supply has been damage and will need to be replaced. In order to remove and replace the previous power supply the solder connections should be removed and the same wires should be re-soldered to the newly purchased power supply.

If the power is supplied to the motor and it fails to move the BRD at all there could be an issue with the amount of current being drawn by the motor from the power supply. In order to test the amount of current being supplied to the motor follow the same steps for testing the voltage of the motor, however the voltmeter will need to be set to read a current and the positive lead of the voltmeter will need to be moved from the voltage to current. The desired draw current of the motor from the power supply is six amperes under the full load. If the motor is not moving when the user switch is thrown a lower amount of current could be running to the motor instead of the necessary six amperes. Similarly to troubleshooting the voltage, if the current is not enough the power supply will need to be replaced; following the same directions for replacing the power supply as above.

If the user activates a toggle switch and the incorrect direction occurs the emergency switch should immediately be thrown. After the emergency power switch is thrown, access the wire connection areas from the power supply and from the motor to ensure that the wiring has not crossed accidentally. An incorrect motor rotation is a result of a reverse in polarity than the BRD was designed for. This could arise in cases where the BRD is repaired. If this is the case simply re-solder the leads from either the power supply or the motor lead, but not both. The motor leads will be easier to solder and will pose a lower risk of damaging any electrical components due to the motor’s lack of heat sensitive electronic components. If reversing the wiring to the motor does not change the direction that the motor rotates; a new power supply will have to be purchased.

While operating the mower if for some reason the motor does not stop rotating when the push button is made contact with there could be a disconnection between the push buttons and the power supply. There could be several instances where the push button does not short the circuit and stop the motor from rotating. If the solder connections became bad between the power supply and the push buttons the push buttons would be unable to short the circuit and power off the system. If this is the case re-solder the connections of the push buttons. In order to test a push button performance the following steps. First put the rail into an “up” or “down” position and access the push button that is not being activated when the rail is in that state. Remove the push button and take a voltmeter and apply the positive and negative terminals of the voltmeter to the pins of the push buttons. While the voltmeter is connected to the pins of the push button manually push the push button and monitor the voltage indicated by the voltmeter. When the button is pushed the voltage should read zero volts indicating that the short has successfully occurred.
If the push button successfully creates a short circuit the other push button should be tested in a similar fashion to ensure the workability of both push buttons. If both push buttons do create a short when they are applied; there could be an issue of the BRD is not properly engaging the push button. In order to test to see if this is the case observe the BRD making contact with the push button. If there has been any previous fixes done to the BRD those fixes may be causing the push button from being properly engaged. Observe the engagement of the push button and if it appears to be fully pressed or not. If the engage does not seem to occur simply attach a small piece of wood, via glue, to the vinyl. This small piece of wood will make up the distance not being covered by the BRD; the necessary distance to engage the push button. This small piece of wood would adjust the distance between the vinyl and the push button allowing for the BRD to engage the push button.

4.3 Toggle Switches

If there is no control over the motor with the user toggle switch there may be a problem with the toggle switches. In order to test the ability of the toggle switch to accurately control the direction of the BRD, first remove the motor spindle from the aluminum block. Then activate each switch in each direction, not forgetting to access the center position as well. Test and determine if the toggle switch is rotating the BRD in the correct direction. If there is no direction resultant when the toggle switch is through it could be a faulty connection or the toggle switch could not be performing correctly. If there is a faulty connection try soldering the connection points between the toggle switch and the motor and the connection between the toggle switch and the power supply. To test a faulty connection connect the voltmeter’s positive and negative leads to the pin where the red and black wires go to. When the switch is in a neutral position the voltmeter should indicate zero volts and when the switch is thrown “up” or “down” the voltage should read approximately four volts. If the switch is thrown and no voltage is indicated by the voltmeter a faulty connection has occurred and soldering should take place.

Another troubleshooting method for the toggle switches exhibiting no direction control or initiation of the BRD’s motor can be done by unscrewing the lever portion of the switch and giving a thorough cleaning of unwanted debris or particulars. These particulars could be preventing the switch from being fully thrown into the “up” or “down” position by not allowing the full range of motion of the toggle switch from being achieved. After unscrewing the toggle lever; test the toggle switch and listen for a light sounding “click” when the switch is fully thrown. In order to determine if a switch has been fully thrown, apart from an auditory response, connect the positive and negative terminals of the voltmeter to the toggle switch. Measure the voltage when the switch is thrown and the voltage should read four volts.