ADVANCED Construction ROBOTICS

TyBOT®

REBAR TYING ROBOT

# TYBOT® 1.5 OWNER MANUAL

50-004-0016 REV A

P: 412-756-3360 | constructionrobots.com

# THANK YOU!

Thank you for adding TyBOT to your crew.

This user manual could include technical, typographical errors, or other inaccuracies. Changes are periodically added to the information herein; these changes will be incorporated in new publication editions.

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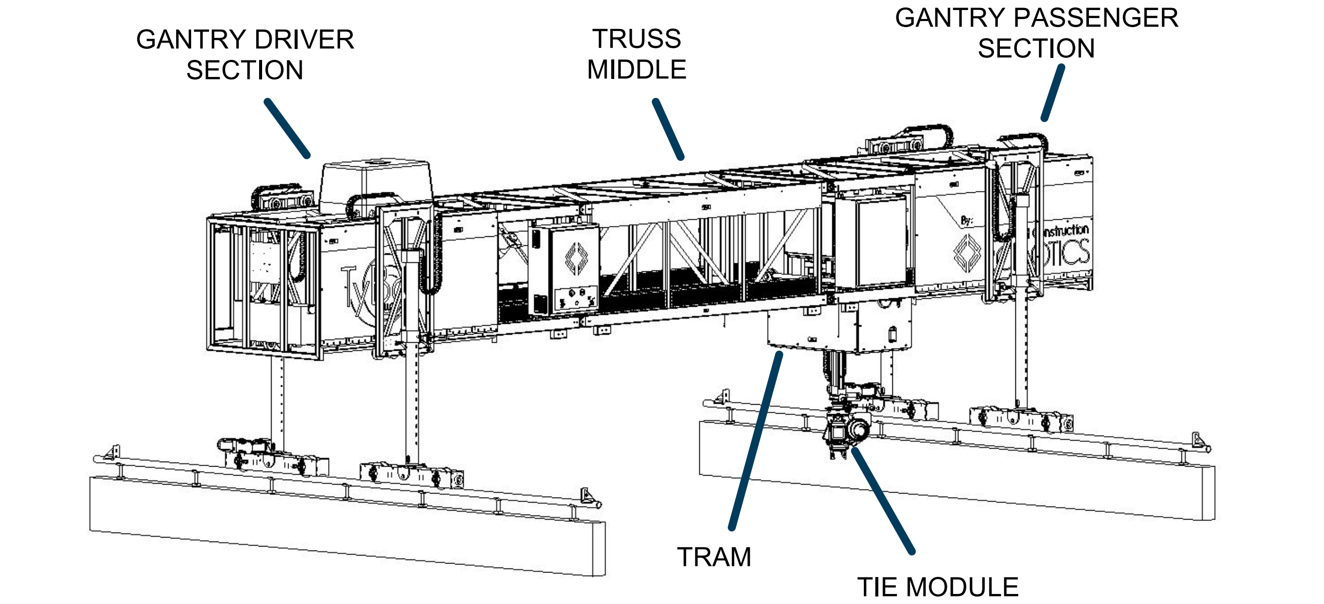
Product information is for informational use only and does not guarantee successful performance as many external factors influence TyBOT's performance.

# Table of Contents

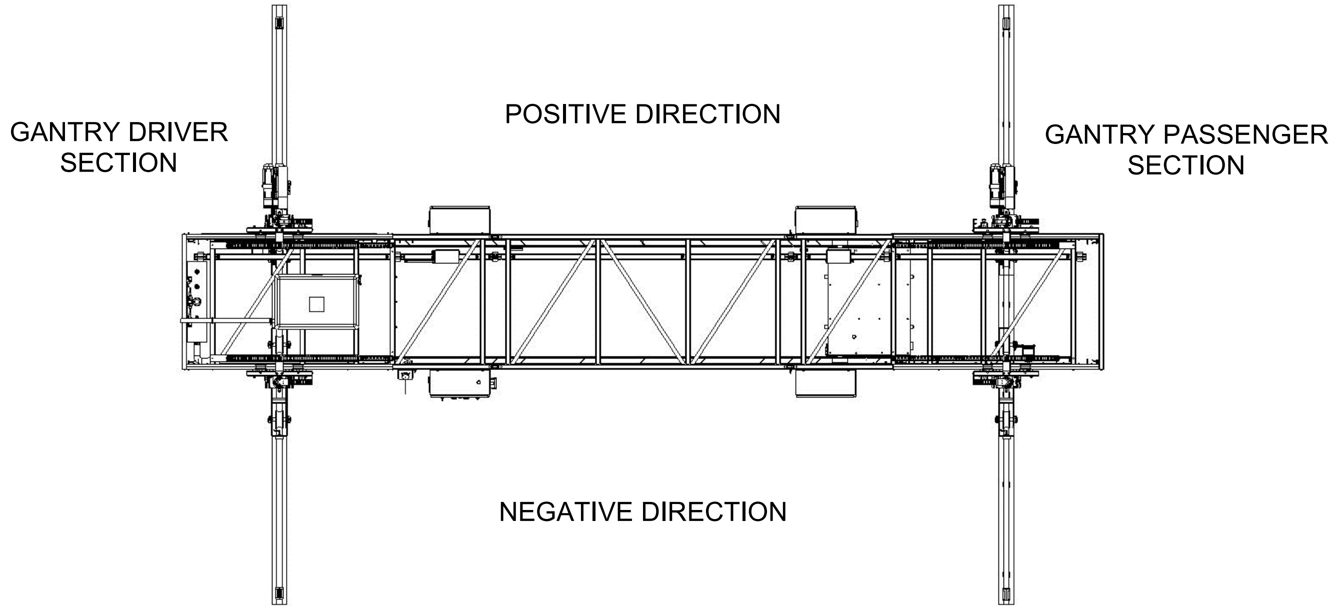
# I. PRODUCT INFORMATION

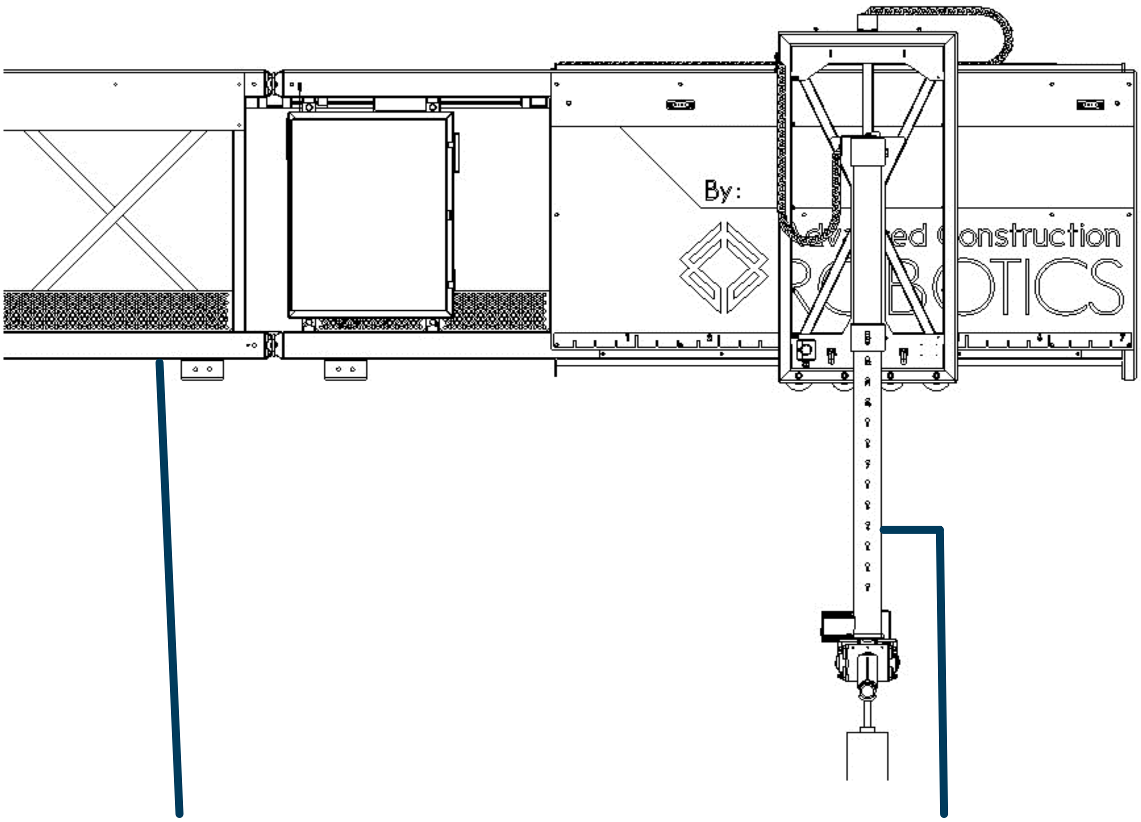
## TyBOT 1.5 Unit Overview

TyBOT is comprised of a Gantry System and a Tram that moves within the Gantry System and actuates the TyBOT Tie Module. The Gantry System has a Gantry Driver Section and a Gantry Passenger Section which have adjustable Legs that ride on standard deck finisher screed rails. The width of the Gantry System is configured through the addition of Truss Middle Sections which are easily added or removed from the Gantry System.




**TOP-DOWN VIEW**



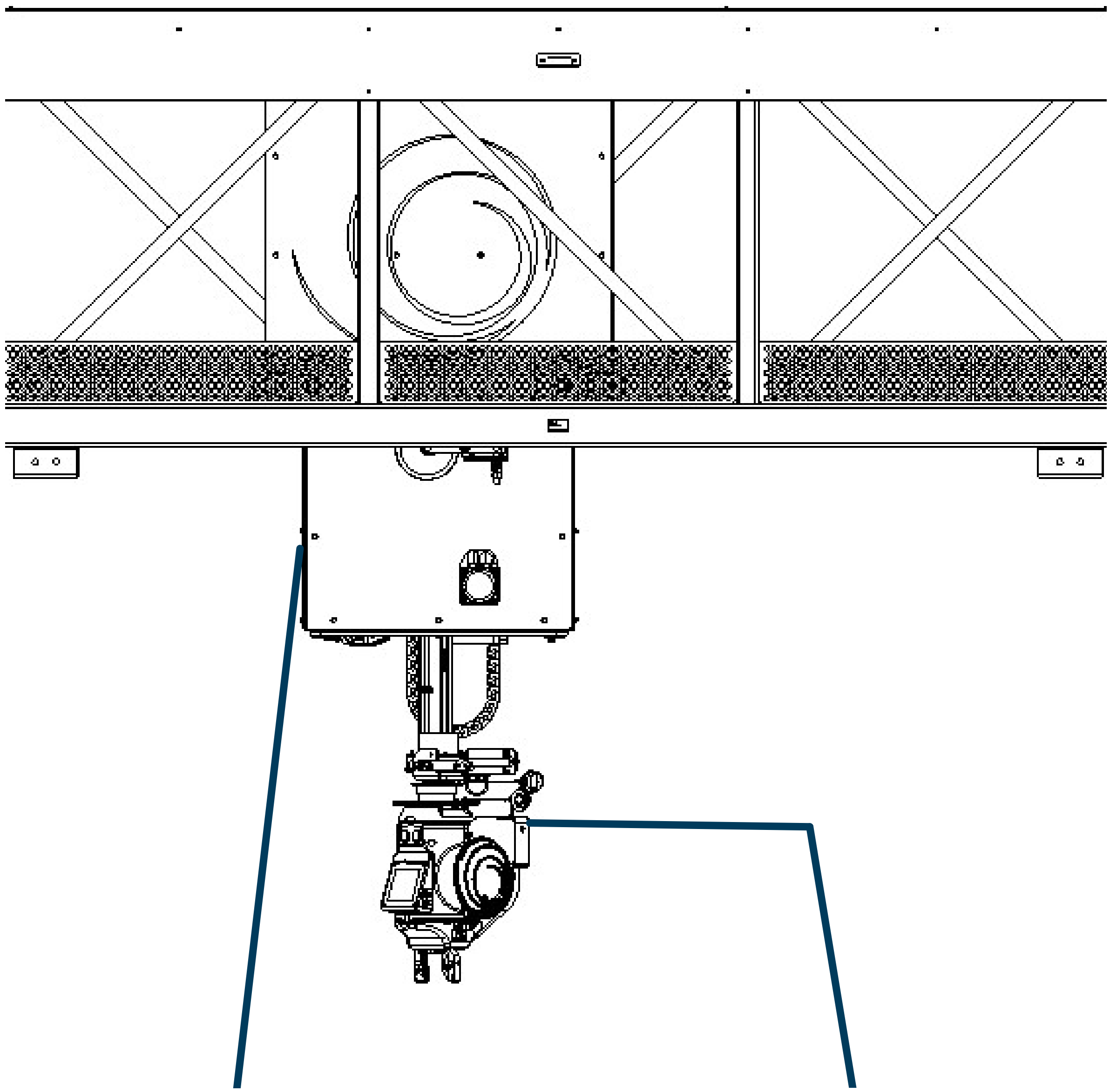



## Gantry Frame

The TyBOT unit's steel Gantry Frame is durable and lightweight. Construction loading is designed to be less than finish machine loading at comparable widths.

## Legs

The TyBOT unit's Legs are adjustable to accommodate varying screed rail widths and heights.



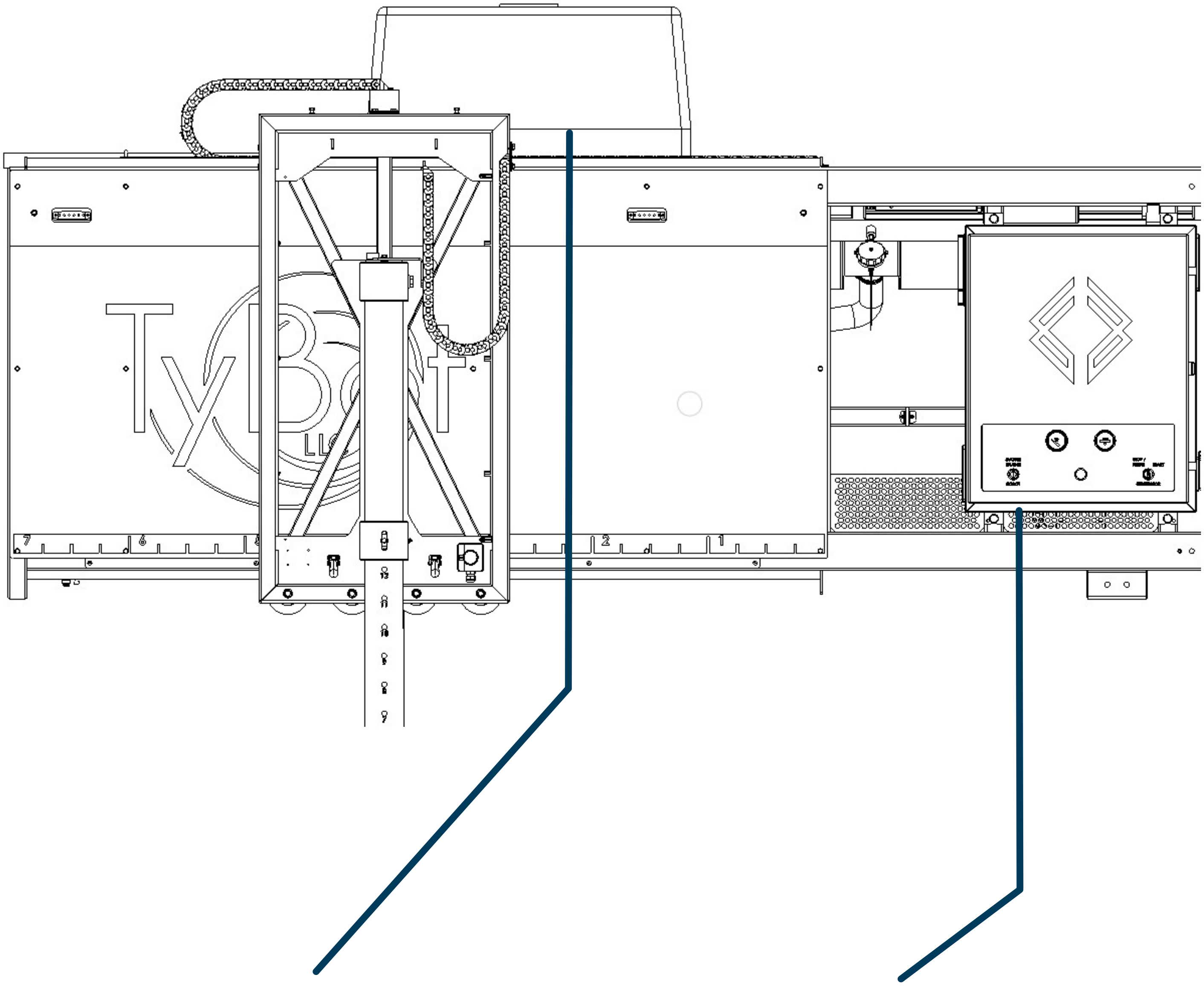
## Tram

The TyBOT unit's Tram moves within the Gantry using a fully integrated track system.

- Autonomously identifies rebar intersections
- Moves the Tie Module into position to autonomously tie all identified rebar intersections
- No special tools required
- Configurable safety zones

## Tie Module

Autonomously ties rebar intersections at coverage proportions of 50% or 100%



**Power Generator**

Cummins Onan QG 5500 EFI GenSet located on the Gantry Driver section

**Electronics Box**

The main control panel for the TyBOT unit located on the Gantry Driver section including the master enable key switch and Generator start/stop controls

## TyBOT 1.5 Unit Specifications

These specifications are to be used as guidelines only. Please contact TyBOT Service and Support for specific bridge configurations including any configurations outside of these specifications.

| | |
|---|---|
| STANDARD RAIL TO RAIL SPACING: | **66 FT (20 M)** |
| RAIL TO RAIL SPACING (MIN/MAX): | **9.5-108 FT (2.9-32.9 M)** |
| STANDARD WEIGHT (66 FT): | **5740 LBS. (2609 KG)** |
| WEIGHT 19 -108 FT (MIN/MAX): | **3740-7660 LBS. (1700-3481 KG)** |
| MAX. WHEEL LOADING (108 FT): | **1382 LBS. PER WHEEL** |
| HEIGHT w/o TIE MODULE (MIN/MAX): | **7.8-10 FT (2.4-3.1 M)** |
| UNIT WIDTH (MIN): | **21 FT (6.4 M)** |
| UNIT WIDTH (20M RAIL SPACING): | **70.4 FT (21.5 M)** |
| TRUSS HEIGHT X WIDTH: | **3.67 x 4.2 FT (1.12 x 1.27 M)** |
| MAX WIND LOAD: | **40 MPH** |
| OPERATING TEMPERATURE | **32°-104°F (0°-40°C)** |
| MAX. LEG HEIGHT ADJUSTMENT: | **3 FT (0.91 M)** |
| LEG HEIGHT ADJUSTMENT INCREMENT: | **3 IN (7.62 CM)** |
| MAX. LEG WIDTH ADJUSTMENT: | **4.83 FT (1.47 M)** |
| WHEEL BASE: | **7.5 FT (2.3 M)** |
| LONGITUDINAL TRAVEL SPEED: | **0.4 FT/S (0.12 M/S)** |
| SCREED RAIL TO DECK PAN (MIN/MAX): | **0-54 IN (0-1.37 M)** |
| SCREED RAIL SUPPORTED: | **2 IN NOMINAL ROUND PIPE** |
| MAX. LONGITUDINAL GRADE (<70FT): | **6 %** |
| MAX. LONGITUDINAL GRADE (>70FT): | **4 %** |
| MAX. TRANSVERSE GRADE: | **4 %** |
| MAX. PLAN VIEW SKEW: | **40 DEG** |
| TYBOT TIE WIRE GAUGE AND COATING: | **16.5 AWG PLASTIC COATED** |
| TYBOT TIE WIRE SPOOL CAPACITY: | **15 LBS (6.8 KG)** |
| MIN. BAR GRID SPACING: | **3 IN X 3 IN (7.62 CM X 7.62 CM)** |
| MAX. BAR INTERSECTION: | **#8 X #9 or 2.125 IN (54 MM) COMBINED** |
| MIN. BAR CHAIR HEIGHT: | **1 IN (2.5CM)** |

## Power Specifications

| | |
|---|---|
| POWER: | **5500 WATTS** |
| FREQUENCY: | **60 Hz** |
| SUPPLIED VOLTAGE, AMPERAGE: | **SPLIT PHASE 240VOLTS, 22.9AMPS** |
| FUEL CONSUMPTION (NO LOAD): | **0.35 GPH (1.3 L/H)** |
| FUEL CONSUMPTION (HALF LOAD): | **0.60 GPH (2.3 L/H)** |
| FUEL CONSUMPTION (FULL LOAD): | **0.95 GPH (3.6 L/H)** |
| GENERATOR FUEL GRADE: | **87 OCTANE (UNLEADED)** |
| GENERATOR FUEL TANK CAPACITY: | **13 GALLONS (49.2 L)** |
| GENERATOR OIL GRADE (+0° C): | **30 SAE VISCOSITY** |
| GENERATOR OIL TANK CAPACITY: | **2 QT (1.8 L)** |

# II. SAFETY

TyBOT unit usage – including configuration, operation, and maintenance – should be in accordance with all safety warnings and precautions described herein, and only by trained and authorized persons. All applicable state and local regulations should be understood and concurrently observed.

Additional copies of this manual can be obtained from TyBOT Service and Support or online at constructionrobots.com.

## Safety Labels

TyBOT unit components and subsystems pose various risks to user safety and the safety of passersby. These risks are identified by safety labels at relevant locations on the unit.

**NOTE: The risks posed by powered equipment and its usage cannot be comprehensively identified or mitigated by labeling alone. Continuously exercise caution when configuring, operating, and maintaining the TyBOT unit. Contact the TyBOT Service and Support Department to immediately replace any label that becomes missing, damaged, or illegible.**

Three classes of safety labels – specified in design and placement by ANSI Z525.4 – are present on each TyBOT unit:

**CAUTION LABELS indicate hazardous situations that, if not avoided, could result in minor or moderate injury.**


**WARNING LABELS indicate hazardous situations that, if not avoided, could result in death or serious injury.**


**DANGER LABELS indicate hazardous situations that, if not avoided, WILL result in death or serious injury.**

## Pinch Caution Labels

### Operation

Figure 1 illustrates the placement of ***CAUTION LABELS*** near the TyBOT unit's Tram travel rails; these pose ***PINCH*** risks during operation.

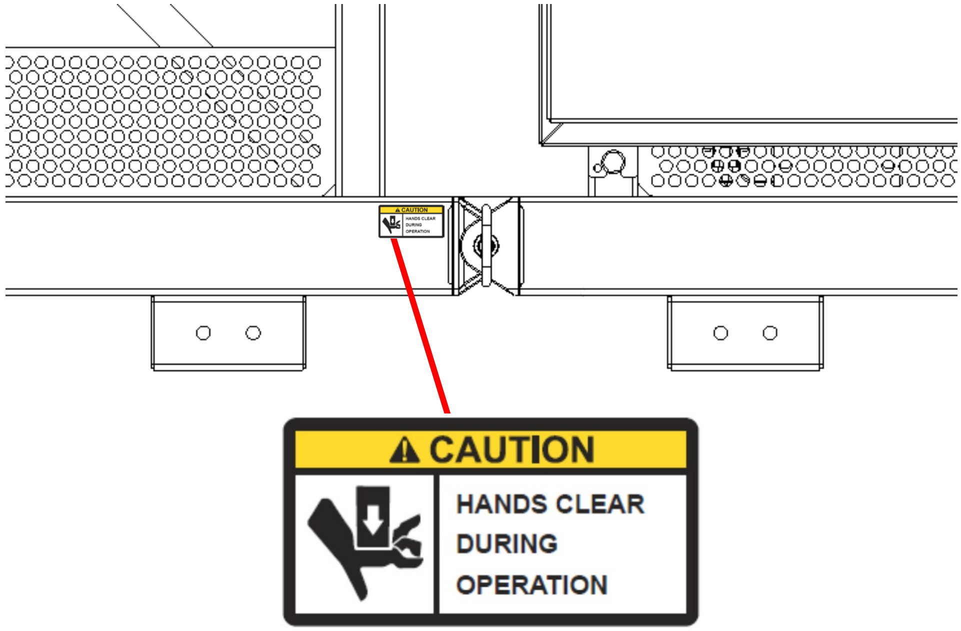



*Figure 1: Pinch Caution Label - Operation*

### Configuration

Figure 2 illustrates the placement of ***CAUTION LABELS*** at the TyBOT unit's Leg adjustment points; these pose ***PINCH*** risks during unit configuration.

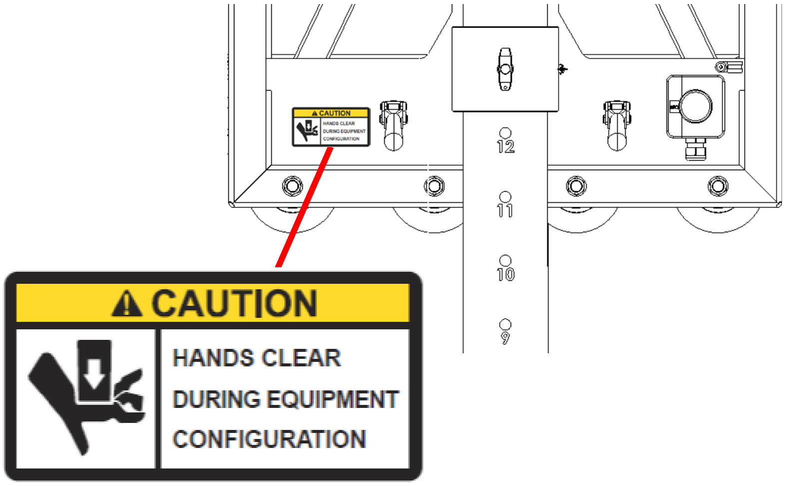



*Figure 2: Pinch Caution Label - Configuration*

## Chain

Figure 3 illustrates the placement of ***CAUTION LABELS*** near the TyBOT unit's drive chains; these pose ***CHAIN PINCH*** risks during operation.

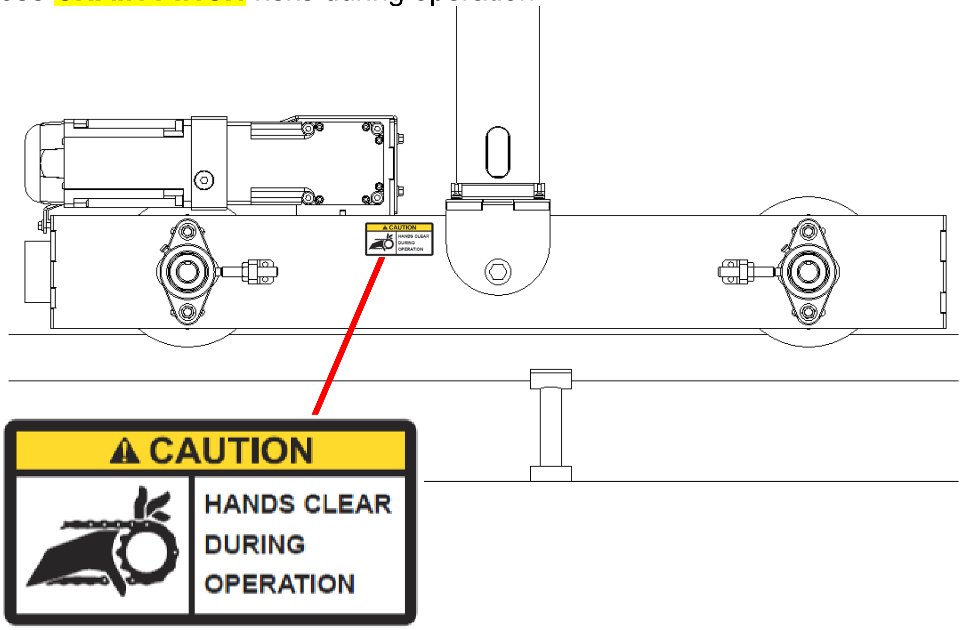



*Figure 3: Pinch Caution Label – Chain*

## Flammable Gas Caution Label

Figure 4 illustrates the placement of a ***CAUTION LABEL*** on the TyBOT unit's fuel tank; the fuel system poses a ***FLAME*** risk, particularly during refueling.

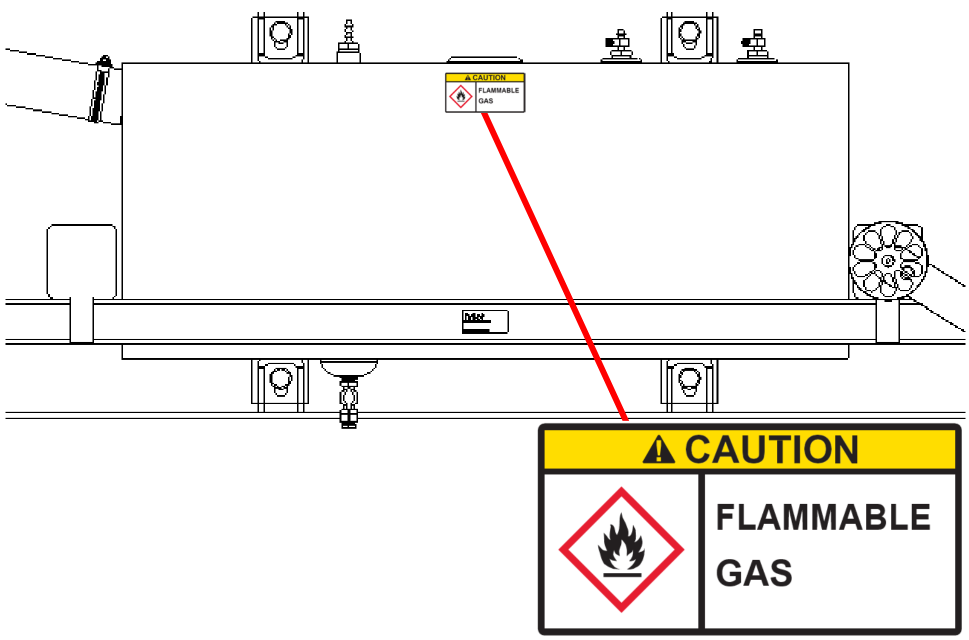



*Figure 4: Flammable Gas Caution Label*

## Fall Warning Label

Figure 5 illustrates the placement of a ***WARNING LABEL*** near the TyBOT unit's fuel filler cap; this location poses a ***FALL*** risk during refueling.

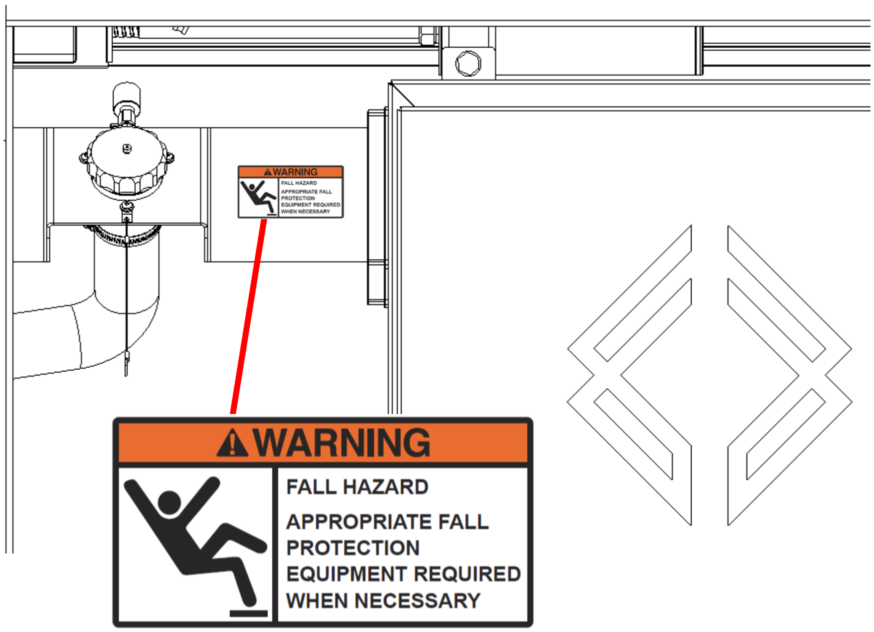



*Figure 5: Fall Warning Label*

## Panel Shock Danger Label

Figure 6 illustrates the placement of ***DANGER LABELS*** on the TyBOT unit's electrical boxes; these pose ***PANEL SHOCK*** risks when the unit is powered.

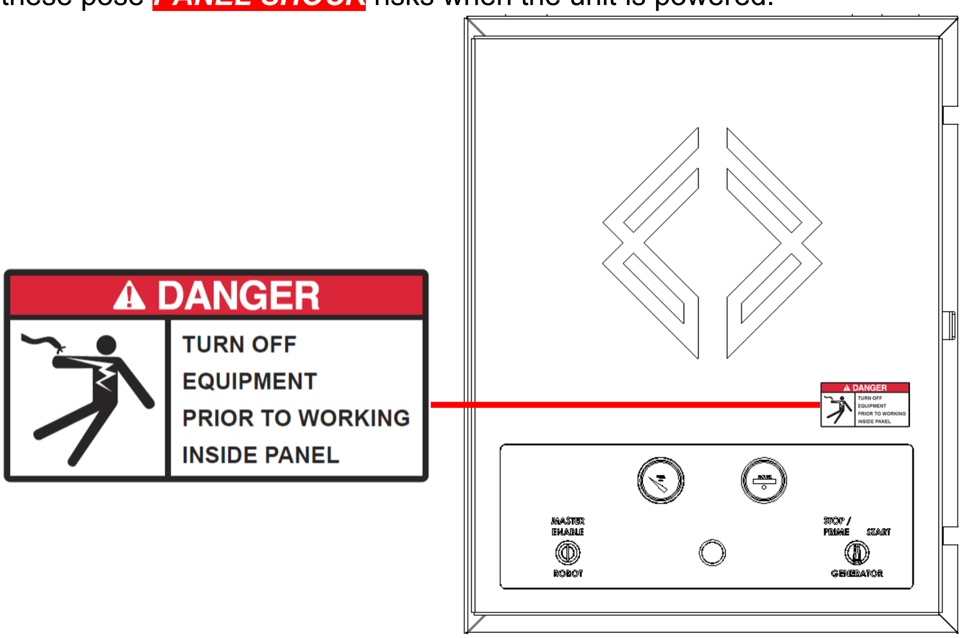



*Figure 6: Panel Shock Danger Label*

### Rail Shock Danger Label

Figure 7 illustrates the placement of ***DANGER LABELS*** on the TyBOT unit's power rails; these pose ***RAIL SHOCK*** risks when the unit is powered.

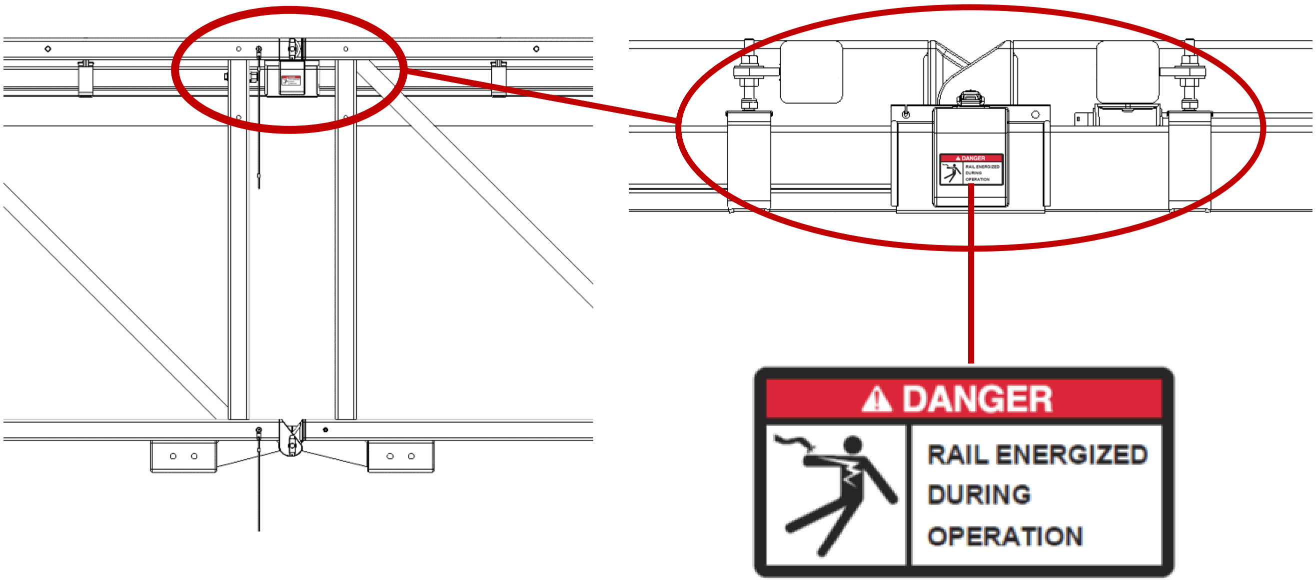



*Figure 7: Rail Shock Danger Label*

## Weights & Rigging Precautions

Consult the table below prior to lifting or loading the TyBOT unit or any of its subcomponents. Verify all relevant weights to be within the capacity of the lifting equipment used and the infrastructure onto which the components will be placed.

| COMPONENT | WEIGHT (APPX) |
|---|---|
| *DRIVER GANTRY* | **1,790 LB** |
| *PASSENGER GANTRY* | **1,300 LB** |
| *TRAM* | **650 LB** |
| *3M TRUSS MIDDLE SECTION* | **400 LB** |
| *1M TRUSS MIDDLE SECTION* | **175 LB** |
| *3M TRUSS TRANSITION SECTION* | **470 LB** |
| *6M TRUSS MIDDLE SECTION* | **860 LB** |

Figure 8 illustrates a TyBOT unit configuration consisting of its minimally required components – Driver Gantry, Passenger Gantry, Tram, and one 3M Truss Middle Section.

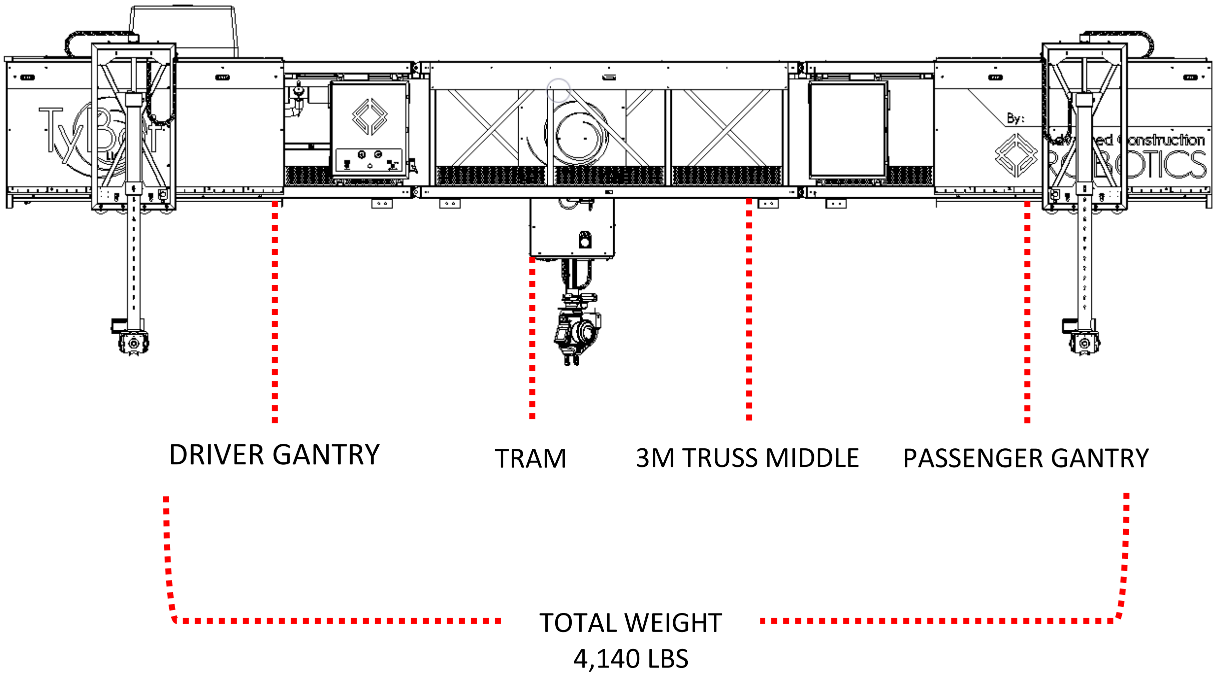



*Figure 8: Configuration Weight Summation*

Figure 9 approximately illustrates the center of mass of each individual TyBOT component. Before attempting to lift the TyBOT unit, the load's overall center of mass should be centered. Refer to Section IV. on Operation for instructions regarding manual movement of the Tram within the Trusses – such movement is required to adjust the load's center of gravity for a balanced lift.

**GANTRY CENTERS OF MASS**

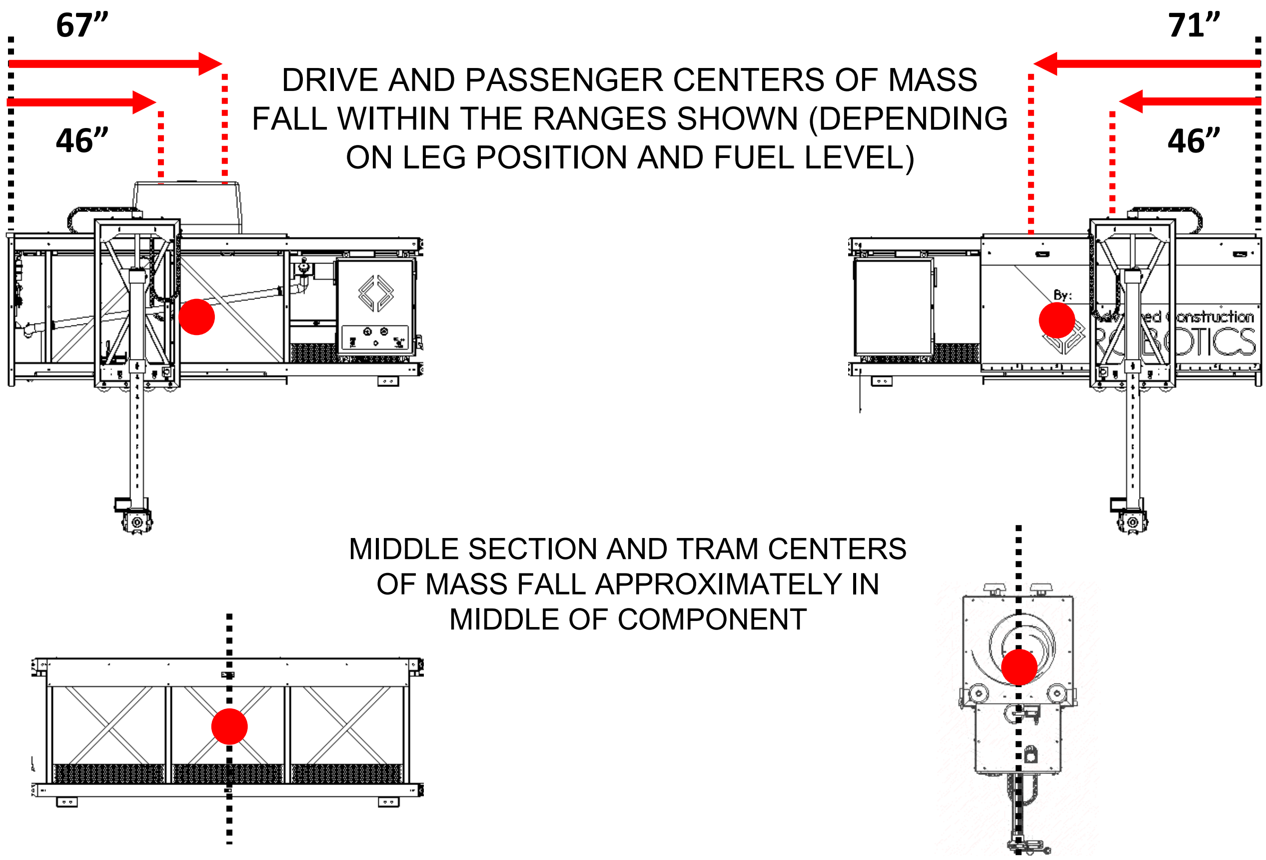



*Figure 9: Component Centers of Mass*

The TyBOT unit and its individual components should be rigged and/or lifted only by trained and authorized persons. Due to variations between equipment and site restrictions, the following figures are offered as a noncomprehensive precautionary guide which should be understood and adapted to suit.

**In any configuration, the TyBOT unit should only be lifted from the top of its Truss Frames at the clevis connectors. No more than two Truss Sections should be outside of either lift point, as in Figure 10.**

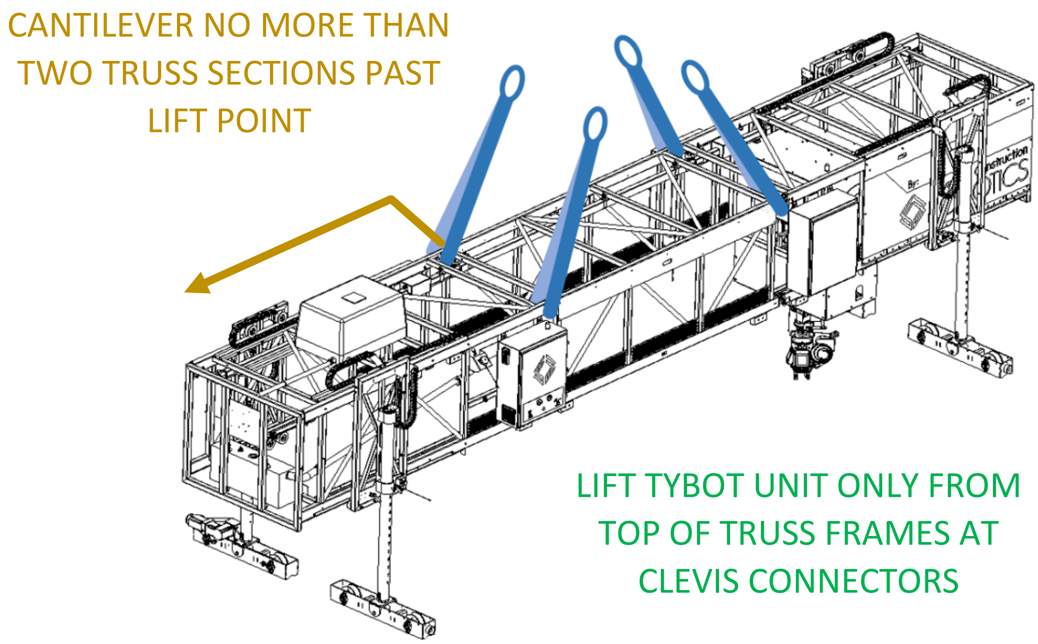



*Figure 10: TyBOT Unit Lift*

An individual Gantry System Section should only be lifted from the top of its Truss Frame; this also applies when lifting one side of the TyBOT unit as is needed during Leg height adjustment (see Figure 11).

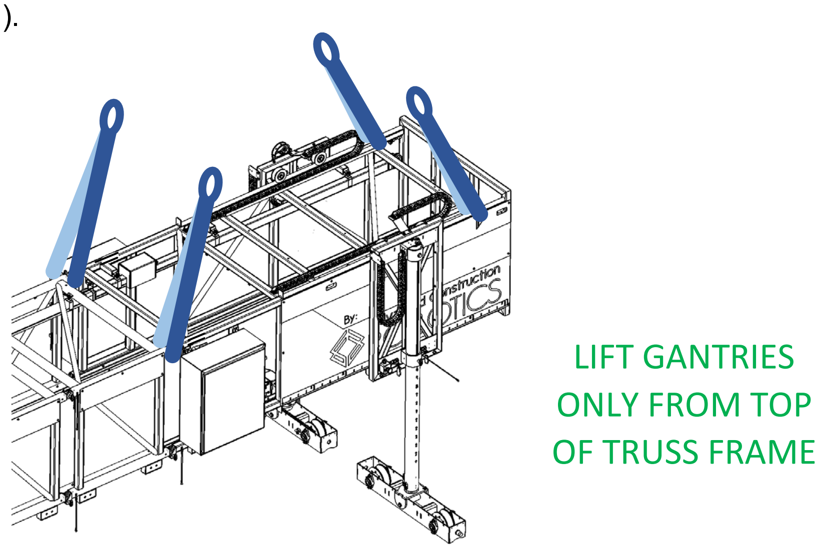



*Figure 11: TyBOT Gantry Lift*

An individual Truss Middle Section may be lifted from the top of its Truss Frame at the clevis connectors, as in Figure 12.

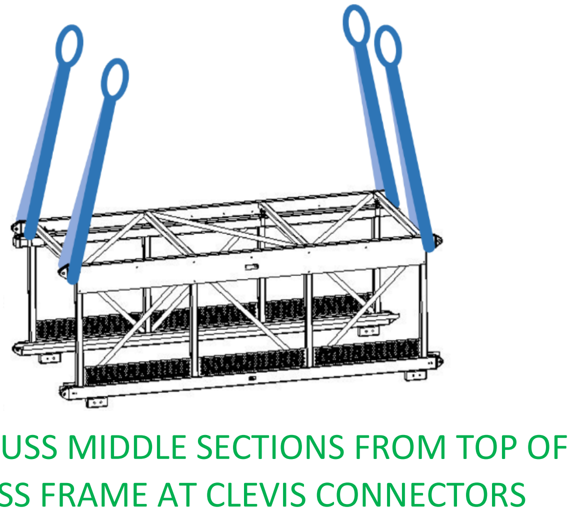



*Figure 12: TyBOT Truss Middle Section Lift*

**Ensure that no Truss panels, wiring harnesses, or power rails are stressed in the process of rigging/lifting the TyBOT unit or its components**.

Though not comprehensive, Figure 13 exemplifies two rigging/lifting conditions that pose safety and machine damage risks.

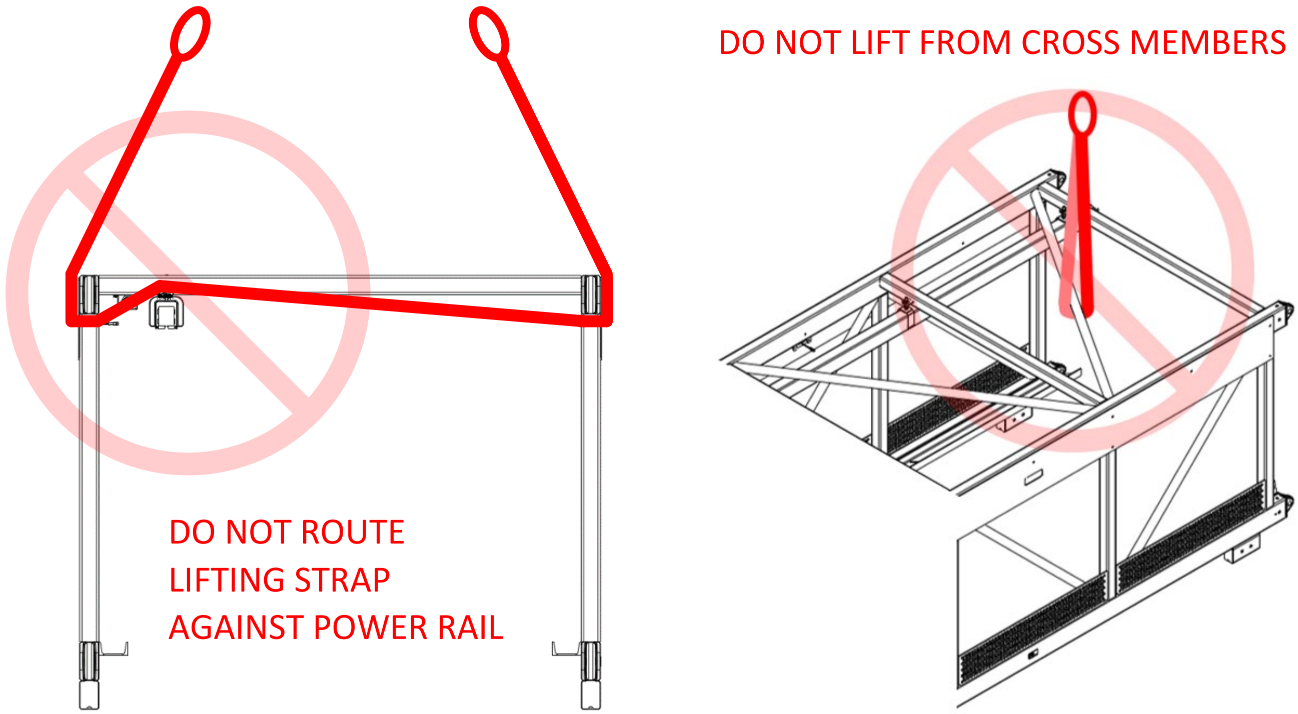



Figure 13: Improper Component Rigging

# Emergency Stops & Movement Stops

Each TyBOT unit is equipped with several E-STOP buttons for the purpose of rapid machine shutdown in the event of an emergency. Each unit is additionally provided with manually configurable movement stops to minimize safety and damage risks. Refer to Operation Section IV. for detailed information regarding the purpose and placement of the movement stops.

## Emergency Stops

Next to each of the TyBOT unit's four support Legs is an emergency stop button (E-STOP). Pushing any of these E-STOPS will immediately disrupt power to the unit. The E-STOPS should be visually checked for damage and cycled through their depressed/undepressed positions prior to each startup (see Figure 14).

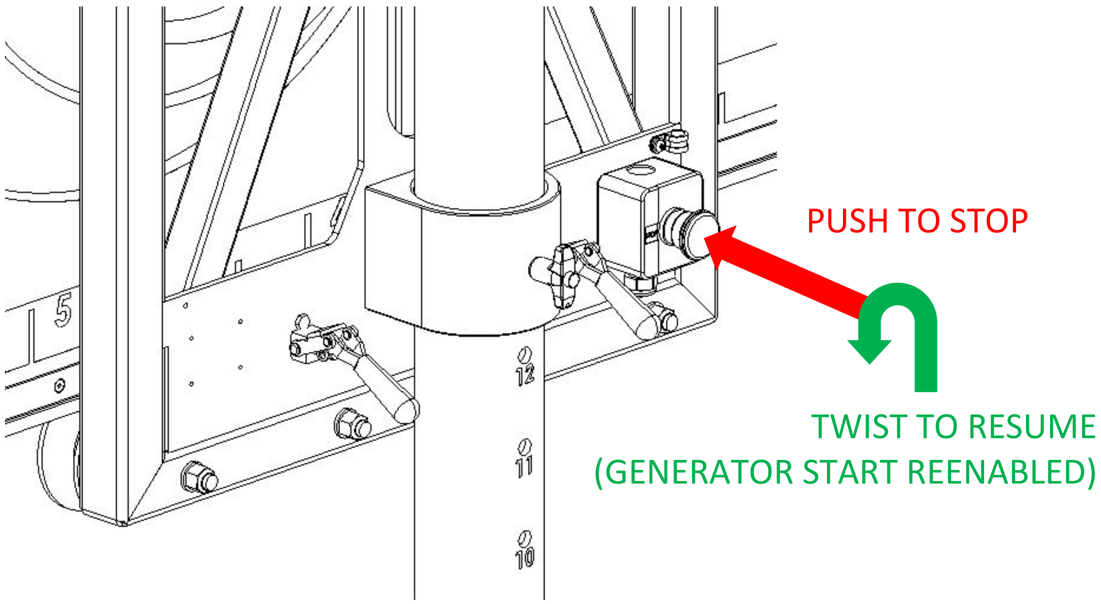



*Figure 14: E-STOP Actuation*

An additional STOP button is located on the TyBOT unit's Belly Box. When pressed, this button ***will not disrupt power to the TyBOT*** unit but will disrupt all tie/travel activity.

## Gantry Stops

The TyBOT unit's up/down-bridge travel should always be limited in both directions by the placement of four Gantry stops on the bridge deck's screed rails – two in front of the unit (positive side) and two behind the unit (negative side), as in Figure 15.

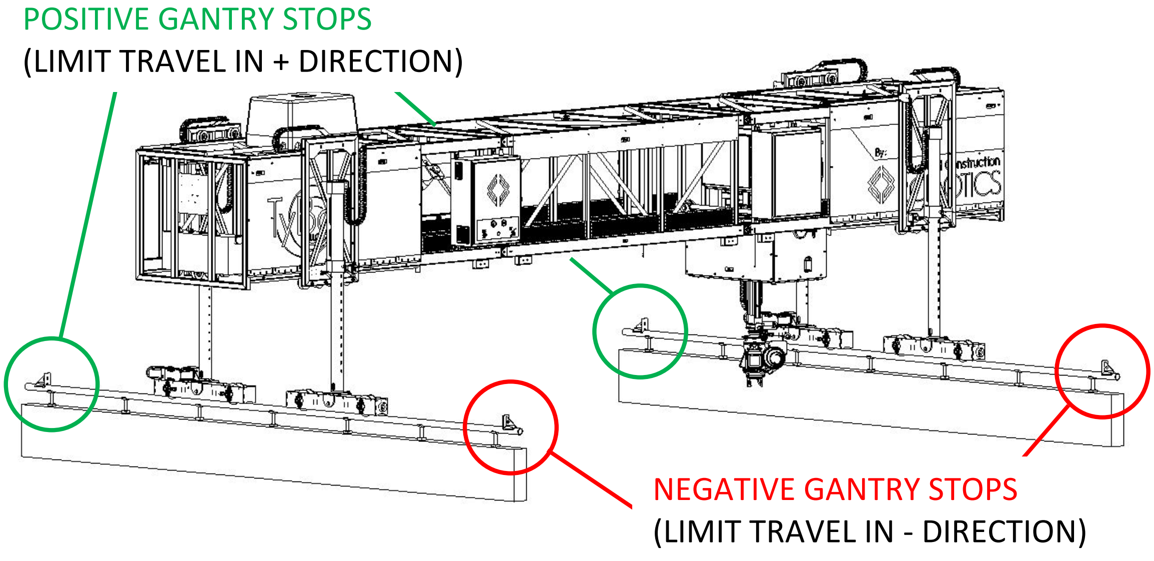



*Figure 15: Gantry Stop*

## Tram Stops

The TyBOT unit's Tram should always be travel-limited by two Tram stops positioned along the Tram travel rails. When properly placed and secured, as in Figure 16, these stops protect the Tram from collision with screed rail support walls and rebar mat obstructions. **Do not remove or bypass either Tram stop.**

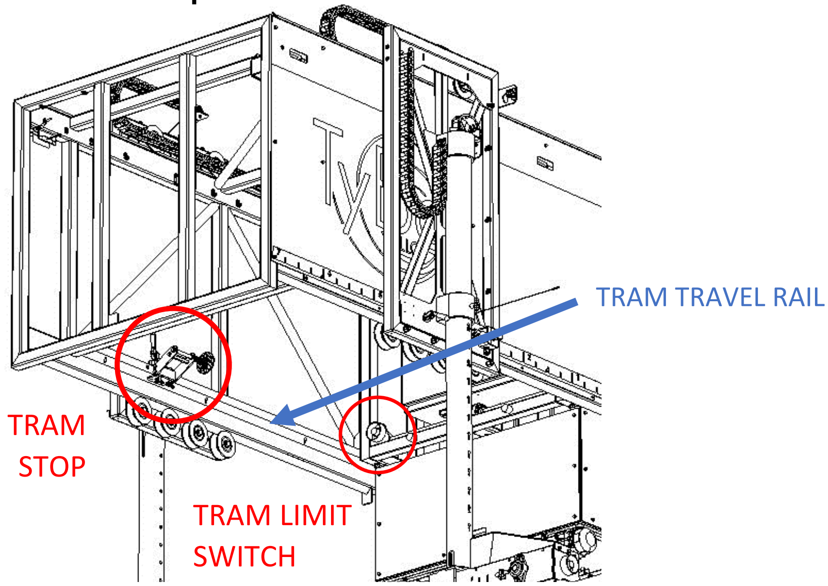



*Figure 16: Tram Stop & Limit Switch*

The Tram travel band (between the Tram stops) should be continuously monitored for obstructions.

**On worksites at which people and/or equipment pass through the Tram travel band, the risk of being struck by the Tram in this area should be clearly conveyed to those potentially affected.**

Figure 17 illustrates the travel band in which this collision risk exists.

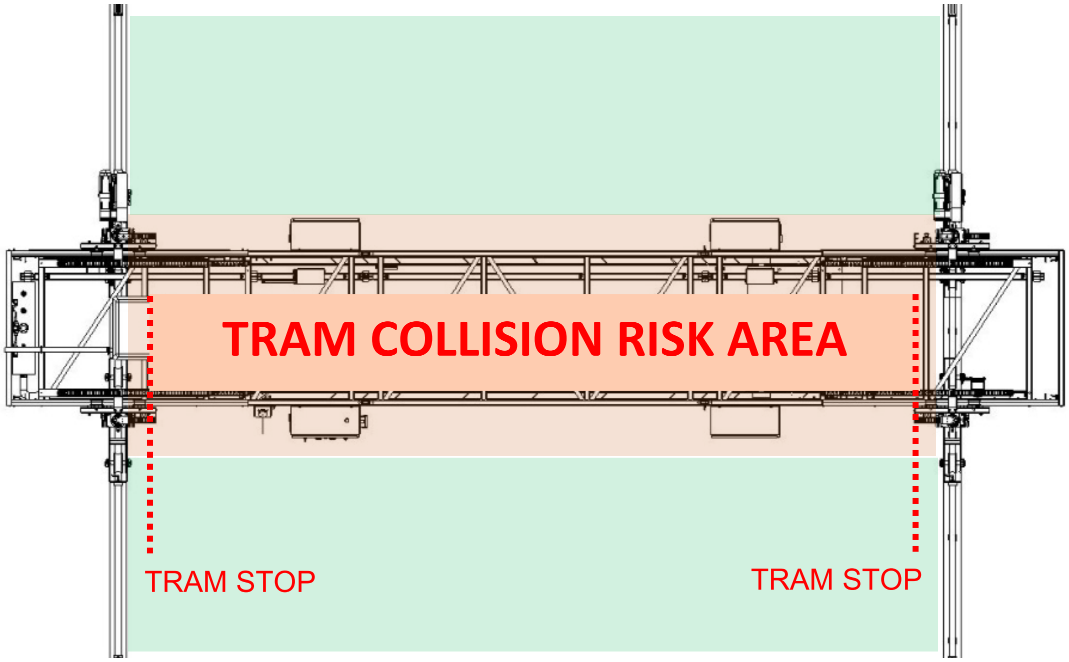



*Figure 17: Tram Travel Band – Collision Risk*

## Tram Lock

The TyBOT unit's Tram is equipped with a lock-pin mechanism for preventing Tram movement in over-road transit (see Figure 18). This mechanism should remain disengaged from the lock bore in the Passenger Gantry Frame when not in over-road transit. Its disengagement should be verified before each startup.

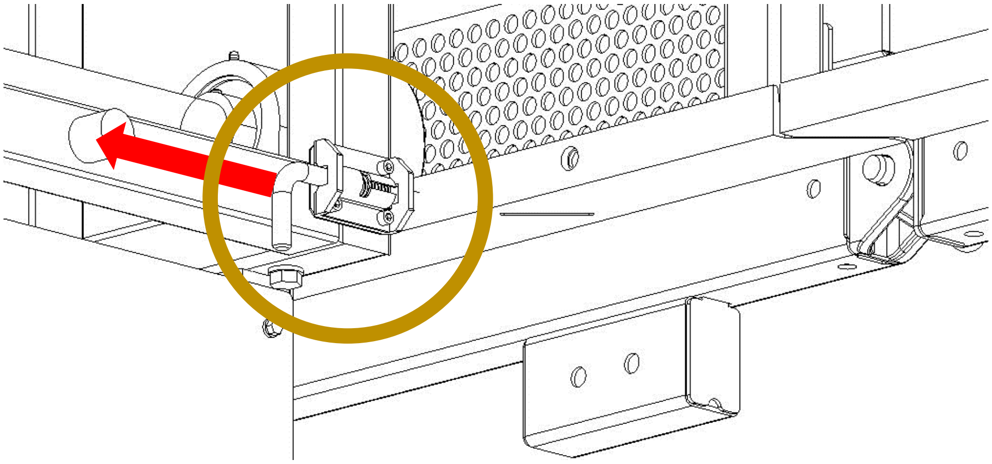


*Figure 18: Tram Lock Release*

# III. CONFIGURATION

TyBOT unit configuration should be in accordance with the protocols described in Section II. on Safety, and only by authorized persons. All applicable state and local regulations should be understood and concurrently observed.

To accommodate a range of bridge designs and sizes, each TyBOT unit is accordingly adjustable in height and width. Appropriate TyBOT unit configuration is prerequisite to effective operation and includes jobsite measurement as well as proper use of the provided configurator tools. These topics, along with adjustment procedures, are detailed herein.

Please contact TyBOT Service and Support for any configuration assistance.

## Jobsite Measurement

Several jobsite measurements should be recorded to begin configuration. These measurements determine the necessary adjustments when input to the configurator tools, found in Reference Section and on the website.

Jobsite measurements essential for proper unit configuration include:

| MEASUREMENT | UNITS | IMPACTED CONFIGURATION |
|---|---|---|
| *SCREED RAIL WIDTH* | FEET - INCHES | TRUSS COMBINATION |
| *SKEW ANGLE* | DEGREES | TRUSS COMBINATION |
| *SCREED RAIL HEIGHT* | INCHES | LEG HEIGHT |

### Screed Rail Width

Screed rail width should be measured perpendicular to the rails, as in Figure 19, and recorded for input to the TyBOT Leg Height Calculation in the TyBOT Configuration Calculator.

**Note that this measurement should be taken from rail-center to rail-center, with precision to the nearest inch.**

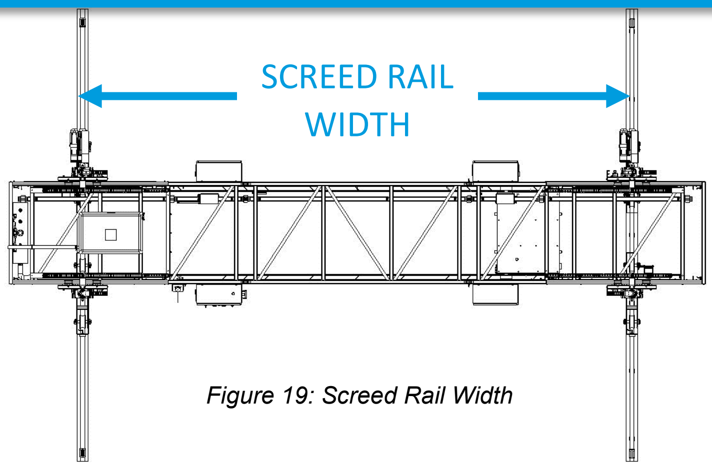



*Figure 19: Screed Rail Width*

## Skew Angle

The TyBOT unit can sit askew on the screed rails to tie diagonally placed rebar and oddly shaped approach areas more efficiently. If skewed operation is intended, the skew angle should be measured and recorded for input to the TyBOT Truss Middle Section Calculation in the TyBOT Configuration Calculator, found at constructionrobots.com.

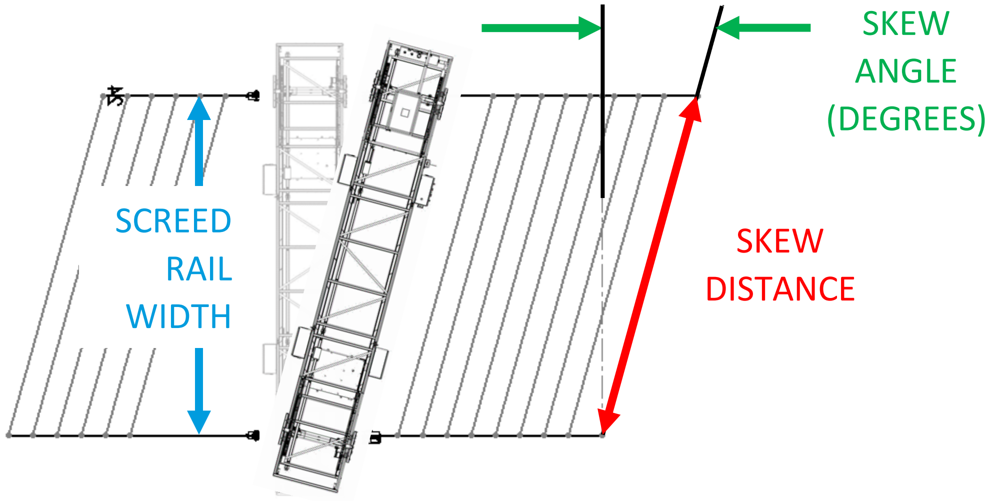



*Figure 20: Skew Angle & Distance*

Operation Section IV. provides instruction regarding manual skewing, whereby the TyBOT unit can be driven from a perpendicular orientation to a skewed orientation.

## Screed Rail Height

Screed rail height should be measured perpendicular to the rebar mat and recorded for input to the TyBOT Leg Height Calculation in the TyBOT Configuration Calculator. Note that this measurement should be taken from rail center to the top of the rebar mat, as in Figure 21, with precision to the nearest inch.

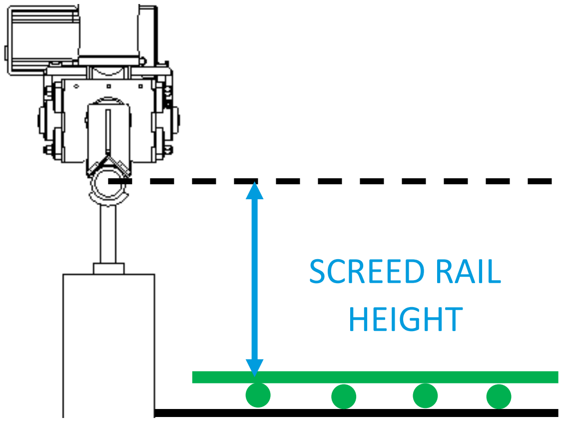



*Figure 21: Screed Rail Height*

# TyBOT Truss Configuration

The TyBOT Truss Middle Section Calculator is a configuration tool provided to determine the optimal TyBOT Truss combination for a given bridge layout and is part of the TyBOT Configuration Calculator. Measurements of screed rail width and skew dimensions are required for its use.

## TyBOT Truss Middle Section Calculator

Figure 22 illustrates the input fields of the TyBOT Truss Middle Section Calculator in the TyBOT Configuration Calculator*:*

**TyBOT Middle Section Calculator**

| | | | |
|---|---|---|---|
| **TyBOT Model** | 2.0 | | Choose 1.5 or 2.0 |
| **Buffer** | 4.5 | **in** | Minimum spacing from leg interface frame to end-stop (Nominal 4.5") |
| Max Angle | 42 | deg | Maximum Skew Angle with NO safety buffer |
| Max Buffered Angle | 37.2 | deg | Maximum Skew Angle with given safety buffer |
| **Known Skew Distance?** | No | | If distance measurement is the skewed distance, select "Yes", otherwise "No" |
| **Distance** | 24.5 | **ft** | Distance measurement |
| **Angle** | 0 | **deg** | Skew angle |
| Skew Distance | 24.5 | ft | Skewed rail-rail distance |
| Orthogonal Distance | 24.5 | ft | Right-angle rail-rail distance |
| Skew Adjustment Value | 0 | ft | Position difference between front and back legs on same end of robot |

*Figure 22: Truss Middle Section Calculator Inputs*

Figure 27 on Page 24 is a quick reference chart that can be used instead of the calculator above.

The orange-filled cells in the calculator shown above are to be filled by the user. The topmost of these, labeled “**Type**” specifies the model of robot: 1.5 or 2.0. The cell “**Buffer**,” limits how close any of the TyBOT unit’s Leg interfaces may come to its end-stops in the output configuration recommendation**.**

**The “Buffer” value is nominally set to 4.5 IN and should not be adjusted below 3 IN, as illustrated in Figure 23.**

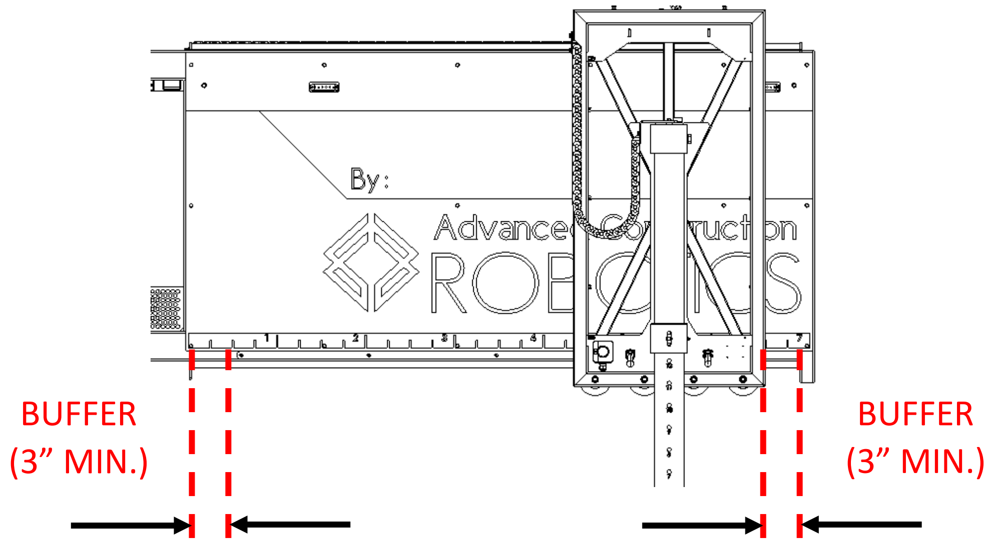



*Figure 23: Leg Interface Buffer*

If an orthogonal (no skew) orientation is intended, the cell labeled “**Known Skew Distance?**” should be set to “**No”** and the cell labeled **“Angle”** should be set to **“0.”** The cell labeled “**Distance**” should then be filled in with the screed rail width measurement, as in Figure 24.

| | | |
|---|---|---|
| **Known Skew Distance?** | No | |
| **Distance** | 24.5 | **ft** |
| **Angle** | 0 | **deg** |
| | | |
| Skew Distance | 24.5 | ft |
| Orthogonal Distance | 24.5 | ft |
| Skew Adjustment Value | 0 | ft |

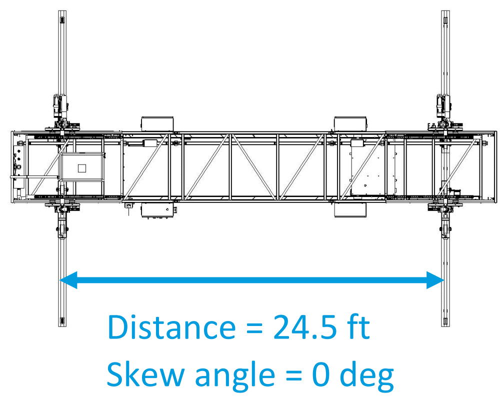



*Figure 24: Orthogonal Configuration*

If a skewed orientation is intended, the skew angle must be measured and filled in. The screed rail width **OR** skew distance can be measured and filled in as the “**Distance”** value to the same effect, as in Figure 25.

| **Known Skew Distance?** | No | |
|---|---|---|
| **Distance** | 24.5 | **ft** |
| **Angle** | 20 | **deg** |
| | | |
| Skew Distance | 26.1 | ft |
| Orthogonal Distance | 24.5 | ft |
| Skew Adjustment Value | 1.8 | ft |

| **Known Skew Distance?** | Yes | |
|---|---|---|
| **Distance** | 26.1 | **ft** |
| **Angle** | 20 | **deg** |
| | | |
| Skew Distance | 26.1 | ft |
| Orthogonal Distance | 24.5 | ft |
| Skew Adjustment Value | 1.8 | ft |

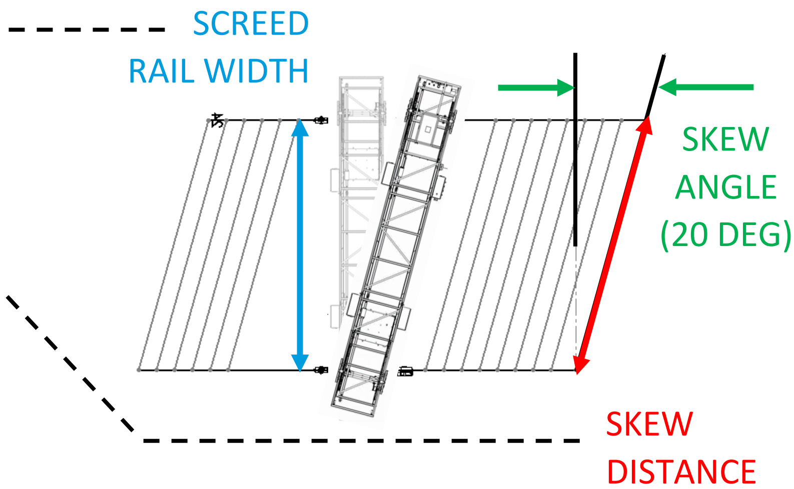



*Figure 25: Skewed Configuration Using Screed Rail Width or Skew Distance*

Figure 26 illustrates the output fields of the TyBOT Truss Middle Section Calculator*:*

| | | | Overhang (ft) | | | Width (ft) | | Weight |
|---|---|---|---|---|---|---|---|---|
| **No 1M Middle** | MS-1 | MS-2 | Min | Balanced | Max | Min | Max | Lbs. |
| Skew Middles | 1 | 1 | 1.6 | 4.2 | 5.0 | 23.1 | 24.3 | 4525 |
| Straight Middles | 1 | 1 | 1.6 | 3.2 | 4.8 | 19.5 | 27.9 | 4525 |
| **With 1 - 1M Middle** | MS-1 | MS-2 | Min | Balanced | Max | Min | Max | Lbs. |
| Skew Middles | 1 | 1 | 3.8 | 5.8 | 5.7 | 26.4 | 27.6 | 4700 |
| Straight Middles | 1 | 1 | 3.6 | 4.8 | 5.7 | 22.8 | 31.2 | 4700 |
| **With 2 - 1M Middle** | MS-1 | MS-2 | Min | Balanced | Max | Min | Max | Lbs. |
| Skew Middles | 1 | 0 | N/A | N/A | N/A | N/A | N/A | N/A |
| Straight Middles | -1 | 0 | N/A | N/A | N/A | N/A | N/A | N/A |

| **Best Configuration:** | | |
|---|---|---|
| **Required # 3M Middle** | 1 | |
| **Required # 1M Middle** | 0 | |
| | | |
| Skewed leg spacing | 7.36 | ft |
| Straight leg spacing | 5.76 | ft |
| | | |
| Weight | 4525 | lbs |

If the MS-1 and MS-2 numbers match then this is the number of middle sections needed for the given configuration. If the MS-1 and MS-2 numbers do not match, then this spacing configuration is not possible.

If all four numbers match (MS-1 and MS-2) for Skew and Straight, then the same configuration can be used for skewed or straight operation, and will be shown as the "Best Configuration" below.

Valid configurations are highlighted in green

Overhang is from center of screed rail in feet. Weight in pounds.

Leg spacing is the sum of the leg adjustment measurements of the passenger and driver side. For skewed operation, the "lagging" leg cannot be closer than the "Skew Adjustment Value" above.

*Figure 26: Truss Middle Section Calculator Outputs*

**As noted on the TyBOT Truss Middle Section Calculator, valid configurations for the input measurements will be highlighted in green. For the example given (screed rail spacing of 24.5’ and an intended skew angle of 20 degrees), the “Best Configuration” includes one 3M middle and zero 1M middles. Note that the recommended Leg spacing values apply to this “Best Configuration” only.**

Figure 27 is a quick reference chart that can be used instead of the TyBOT Truss Middle Section Calculator (larger copy found in Reference Section):

Skew Angle (degrees)

| Rail-to-Rail (ft) / 1 | 0 | 2.5 | 5 | 7.5 | 10 | 12.5 | 15 | 17.5 | 20 | 22.5 | 25 | 27.5 | 30 | 32.5 | 35 | 37.5 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 1 | 1 | 1 | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE |
| 22.5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | FALSE | FALSE | FALSE | FALSE |
| 25 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | FALSE | FALSE | FALSE | FALSE |
| 27.5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | FALSE | FALSE |
| 30 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | FALSE |
| 32.5 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | FALSE | FALSE | FALSE | FALSE |
| 35 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | FALSE | FALSE | FALSE | FALSE | FALSE |
| 37.5 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | FALSE | FALSE |
| 40 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | FALSE |
| 42.5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | FALSE | FALSE | FALSE |
| 45 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | FALSE | FALSE | FALSE | FALSE | FALSE |
| 47.5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | FALSE | FALSE | FALSE |
| 50 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | FALSE |
| 52.5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | FALSE | FALSE | FALSE |
| 55 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | FALSE | FALSE | FALSE | FALSE | FALSE |
| 57.5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | FALSE | FALSE | FALSE |
| 60 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | FALSE |
| 62.5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | FALSE | FALSE |
| 65 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | FALSE | FALSE | FALSE | FALSE | FALSE |
| 67.5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | FALSE | FALSE | FALSE | FALSE |
| 70 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | FALSE | FALSE |
| 72.5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | FALSE | FALSE |
| 75 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | FALSE | FALSE | FALSE | FALSE |
| 77.5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | FALSE | FALSE | FALSE | FALSE |
| 80 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | FALSE | FALSE |
| 82.5 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | FALSE |
| 85 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | FALSE | FALSE | FALSE | FALSE |
| 87.5 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | FALSE | FALSE | FALSE | FALSE | FALSE |
| 90 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | FALSE | FALSE |
| 92.5 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | FALSE |
| 95 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | FALSE | FALSE | FALSE |
| 97.5 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE |
| 100 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | FALSE | FALSE | FALSE |

\# in cell = # of 3m Middle Sections | 0 (1m Middle) | 1 (1m Middle) | 2 (1m Middle)

*Figure 27: TyBOT Truss Middle Section Quick Reference*

## Installing & Removing Truss Middle Sections

The processes of installing and removing TyBOT unit Truss Middle Sections should be in accordance with the protocols described in Section II. on Safety and completed only by authorized persons. All applicable state and local regulations should be understood and concurrently observed. Ensure that the machine is powered off during this process, otherwise there will be an exposed electrical hazard.

Truss Middle Section installation and removal both require that the TyBOT unit be on solid and level ground. Adequate lift capacity must be available above each Truss Middle Section and the location to which the Passenger-Side Gantry will shift upon reassembly of the unit. As in Figure 28, adequate space must be available into which the TyBOT unit can be disassembled/expanded.

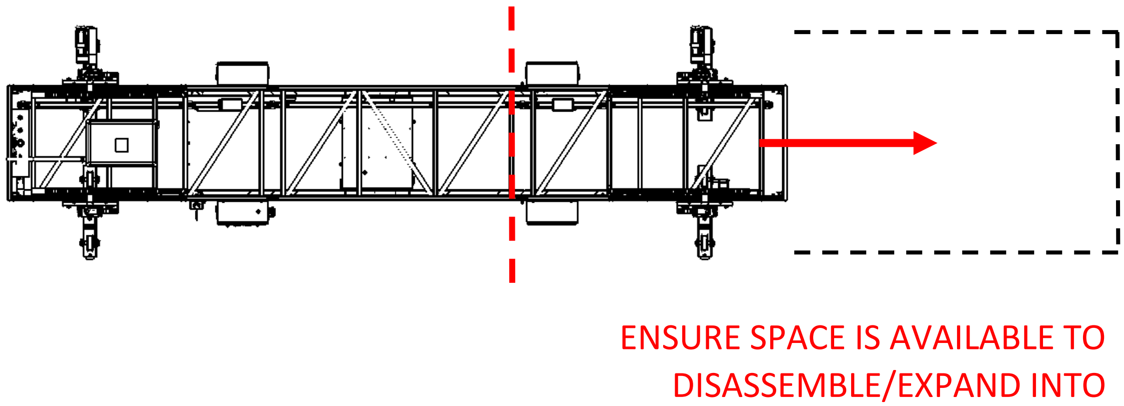



*Figure 28: Disassembly Space*

Truss Middle Section installation and removal both require that the TyBOT unit's Tram be driven into the Driver-Side Gantry, as in Figure 29. The TyBOT unit should then be powered down before continuing the disassembly procedure.

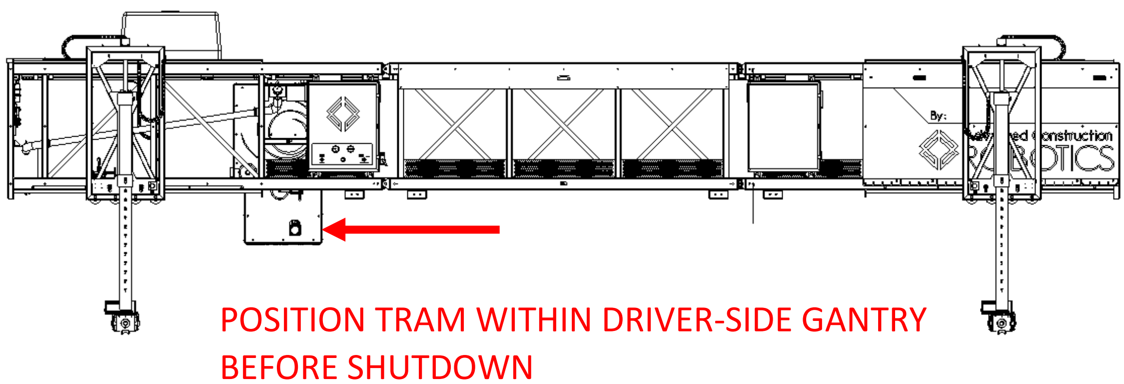



*Figure 29: Tram Position - Disassembly*

Removal of the Passenger-Side Gantry is prerequisite to Truss Middle Section installation and removal. Disconnect the Gantry System's power rail by first opening the junction cover and then sliding each conductor out of its spring clip, as in Figure 30. The power rail should then be slid a few inches away from the adjacent Truss Middle Section to verify complete power rail disconnection.

**SAFETY NOTE: NEVER REMOVE THE JUNCTION COVER WHILE THE MACHINE IS POWERED ON.**

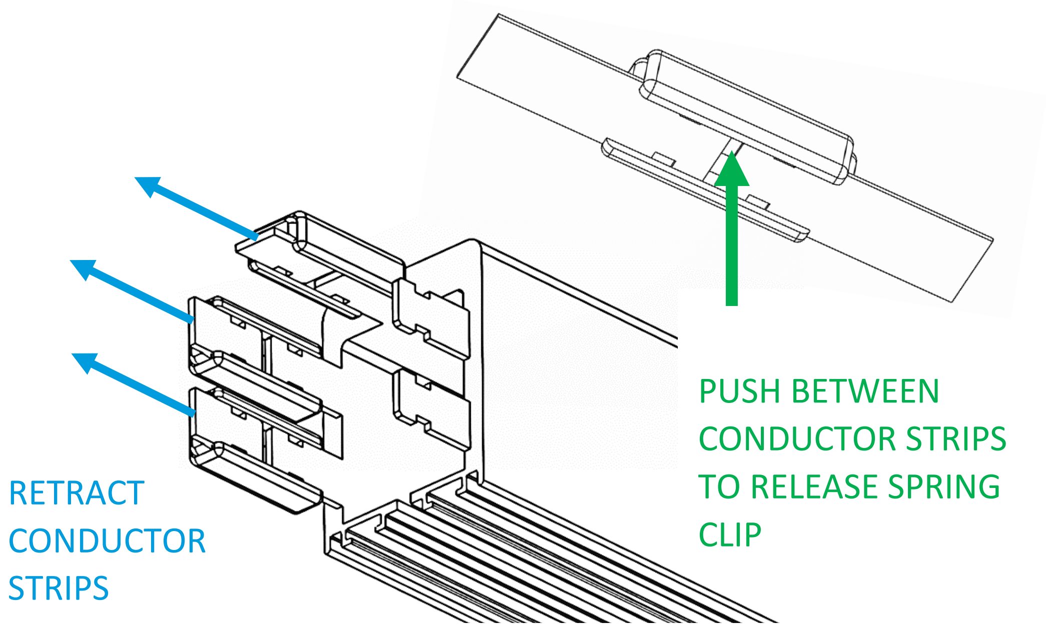



*Figure 30: Power Rail Disconnection*

Disconnect the Passenger-Side Gantry wire harness at its junction-box termination just above the power rail by gently turning ¼ turn counterclockwise, as in Figure 31.

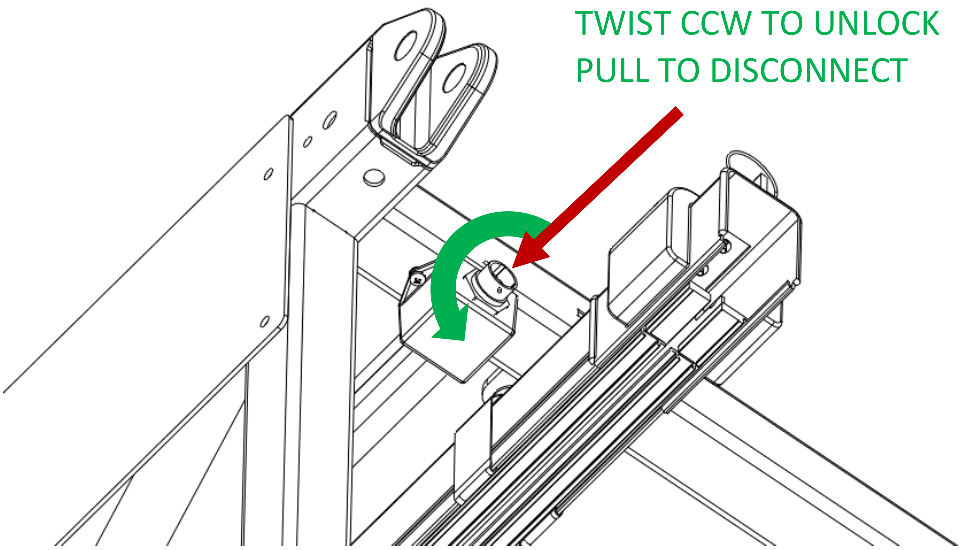



*Figure 31: Wire Harness Disconnection*

With its power rail and wire harness disconnected, the Passenger-Side Gantry should be rigged and lifted such that an assembly stand can be installed under the Truss Middle Section adjacent to the Gantry System, as in Figure 32.

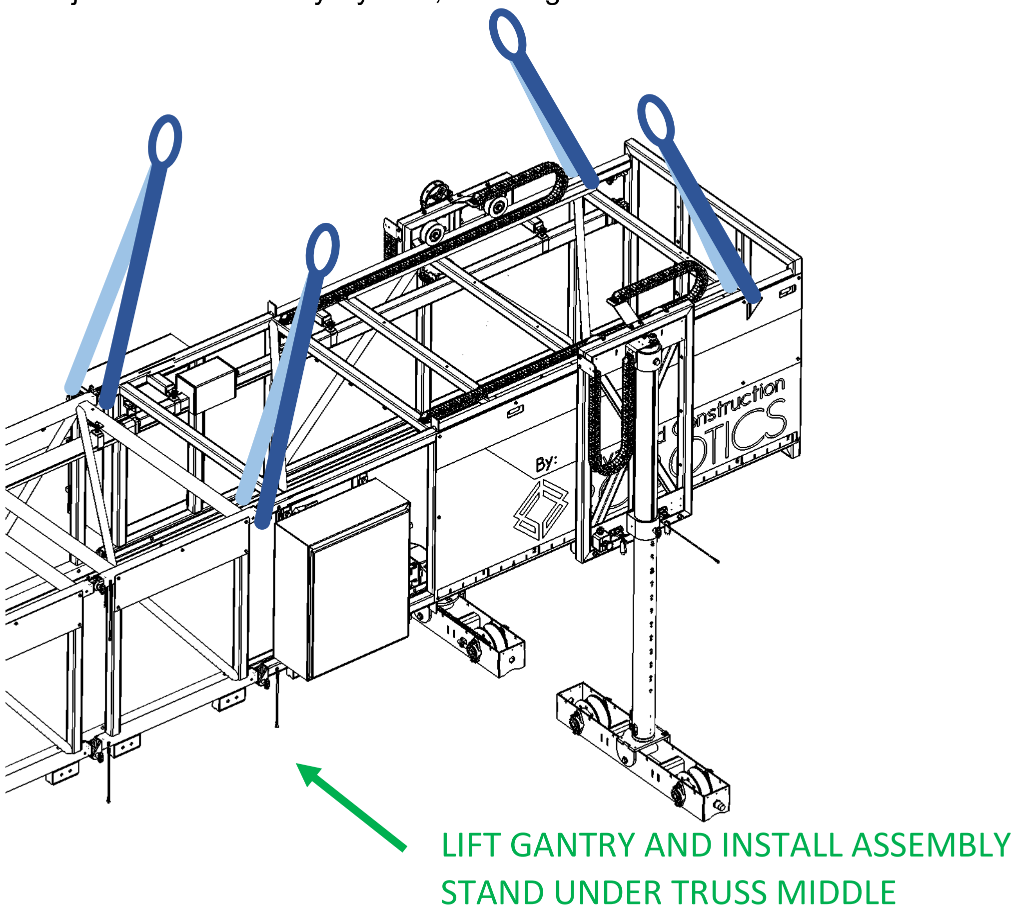



*Figure 32: Passenger-Side Gantry Lift*

Extend the assembly stand Legs such that their feet are approximately 6” lower than the Passenger-Side Gantry wheels. Gently lower the load until the assembly stand feet barely touch the ground, supporting the Gantry System weight as in Figure 33.

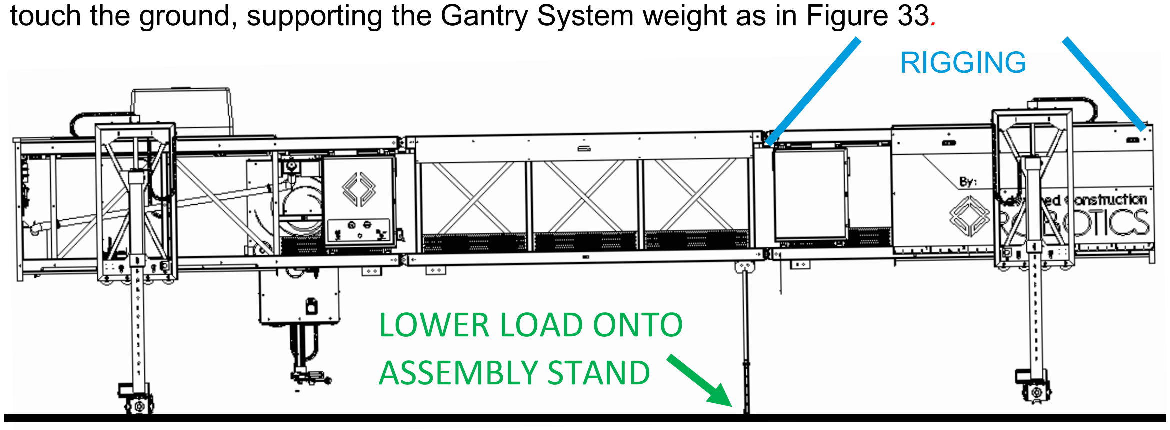



*Figure 33: Load Transfer to Assembly Stand*

Adjust the load as necessary to minimize tension in the four Gantry pins. Remove each pin by hand, starting with the top pins followed by the bottom pins, and slowly shift the Passenger-Side Gantry away from the adjacent Truss Middle Section as in Figure 34.

**DO NOT STRIKE A PIN TO FORCE ITS REMOVAL. IF A PIN IS BOUND, ADJUST THE LOAD TO RESOLVE THE BINDING CONDITION.**

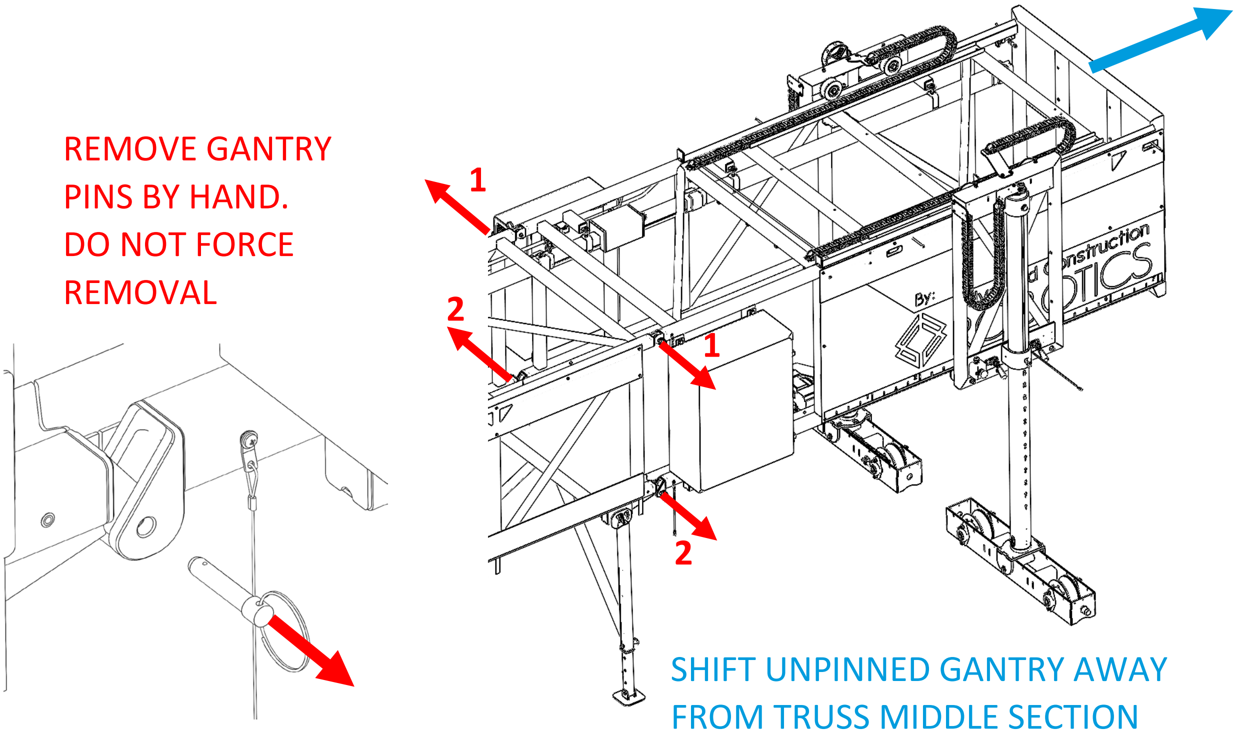



*Figure 34: Truss Pin Removal*

Install a second assembly stand under the removed Passenger-Side Gantry. Extend the assembly stand Legs such that their feet are level with the Gantry wheels. As in Figure 35, lower the Gantry System to solid, level ground away from the TyBOT unit to create space for Truss Middle Section installation/removal.

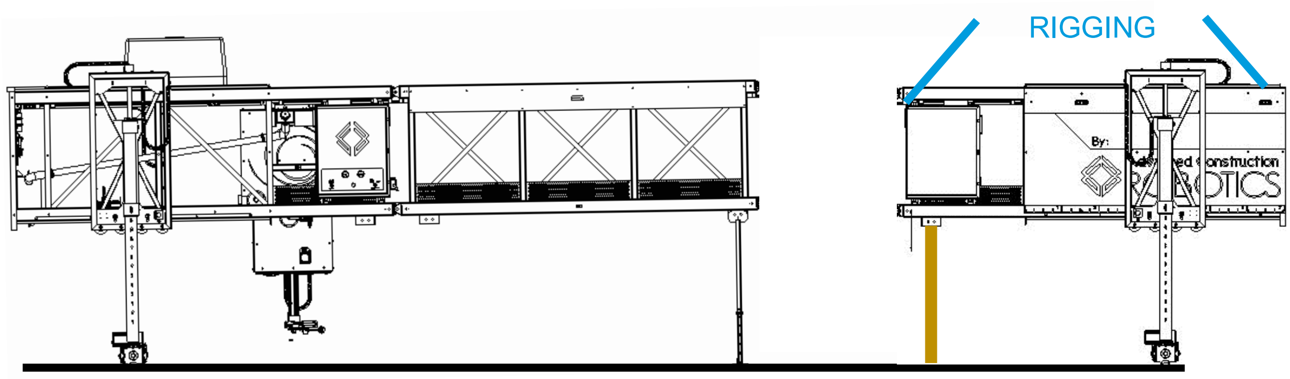



*Figure 35: Passenger-Side Gantry Support*

Install a Truss Middle Section to the disassembled TyBOT unit by first rigging and lifting the Section as in Figure 36. Orient the Truss Middle Section toward the Driver-Side Gantry such that the power rails and clevis connectors are aligned.

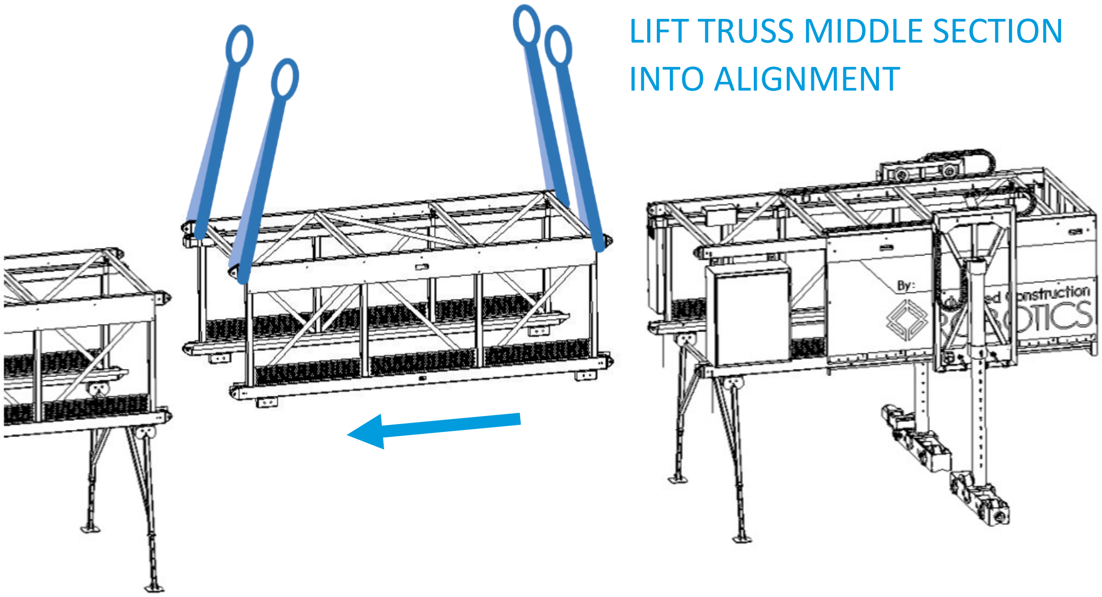



*Figure 36: Aligning Truss Middle Section*

Adjust the load as necessary to allow the lower two Gantry pins to be inserted by hand. Once these are in place, insert the upper two Gantry pins by hand.

**DO NOT STRIKE A PIN TO FORCE ITS INSERTION. IF A PIN IS BOUND, ADJUST THE LOAD TO RESOLVE THE BINDING CONDITION.**

With the Gantry pins installed, lift the Truss Middle Section just enough to relieve weight from the assembly stand Legs. Reposition the assembly stand to the Passenger-Side of the newly installed Truss Middle Section, as in Figure 37, and lower the load to solid, level ground.

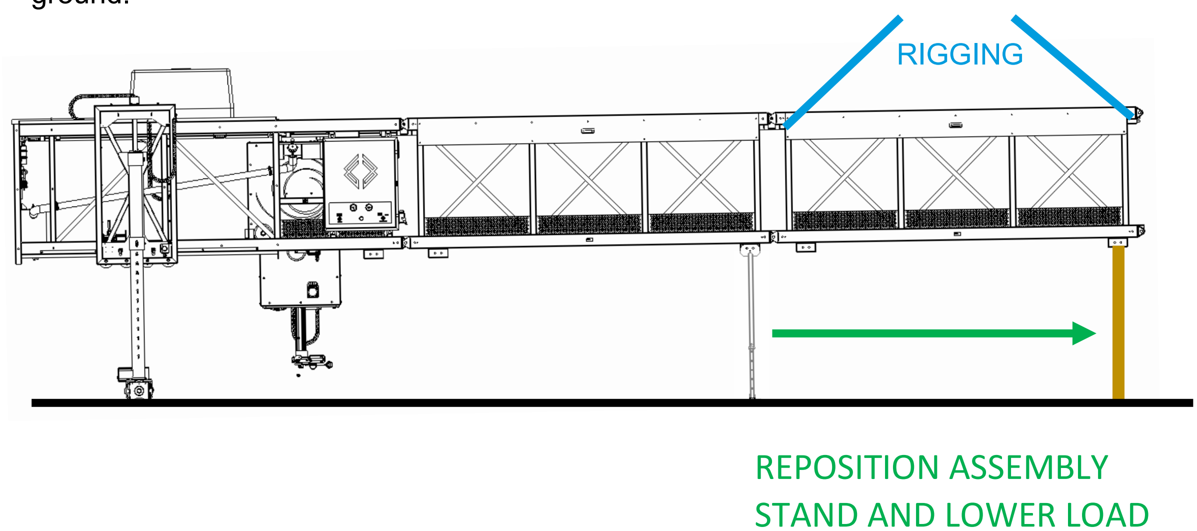



*Figure 37: Reposition Assembly Stand*

Complete the Truss Middle Section installation by connecting the wire harness and power rails on the Driver-Side. Gently hand tighten the harness connectors ¼ turn until they click, do not use a wrench or over-tighten. Ensure that the power rail conductor strips are fully secure in the spring clips before closing the junction cover.

Truss Middle Section removal and reinstallation of the Passenger-Side Gantry follows the above procedure in reverse. Note that all power rail junctions should be properly covered before attempting to start the reconfigured TyBOT unit.

# TyBOT Leg Height Configuration

The TyBOT Leg Height Calculator is a configuration tool provided to determine the TyBOT Leg height for a given bridge layout and is part of the TyBOT Configuration Calculator. Measurements of screed rail height and crown height are required for its use.

## TyBOT Leg Height Calculator

Figure 38 illustrates the TyBOT Leg Height Calculator in the TyBOT Configuration Calculator*:*

### TyBOT Leg Height Calculator

**Inputs**

| | | | |
|---|---|---|---|
| Rail to Rebar | 15 | in | Maximum Screed Rail to smallest bar size height |
| Max Crown | 5 | in | Maximum Crown Height |

| **Outputs** | Min Pin | Max Pin | |
|---|---|---|---|
| Camera to Rebar | 32 | 60 | in |
| Pin Setting | 9 | 13 | hole # |
| Clearance to Mat | 0.75 | 12.75 | in |

The MINIMUM and MAXIMUM pin values are listed. If it is red, then an acceptable pin height setting is not achievable for the desired configuration. The highest pin height setting is preferred for maximum clearance over the mat.

Pin hole 1 is the bottom hole.

| | | |
|---|---|---|
| Minimum Camera to Rebar | 27 | in |
| Maximum Camera to Rebar | 60 | in |
| Maximum Rail to Rebar | 69 | in |
| Minimum Rail to Rebar | 0 | in |

*Figure 38: TyBOT Leg Height Calculator Interface*

Figure 39 is additionally provided as a Leg height configuration reference. Note that screed rail height (SRH) is nonuniform across crowned rebar mats. In such cases, the screed rail height value used for configuration should be the maximum measurement and it should be verified that the Tie Module can clear the tallest part of the crown before proceeding.

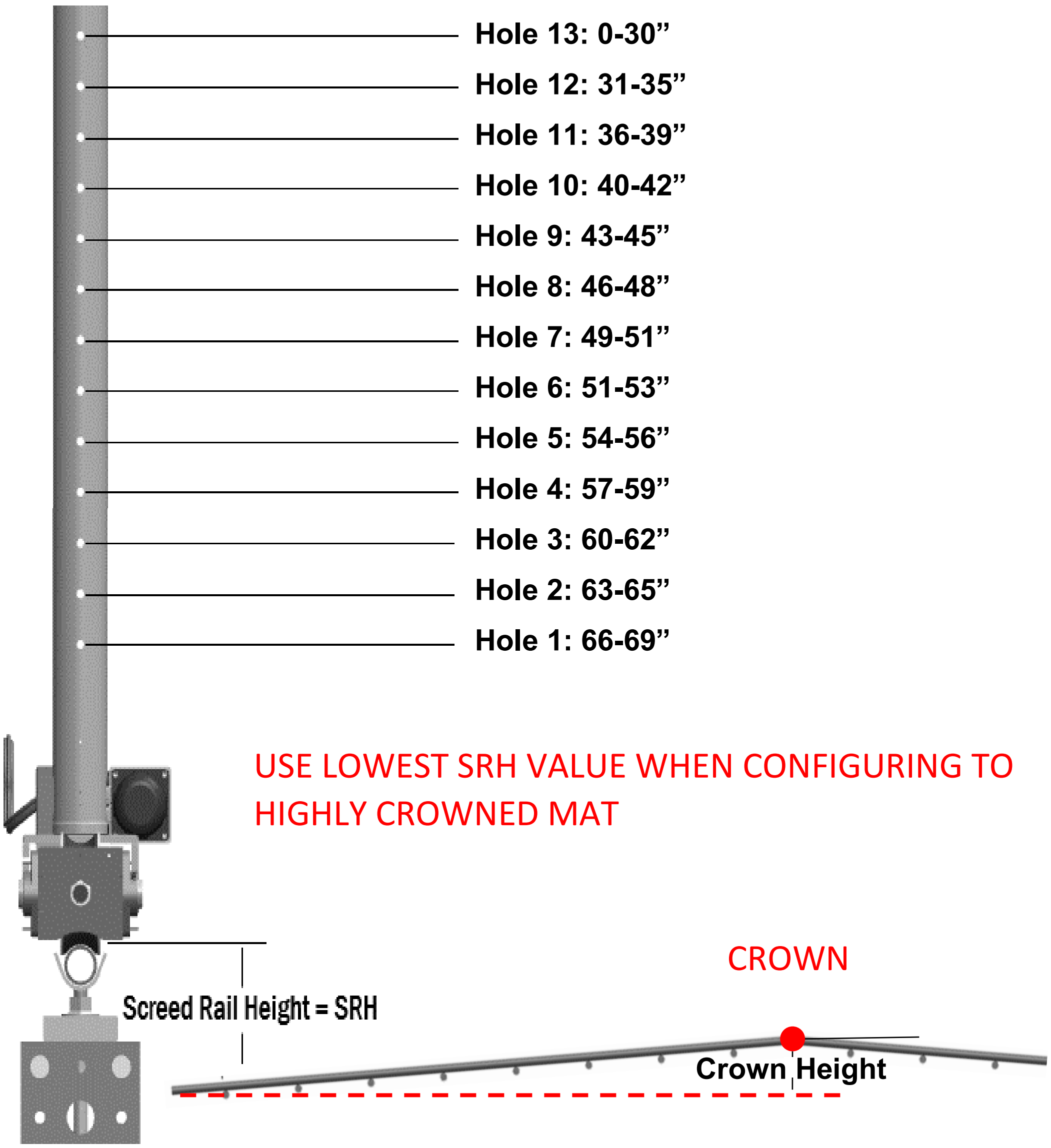


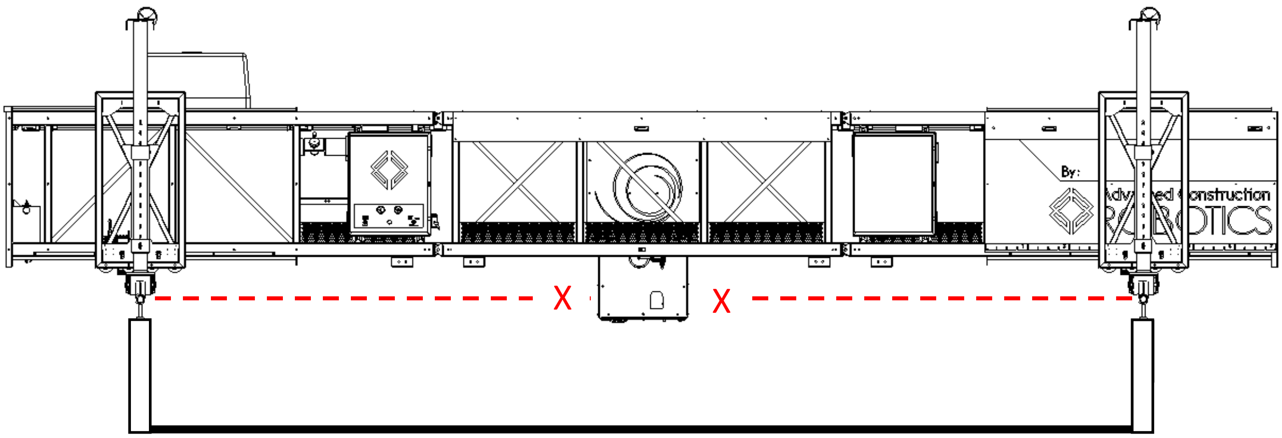

*Figure 39: Leg Height Quick-Reference*

## Increasing & Decreasing Leg Height

TyBOT unit Leg height adjustment should be in accordance with the protocols described in Section II. on Safety and completed only by authorized persons. All applicable state and local regulations should be understood and concurrently observed.

**INCREASE AND DECREASE OF THE TYBOT UNIT'S LEG HEIGHT SHOULD BE COMPLETED ON SOLID AND LEVEL GROUND**.

**EXCEPTION:** To maintain adequate clearance between the ground surface and the TyBOT unit's Tram, adjustments at Leg pin holes **1-3** should be completed on-bridge, as Figure 40. *Special precaution for such cases is detailed following the general Leg height adjustment procedure.*




LOW-POSITION ADJUSTMENT (PIN HOLES **1-3**)
MUST BE DONE ON-BRIDGE FOR TRAM CLEARANCE
ALL OTHER HEIGHT ADJUSTMENTS MUST BE DONE
OFF-BRIDGE FOR GREATEST SAFETY

*Figure 40: Low-Position Leg Height Adjustment (On-Bridge)*

Adequate lift capacity must be available above each of the TyBOT unit's Gantries to commence Leg height adjustment. The unit's Tram should be manually positioned between the Gantries and the Z-actuator should be raised to the top of its range as in Figure 41. The Tie Module should also be removed.

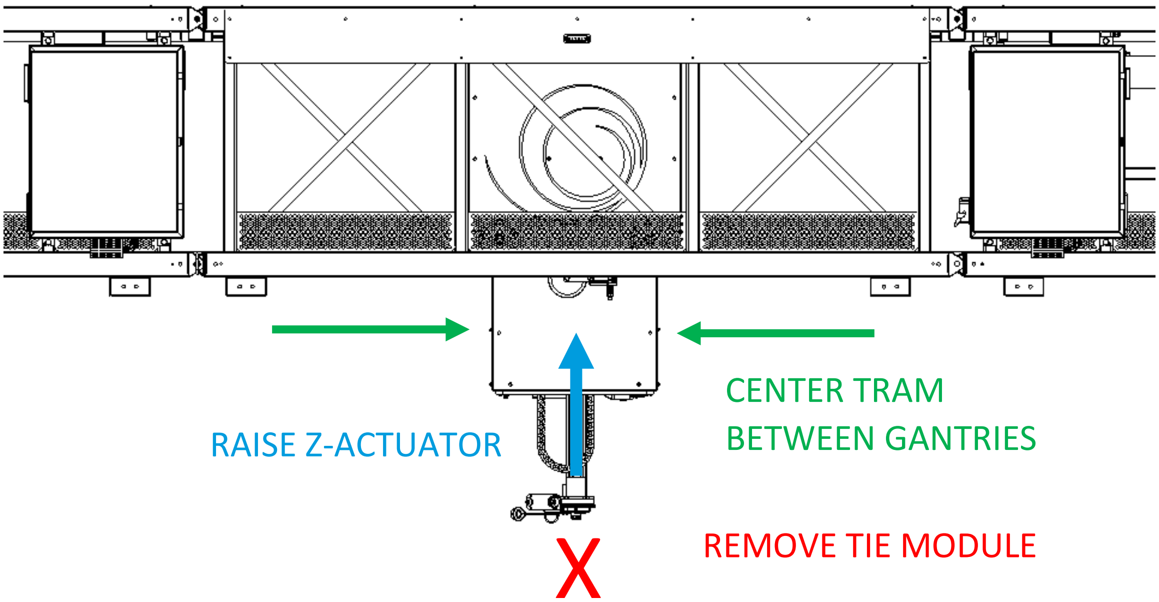



*Figure 41: Leg Height Adjustment Precautions*

Begin Leg height adjustment by rigging the Driver-Side Gantry as in Figure 42. The Gantry System should then be lifted such that the weight of the unit is barely relieved from the Driver-Side Gantry's drive wheels.

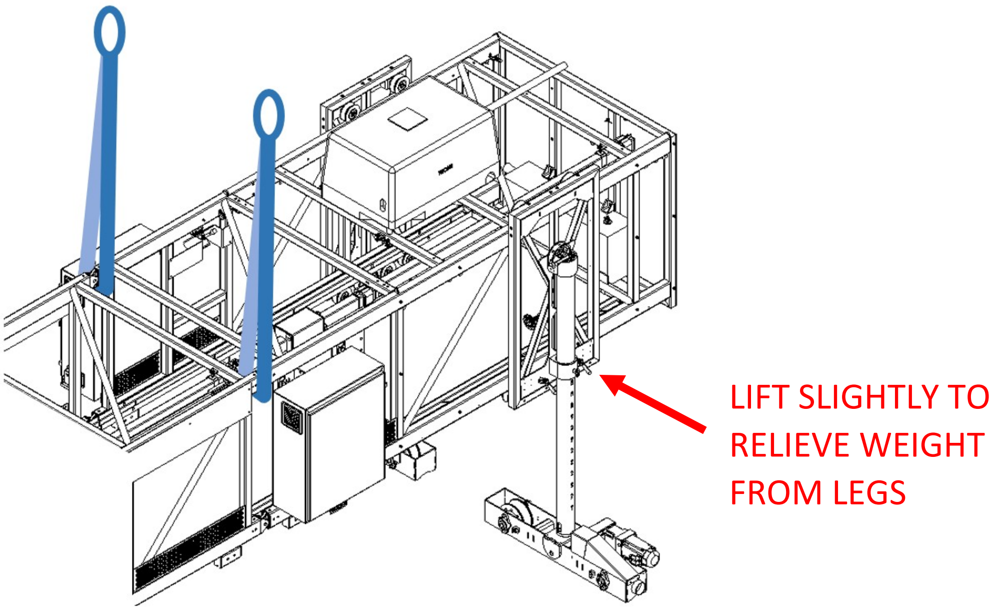



*Figure 42: Leg Height Adjustment Rigging*

Adjust the load as necessary to minimize tension in the Driver-Side Gantry's two Leg pins. Remove each pin by hand. As in Figure 43, lift or lower the load to align the Leg bracket bores to the pin hole suggested by the TyBOT Leg Height Calculator, found on constructionrobots.com, for the given bridge layout. Reinsert the Gantry System's Leg pins by hand.

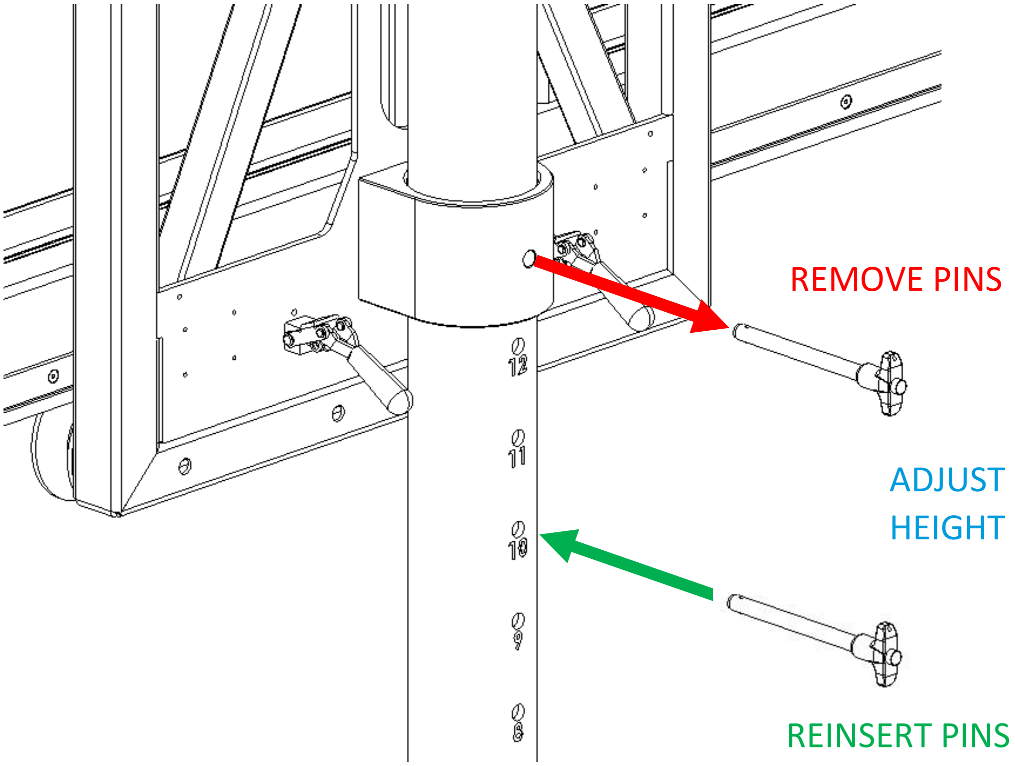



*Figure 43: Leg Pin Removal & Insertion*

**DO NOT STRIKE A PIN TO FORCE ITS REMOVAL OR INSERTION. IF A PIN IS BOUND, ADJUST THE LOAD TO RESOLVE THE BINDING CONDITION.**

Lower the load and unrig the Driver-Side Gantry. Repeat the above process on the Passenger-Side Gantry to bring all four Legs to the height suggested by the TyBOT Leg Height Calculator.

Leg height adjustments at pin holes **1-3** should be completed on-bridge. The procedure for such cases is identical to the procedure detailed above but for added fixturing between the Bogies and screed rails. Before lifting either Gantry System, each of the TyBOT unit's four Bogies should be weighted or strapped to the screed rail walls to ensure that the Gantry System drive wheels do not uncouple from the screed rails as the Gantry System is lifted (see Figure 44).

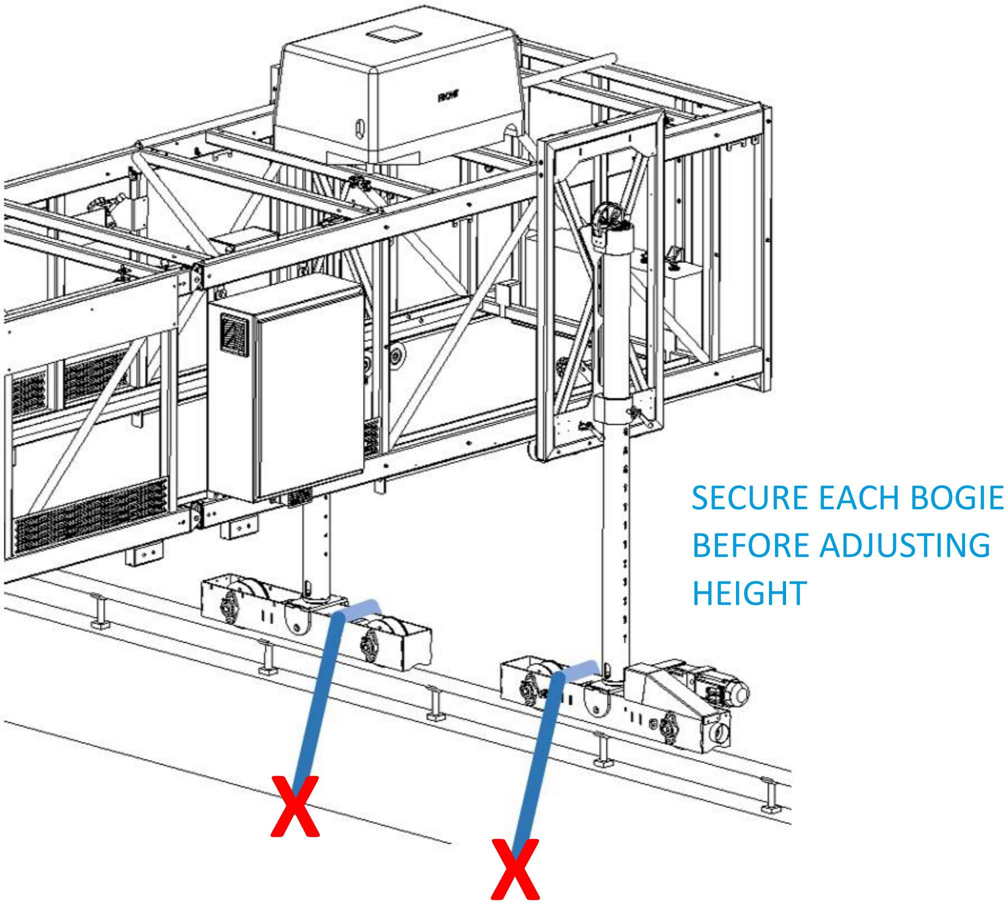



*Figure 44: On-Bridge Fixturing Prior to Leg Height Adjustment*

# IV. OPERATION

TyBOT unit operation should be in accordance with the protocols described in Section II. on Safety, and only by authorized persons. All applicable state and local regulations should be understood and concurrently observed.

TyBOT unit operation encompasses pre-operational inspections and startup/shutdown procedures for safe and efficient usage. These topics are detailed herein, along with advanced topics such as operational tuning and reading performance metrics.

## Pre-Operational Checks

Prior to TyBOT unit operation, the work area should be inspected for - and cleared of - potential obstructions. Machine travel limiters should be inspected and configured as described below.

### Screed Rail Obstructions

The screed rails on which the TyBOT unit travels should be inspected before each startup for obstructions and discontinuities. Jobsite materials, tools, and personal belongings are often placed next to or atop screed rails and screed rail support walls. Figure 45 illustrates the minimum screed rail clearances required for noninterfering travel.

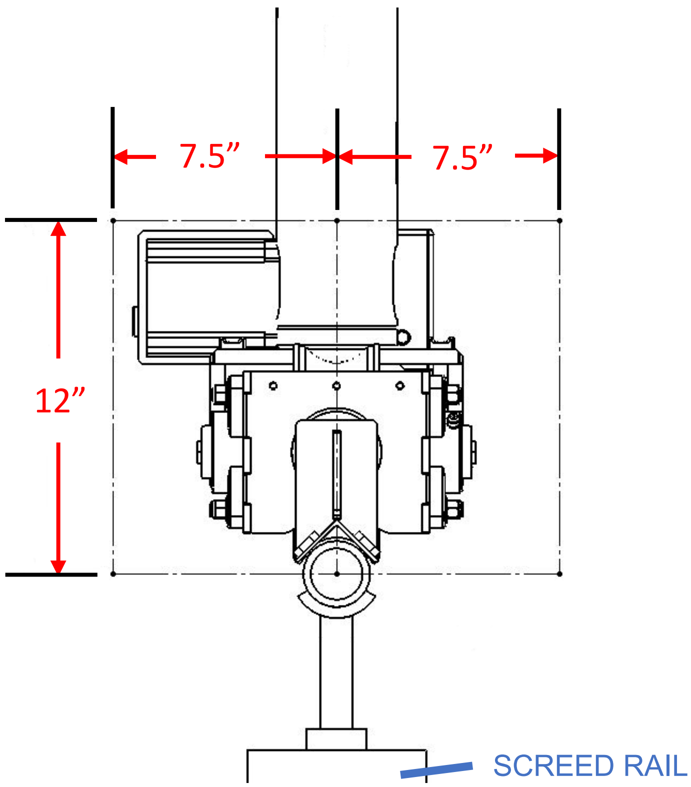



*Figure 45: Minimum Screed Rail Clearances*

## Rebar Mat Obstructions

As it travels within the Truss framework, the TyBOT unit's Tram can potentially collide with obstacles or infrastructure on the rebar mat (see Figure 46). As detailed below, Tram stops are provided to bound the Tram's allowed travel areas. Before these stops are positioned, a thorough inspection of the rebar mat should determine what obstacles exist in the unit's travel path; remove these obstacles if possible.

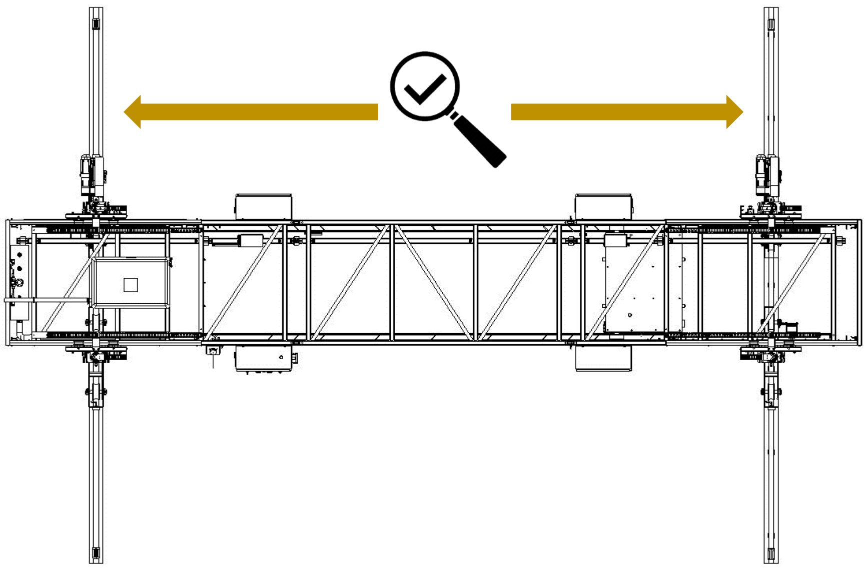


*Figure 46: Rebar Mat Inspection*

## Tram Travel Rail Obstructions

The TyBOT unit's Tram travels within the Truss framework as seen in Figure 47 The Tram travel rails should be inspected before each startup for objects – such as tools and jobsite debris - that will impede travel.

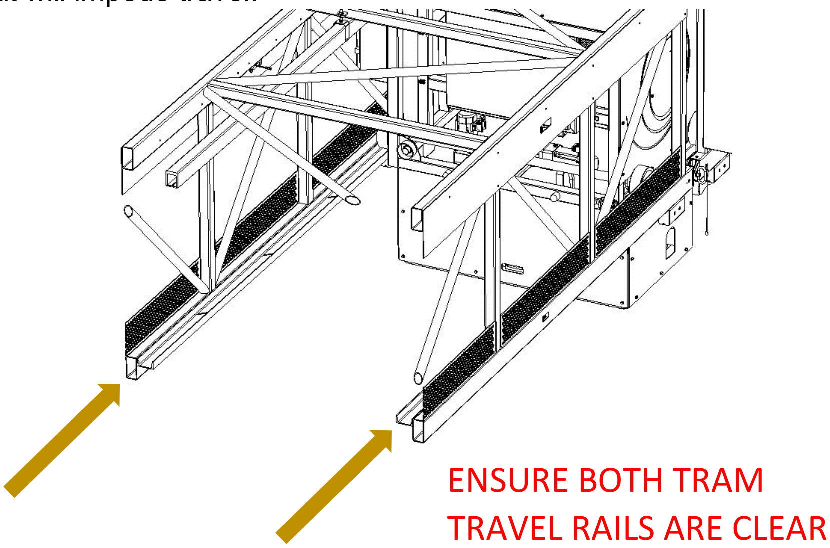



*Figure 47: Tram Travel Rail Inspection*

## Gantry Stop Placements

The TyBOT unit's up/down-bridge travel should always be limited in both directions by the placement of four Gantry stops on the bridge deck's screed rails – two in front of the unit (positive side) and two behind the unit (negative side), as in Figure 48. The positive Gantry stops should be positioned such that when moving the TyBOT unit in the positive direction, each of the positive Bogie limit switches will contact its corresponding Gantry stop before an obstacle or screed rail end can be encountered. When moving the TyBOT unit in the negative direction, each of the negative Bogie limit switches should contact its corresponding Gantry stop before an obstacle or screed rail end can be encountered.

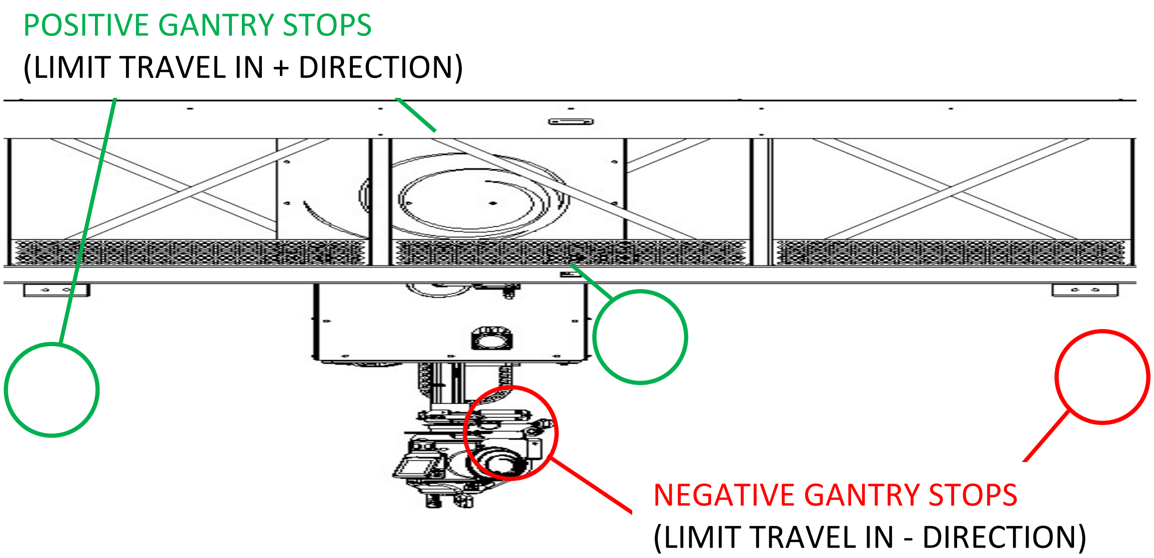



*Figure 48: Gantry Stop Placements*

Note that contact between a Bogie limit switch and its corresponding Gantry stop will only interrupt movement of the contacting Gantry System – the opposing Gantry System will be able to travel until it also contacts a Gantry stop or the 'skew limit' is reached (see Page 20 for information regarding skew limit).

Each Gantry stop should be monitored and repositioned as jobsite conditions change. Always orient each Gantry stop's upright surface toward its corresponding Bogie limit switch, as in Figure 49.

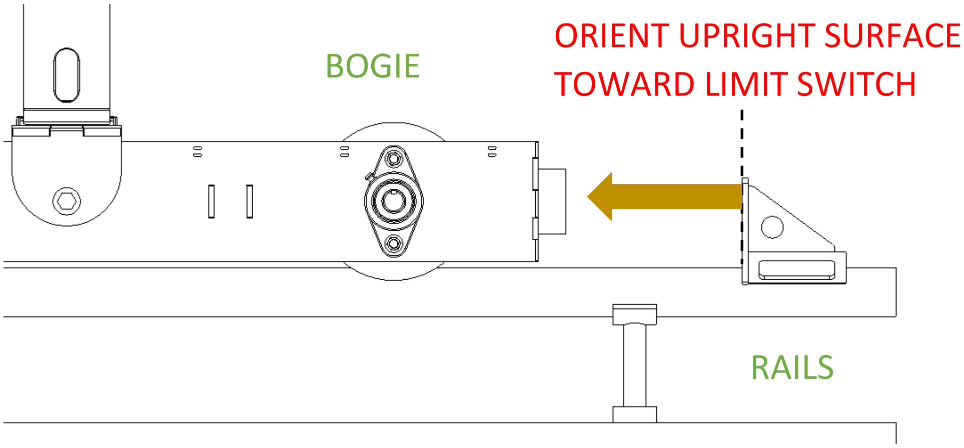



*Figure 49: Gantry Stop Orientation*

## Tram Stop Placements

The TyBOT unit's Tram should always be travel-limited by two Tram stops positioned along the Tram travel rails. When properly placed and secured, as in Figure 50, these stops protect the Tram from collision with screed rail support walls and rebar mat obstructions. During autonomous operation, the start and end of each tie pass are defined by the Tram stop positions. Both stops should be monitored and adjusted (see Page 38) to safely maximize the length of each autonomous tie pass.

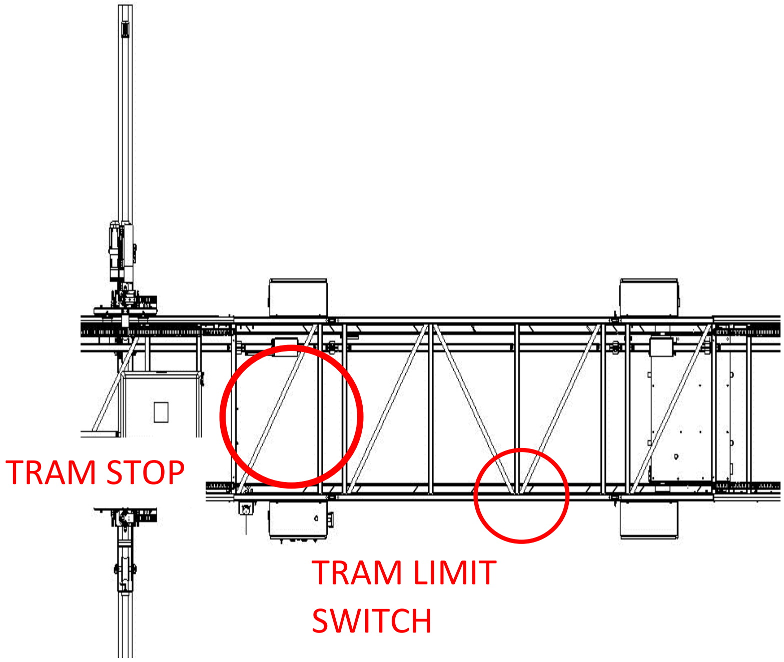



*Figure 50: Tram Stop & Limit Switch*

## Tram Lock Release

The TyBOT unit's Tram is equipped with a lock-pin mechanism for preventing Tram movement in over-road transit (see Figure 51). This mechanism should remain disengaged from the lock bore in the Passenger-Side Gantry Frame when not in over-road transit. Its disengagement should be verified before each startup.

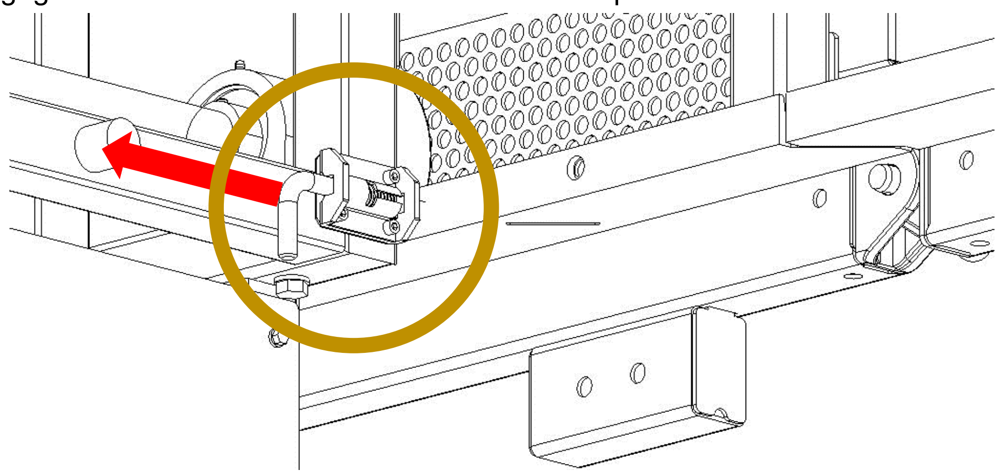


*Figure 51: Tram Lock Release*

## Leg Interface Locks

The TyBOT unit's four Leg interfaces can slide along the Gantry System Frames to accommodate varying screed rail widths and skew angles. Two of the Leg interfaces are equipped with two toggle clamps for holding the interface at a desired location along its Gantry System's Frame (see Figure 52). Once positioned for a bridge deck configuration, **lock both toggle clamps on only the Driver Gantry Leg interface**. The Passenger Gantry must have both clamps unlocked to prevent over-constraining the unit. **Locking more than one of the Leg interfaces creates a risk of derailing the machine.**

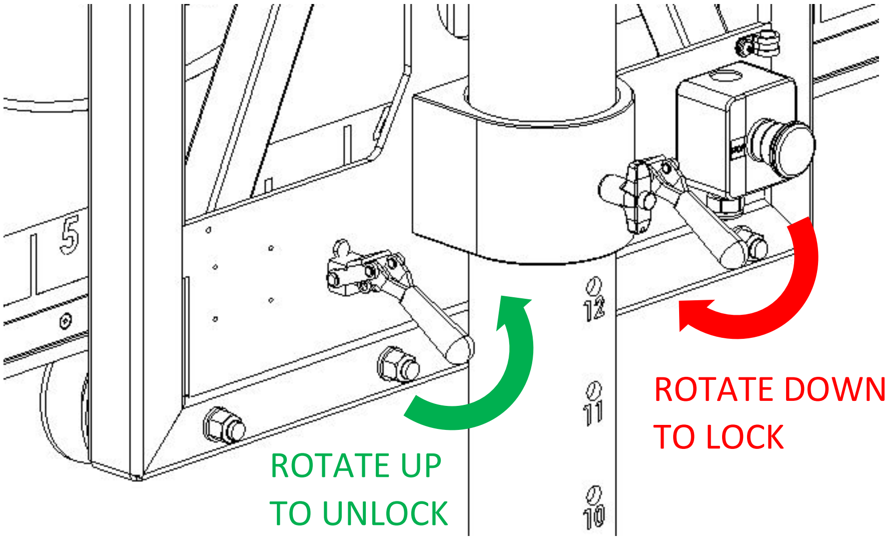



*Figure 52: Leg Interface Locks*

## E-Stop Actuation

Next to each of the TyBOT unit's four support Legs is an emergency stop button (E-STOP). Pushing any of these E-STOPS will immediately disrupt power to the unit. Prior to startup, each E-STOP should be visually checked for damage and cycled through its depressed/undepressed positions (see Figure 53). Movement through these positions should be smooth and unforced; a damaged or stuck E-STOP must be serviced before machine startup.

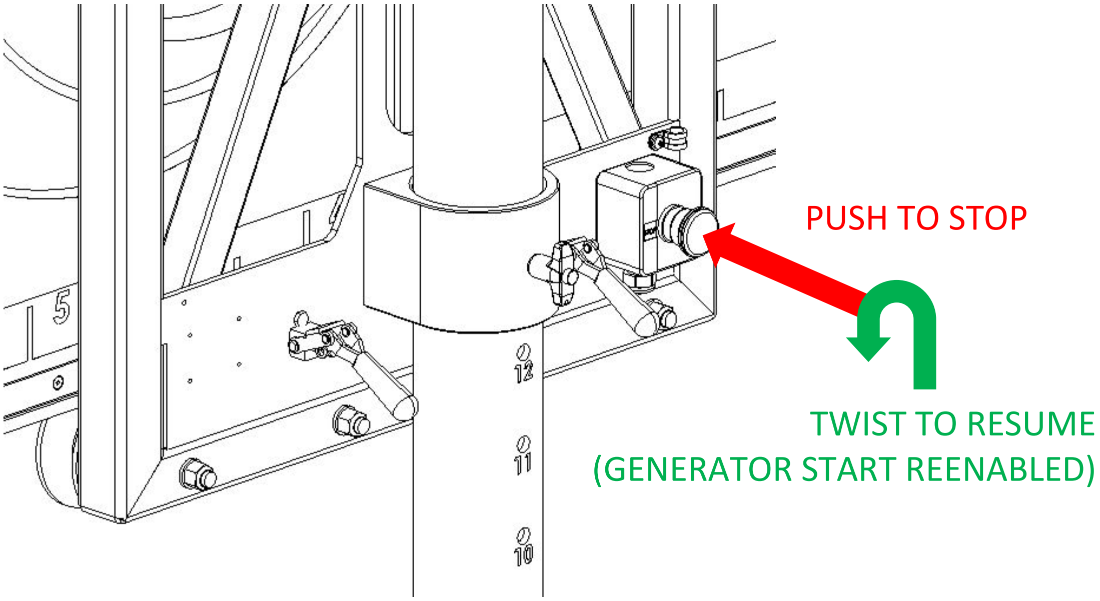



*Figure 53: E-Stop Actuation*

An additional STOP button is located on the TyBOT unit's Belly Box (see Page 44). When pressed, this button will not disrupt power to the TyBOT unit but will disrupt all tie/travel activity.

## Fueling

The TyBOT unit is powered by a genset located on the Driver-Side Gantry. The genset's fuel supply tank, located at the closed end of the Driver-Side Gantry, should be visually checked before each startup for apparent damage and leaks. Also, inspect all fuel lines and fittings.

After a visual check of the fuel tank and fuel lines, insert and turn the MASTER ENABLE key on the face of the Driver-Side Gantry EBOX (see Figure 54). Allow the fuel gauge to stabilize for appx. 30 seconds. If the fuel gauge indicates a low fuel level, remove the filler cap next to the EBOX and fill with fresh gasoline (87-octane or higher).

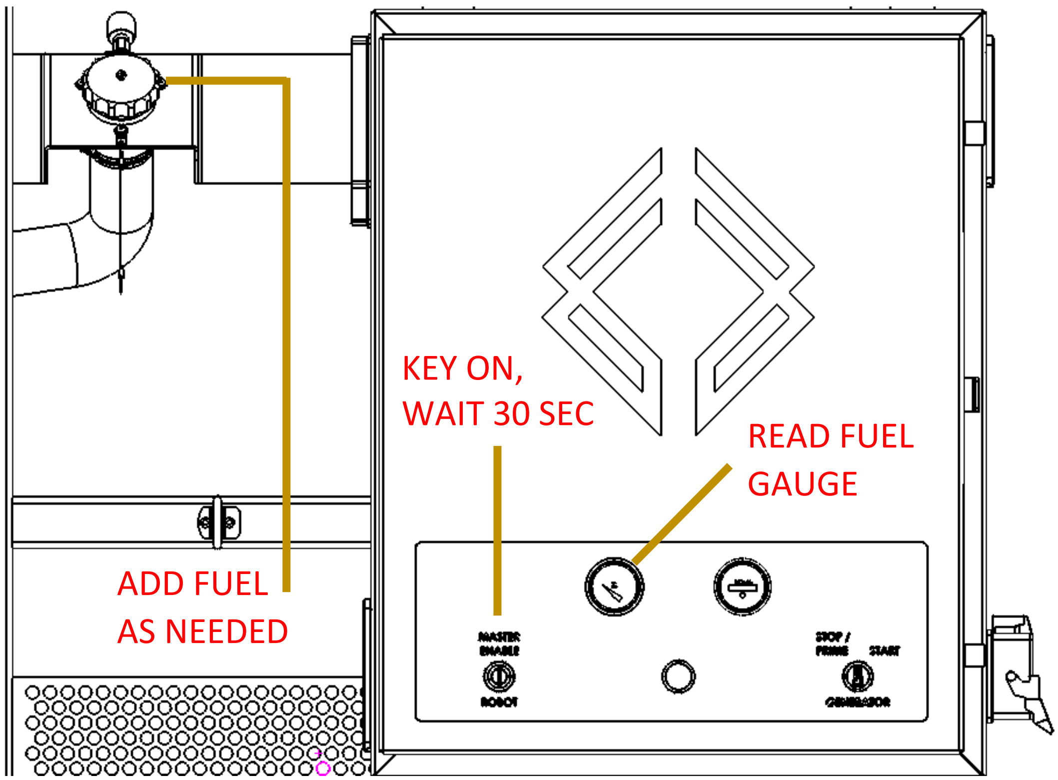



*Figure 54: Fuel Gauge & Filler Cap*

## Tie Module Operation

The TyBOT unit's Tie Module should be removed from the Tram and stored securely when in over-road transit. Installation of the Tie Module can be completed before machine startup, but further setup (wire feed & yaw value adjustment) requires power from the genset – see Section V. on Tie Module for Tie Module setup procedures.

## Controls Overview

The TyBOT unit is remotely controlled by the Belly Box illustrated in Figure 55. The Belly Box should be stored securely when the TyBOT unit is not in operation and should remain with the operator when in manual or autonomous operation mode. Refer to Page 56 for instructions regarding Belly Box maintenance.

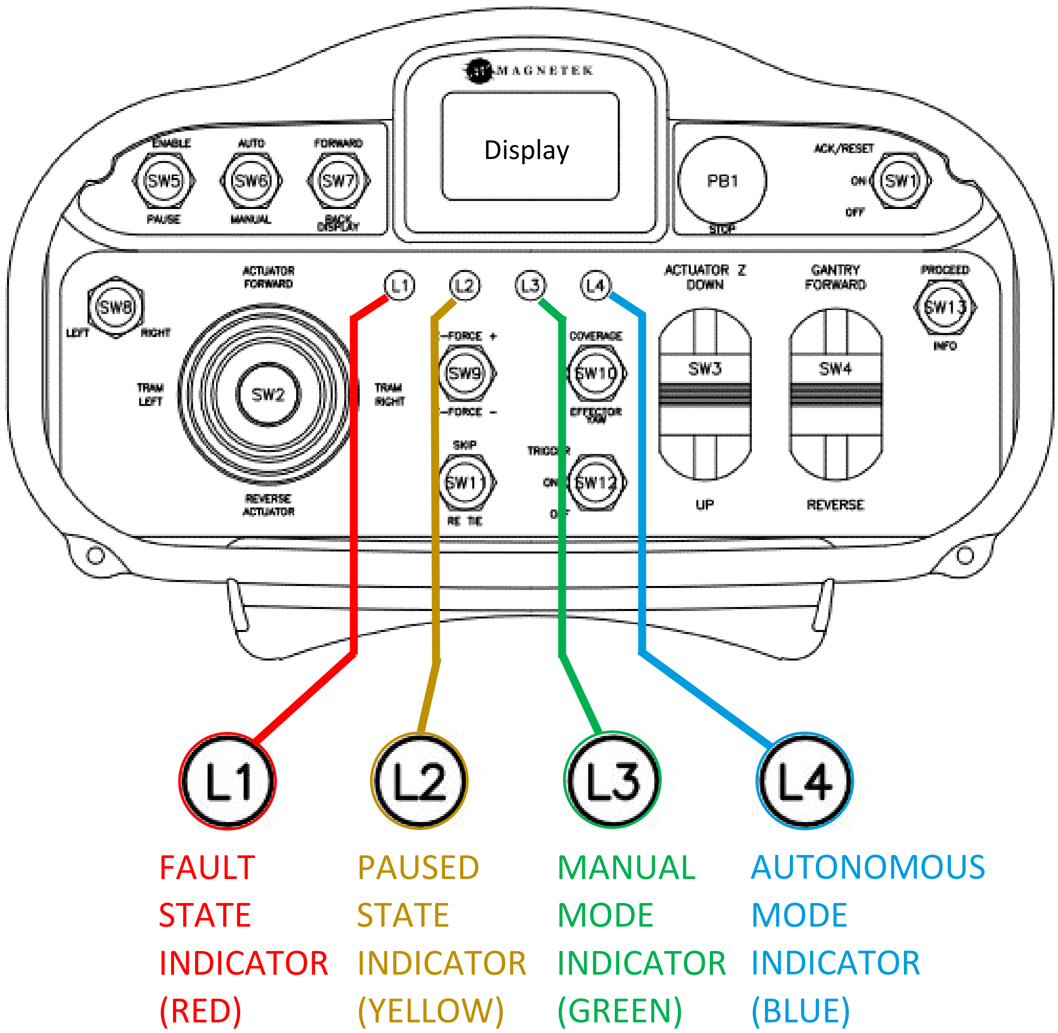



*Figure 55: Belly Box Layout*

Refer to Figure 55 for the layout location of each of the following controls:

### Display – LCD DISPLAY SCREEN

The display screen will show text prompts and information for the user. This includes information such as faults and warnings, fuel level, and user prompts.

## PB1 – STOP BUTTON

Press the 'STOP' button when in manual or autonomous operation mode to halt all motion of the machine. This **is not an E-STOP and will not** disrupt power to the TyBOT unit. E-stops are located on the Leg interfaces, and pressing them **will** cut power to the TyBOT unit.

## SW1 – ON/OFF & ACKNOWLEDGE/RESET

Toggle SW1 to its middle position to power on the Belly Box. Power off the Belly Box by toggling down. Acknowledge prompts by momentarily toggling up. When powering on the Belly Box, the display will show "Rx Offline." Toggle SW1 up to "Reset" to connect the Belly Box to the machine.

A fault code's appearance on the Belly Box screen will be accompanied by light-up of the RED indicator. Upon resolution of the fault(s) (see Section VI. on Troubleshooting), momentarily toggle SW1 up to acknowledge/clear the code(s). When troubleshooting indicates a RESET to be necessary, place the unit into a PAUSED state (see SW5, below) before holding SW1 up for eight seconds. Completion of the RESET command will be indicated by light-up of all four indicators.

## SW2 – MANUAL TRAM CONTROLS

In manual operation mode, move the joystick left/right to drive the Tram within the Truss framework. Move the joystick up/down to adjust the Tie Module's +/- position within the Tram.

## SW3 – Z-ACTUATOR UP/DOWN

In manual operation mode, move the joystick up/down to adjust the Tie Module's distance from the rebar mat.

## SW4 – MANUAL GANTRY DRIVE

In manual operation mode, move the joystick up/down to drive the TyBOT unit on the screed rails.

## SW5 – PAUSE/ENABLE

Momentarily toggle SW5 up to place the TyBOT unit into manual operation mode (GREEN indicator ON). When in either manual or autonomous operation mode, momentarily toggle SW5 down to pause TyBOT movement and tie activity (YELLOW indicator ON).

## SW6 – AUTONOMOUS/MANUAL OPERATION MODE SELECTION

When in manual operation mode (GREEN indicator ON), momentarily toggle SW6 up to place the TyBOT unit into autonomous operation mode (BLUE indicator ON). To switch from autonomous operation back to manual, momentarily toggle SW6 down.

## SW7 – FORWARD/BACK DISPLAY

Momentarily toggle SW7 to recall previously displayed messages to the Belly Box screen.

## SW8 – LEFT/RIGHT MULTI-CONTROL

SW8 has two functions: selection of autonomous tie pass direction (see Page 52) and targeting of Gantry System travel in manual operation mode (see Page 54).

## SW9 – Z-FORCE LIMIT ADJUSTMENT

Hold SW7 up/down to adjust the upper limit on downward force applied through the Z-actuator in autonomous operation mode. Refer to Page 54 for instructions regarding Z-force limit adjustment.

## SW10 – TIE COVERAGE SELECTION & EFFECTOR YAW DISPLAY

SW10 has two functions: selection of tie coverage proportion and digital readout of the Tie Module's yaw value.

> Hold SW10 up to switch between the two tie coverage proportions supported in autonomous operation mode – 100% and 50%. This is further described on Page 55.
>
> Hold SW10 down to display the Tie Module's yaw value on the Belly Box screen. Adjustment to the yaw value is described in Section V., Tie Module Installation, Removal, and Maintenance.

## SW11 – SKIP TIE & RE-TIE

In autonomous operation mode, momentarily toggle SW11 up to skip the current tie attempt.

In autonomous operation mode, momentarily toggle SW11 down to re-attempt the previous tie attempt.

## SW12 – TRIGGER ON/OFF

In manual operation mode, momentarily toggle SW12 up to execute a tie attempt without affecting the Tie Module's location. This feature is useful for troubleshooting and resolving wire-feed issues, as described in Section V., Tie Module Installation, Removal, and Maintenance.

Toggle SW12 down when in manual or autonomous operation mode to power off the Tie Module. Return SW12 to the middle position to turn on power to the Tie Module.

## SW13 – PROCEED & EXPAND INFO

SW13 has two functions: continuation of autonomous tie activity (see Page 52) and digital readout of additional text content.

## Startup Procedure

1) Complete the pre-operational checks detailed on starting on Page 36.
2) Check the fuel level (and fill if necessary) per the FUELING procedure detailed on Page 43. Leave the MASTER ENABLE key in its ON position.
3) Turn the GENERATOR switch to its STOP/PRIME position and hold for 5 seconds – during this time the fuel pump should audibly build fuel pressure to the genset. Turn the GENERATOR switch to its START position and hold until the genset starts. Allow the switch to spring back to its middle position, as in Figure 56.

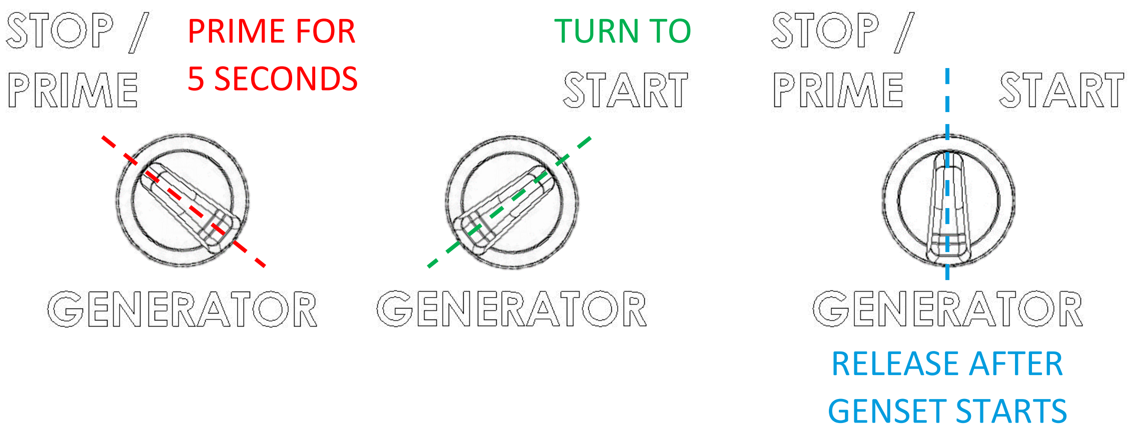



*Figure 56: Prime & Start Process*

4) Turn on the Belly Box and momentarily toggle SW1 up to acknowledge signal transmission (TX) to and reception (RX) from the TyBOT unit. The Belly Box screen will display current fuel and spool capacities before prompting input of screed rail measurements.

5) When the Belly Box's readout screen prompts input of "*Rail Width?*," set the appropriate screed rail width value using SW3 and SW4, as in Figure 57. Momentarily toggle SW1 up to acknowledge the input is correct.

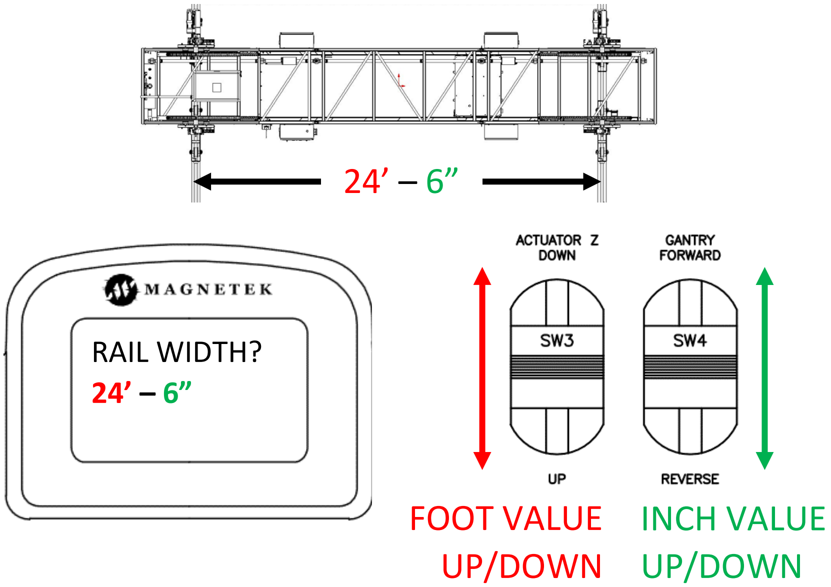



*Figure 57: Setting Screed Rail Width*

6) When the Belly Box's readout screen prompts input of "*Rail Radius?*," set the appropriate screed rail bend radius value using SW3. Left-bending (toward the Driver Truss) rail configurations should be assigned positive polarity, as in Figure 58. Right-bending (toward the Passenger Truss) rail configurations should be assigned negative polarity, as in Figure 59. To change the polarity, use the Tram LEFT and Tram RIGHT Joystick to change the sign of the radius. Momentarily toggle SW1 up to acknowledge the input is correct. The TyBOT unit will default to a paused state as signaled by the YELLOW indicator.

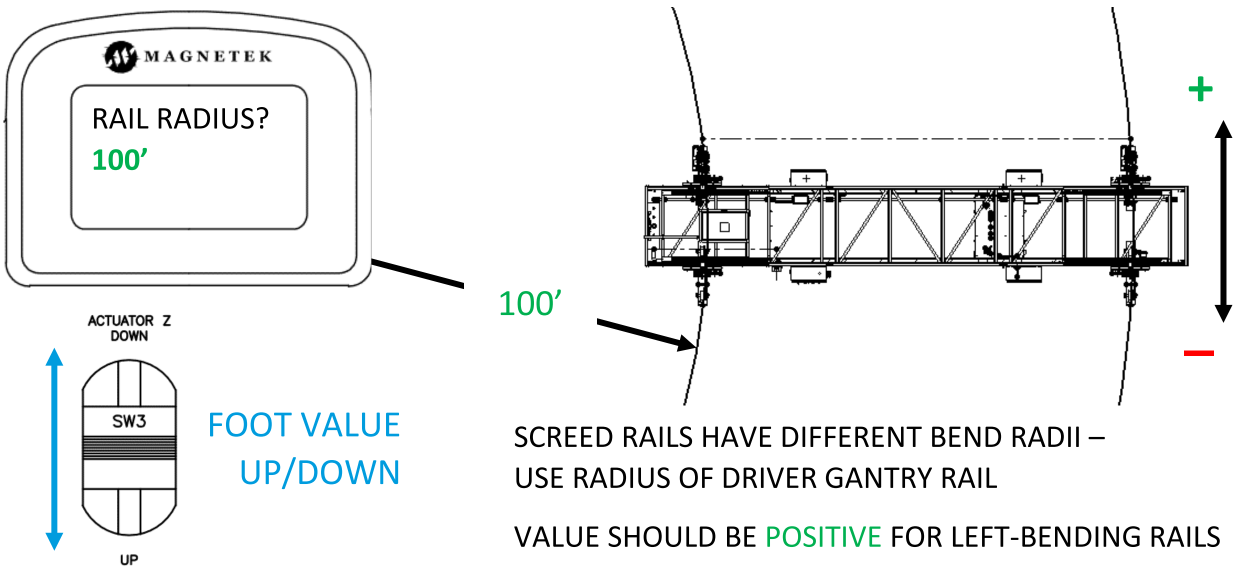



*Figure 58: Setting Left-Bending Rail Radius (POSITIVE)*

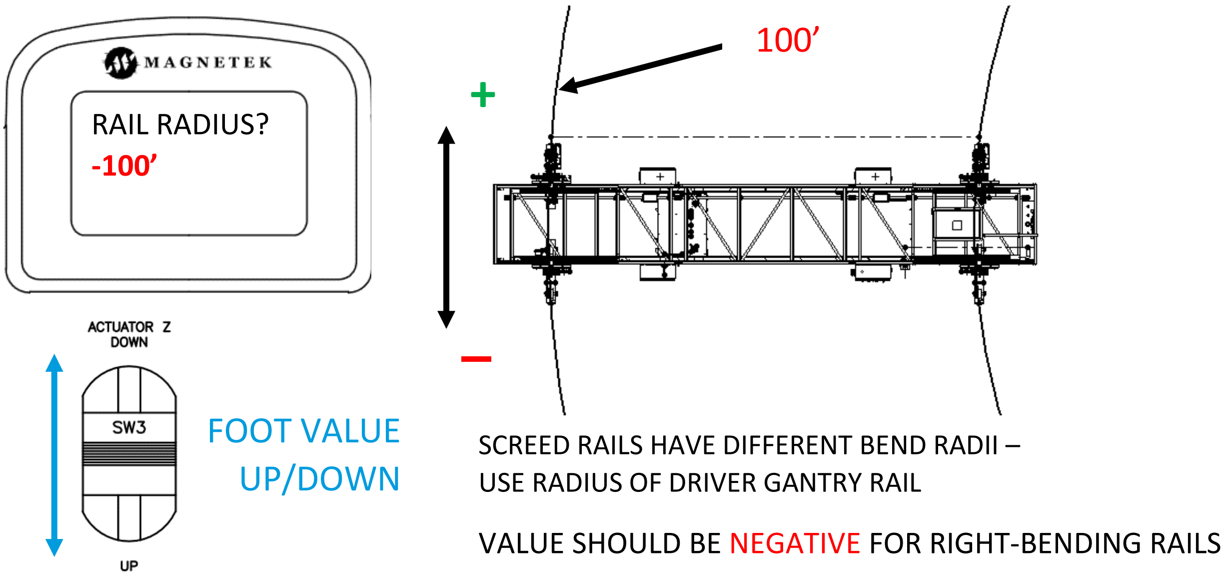



*Figure 59: Setting Right-Bending Rail Radius (NEGATIVE)*

**7)** Install and setup the Tie Module as described in Section V. on the Tie Module. The TyBOT unit should now be prepared for operation.

## Shutdown Procedure

**1)** Manually move the TyBOT unit to the desired shutdown location and position the Tram away from walkways.

**2)** Remove the Tie Module from the Tram as described in the Section V. on the Tie Module. *Stow and secure the Tie Module.*

**3)** Turn the GENERATOR switch to its STOP/PRIME position and hold to power down the TyBOT unit.

Alternatively, the TyBOT unit can be remotely powered down using Belly Box controls. Simultaneously toggle down and hold SW5 (PAUSE) and SW6 (MANUAL MODE). Toggle down and hold SW1 (BELLY BOX POWER OFF) until the TyBOT unit powers down. Adhere to the remaining shutdown steps.

**4)** Power down, stow and secure the Belly Box in the spare electrical box on the Passenger-Side Gantry.

**5)** Turn the MASTER ENABLE key to its OFF position. Remove the key from the Driver-Side Gantry EBOX.

## Machine Operation

Machine operation should commence only upon completion of the pre-operational checks and startup procedure detailed above. For greatest tie efficiency, manual maneuvering of the TyBOT unit is often necessary before transitioning into autonomous mode.

### Manual Operation

Momentarily toggle SW5 up (ENABLE) [or SW6 down (MANUAL)] to enable manual movement controls. SW2 and SW3 can then be used to position the Tram and Tram actuators, while SW4 can be used to drive the TyBOT unit on the screed rails (see Figure 60 & Figure 61).

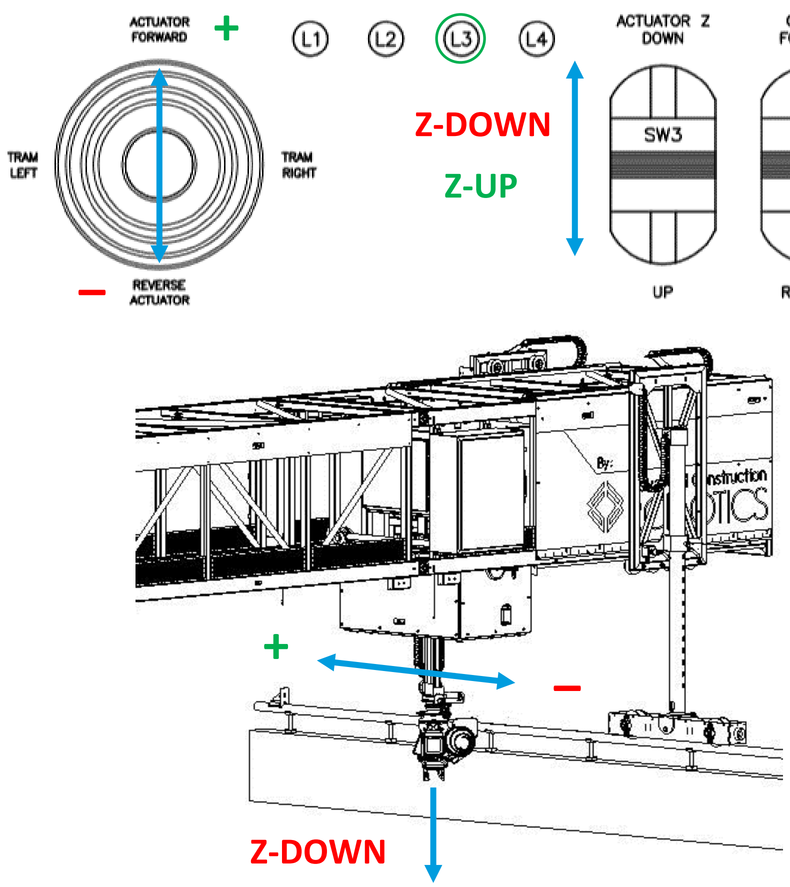



*Figure 60: Manual Tram Actuator Movement*

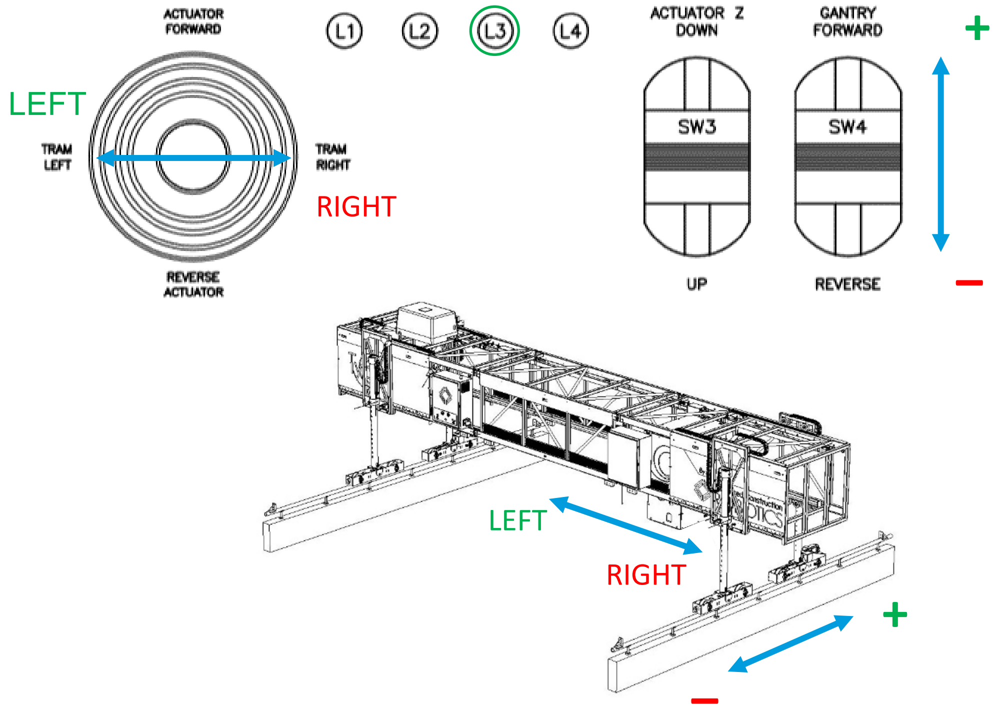



*Figure 61: Manual Tram & Gantry System Movement*

Tram stop (see Figure 16) adjustment is a manual procedure to safely maximize the Tram's travel length. This adjustment should be made with the Tie Module installed and lowered towards the rebar mat, as in Figure 62. At the intended end of each tie pass, position the Tram such that a buffer space of six inches exists between any component of the TyBOT unit and the nearest obstacle. Move/ secure the appropriate Tram stop against its corresponding limit switch to thereafter maintain the clearance buffer.

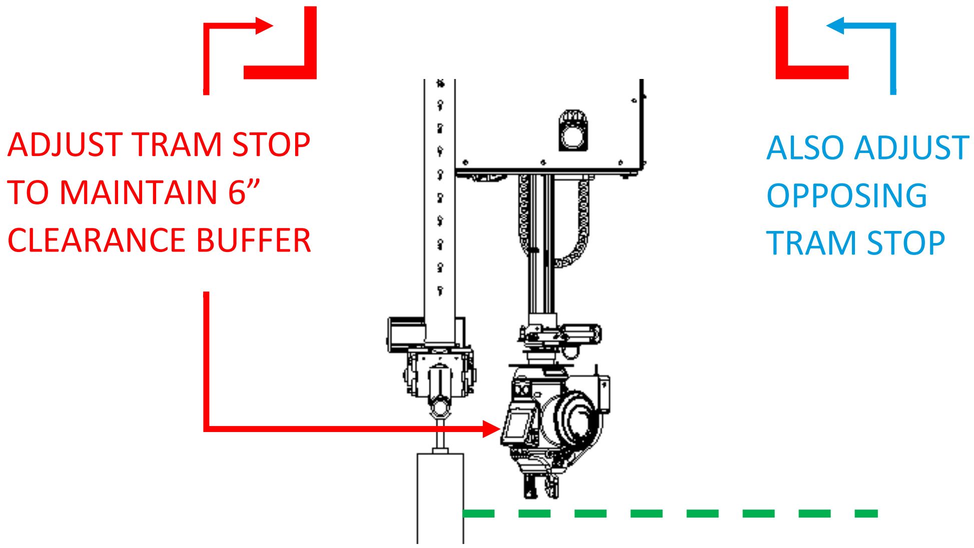



*Figure 62: Tram Stop Adjustment*

## Autonomous Operation

Autonomous operation should be preceded by manual movement of the TyBOT unit's Tram to the intended starting point of the first tie pass. With the Tram stops properly adjusted and the TyBOT unit in manual operation mode (GREEN indicator ON), momentarily toggle SW6 up (AUTO) to place the unit in autonomous operation mode (BLUE indicator on). The Belly Box screen will prompt the operator to select a direction for the ensuing tie pass. Momentarily toggle SW8 left/right to select the intended Tram travel direction; autonomous tie operation will immediately commence.

Remain watchful of tie activity and Tram movement through the duration of each autonomous tie pass. Some tie attempts will likely be unsuccessful due to resolvable conditions such as wire obstruction by a rebar chair – the TyBOT unit will automatically reattempt a tie two times if a mis-tie is sensed. To manually reattempt a tie, immediately and momentarily toggle SW11 down.

Some tie attempts may be unsuccessful due to unresolvable conditions, such as at large rebar lap joints – these intersections should be skipped by immediately and momentarily toggling SW11 up.

At the end of each autonomous tie pass (Tram stop reached), the Belly Box screen will prompt the operator to approve incremental travel to the next tie pass, as in Figure 63. If safe to do so, momentarily toggle SW13 up (PROCEED) – the TyBOT unit will travel forward on the screed rails and commence the next tie pass.

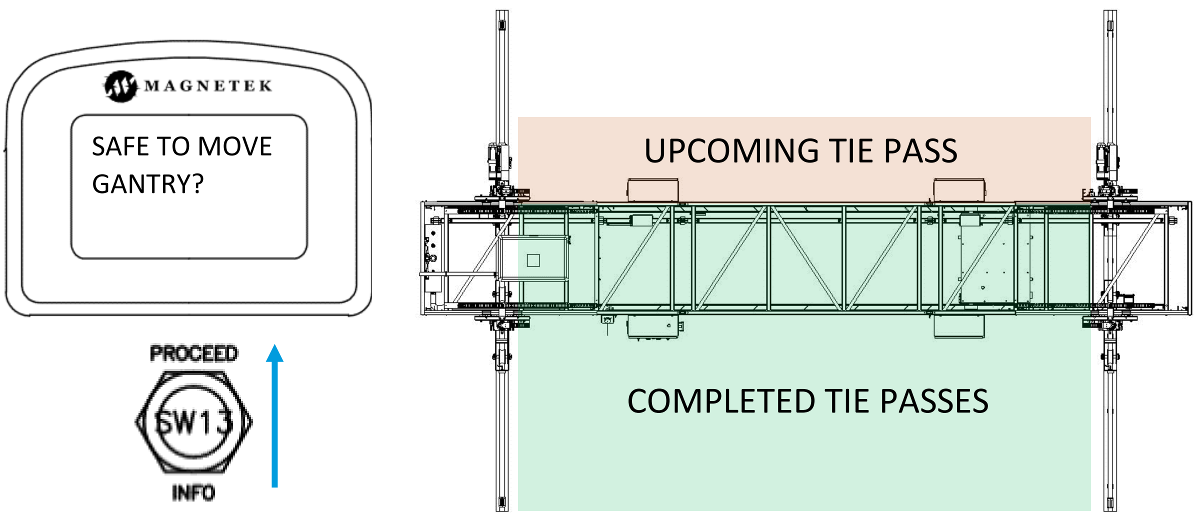



*Figure 63: Tie Pass Procedure*

If the incremental Gantry System travel after a tie pass completion brings the TyBOT unit to the Gantry stops, the Belly Box screen will read out "Op Complete." Manually move the unit to the desired shutdown location and follow the shutdown procedure detailed on Page 49.

# Advanced Operation

Detailed below are advanced topics that should be understood and implemented for greatest operational performance.

## Manual Skewing

The TyBOT unit can be manually skewed on the screed rails to more efficiently tie diagonally placed rebar and oddly shaped approach areas, as in Figure 64.

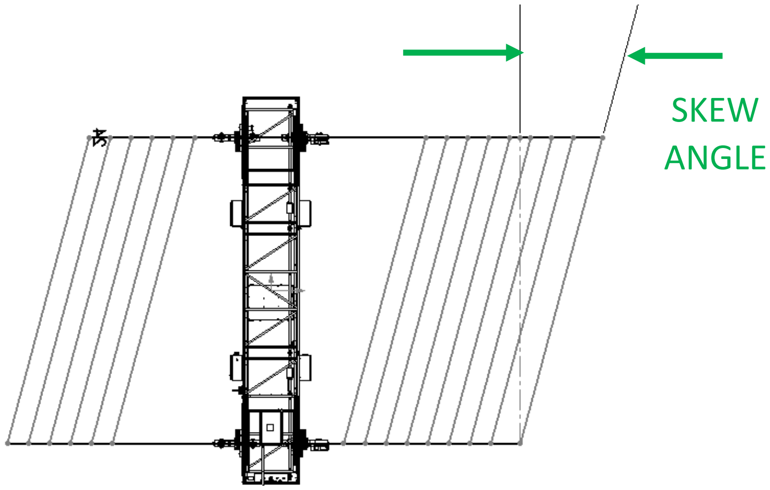



*Figure 64: Skewed Rebar Mat*

Consult Truss Middle Section Calculator Section starting on Page 21 to determine the appropriate Truss combination for a given bridge width at an intended skew angle.

**DO NOT ATTEMPT TO SKEW THE MACHINE IN A CONFIGURATION NOT SUGGESTED BY THE CONFIGURATOR.**

After verifying the described skew prerequisites, hold SW8 to the left while moving the MANUAL GANTRY DRIVE (SW4) joystick to independently drive the Driver-Side Gantry on its respective screed rail, as in Figure 65. Hold SW8 to the right while moving the MANUAL GANTRY DRIVE (SW4) joystick to independently drive the Passenger-Side Gantry on its respective screed rail.

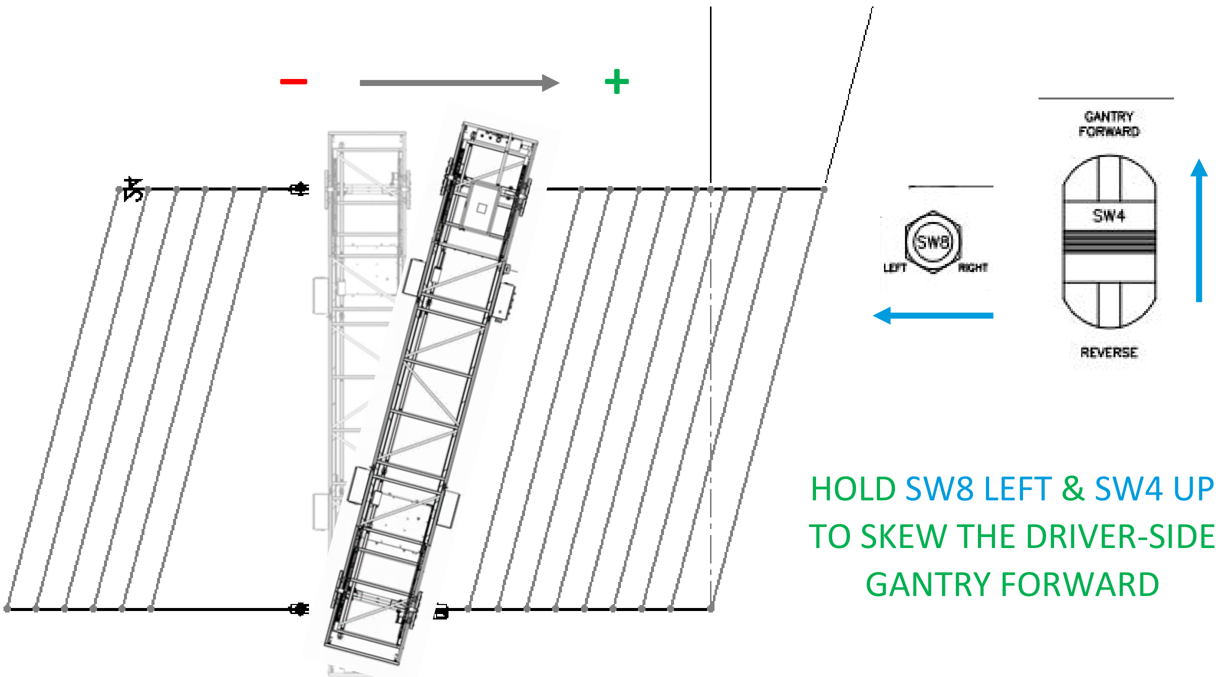



*Figure 65: Manual Skewing*

## Z-Force Limit Adjustment

Low ambient jobsite temperature may necessitate adjustment to a higher Z-force limit. If the TyBOT is reaching intersections but not attempting to tie them, you may need to increase the Z-Force limit. If the TyBOT is impacting intersections very hard or the Tie Module is deflecting significantly when reaching an intersection, you may need to decrease the Z-Force limit. The limit is adjustable between 1 (lowest downward force) and 5 (highest downward force) by holding SW7 up/down.

## Tie Coverage Proportion

Tie coverage proportion should be switched from 100% (default) to 50% according to bridge deck specification. The tie pattern executed at 50% coverage is 'checkered,' as illustrated in Figure 66. Hold SW10 up to toggle between the supported tie coverage proportions.

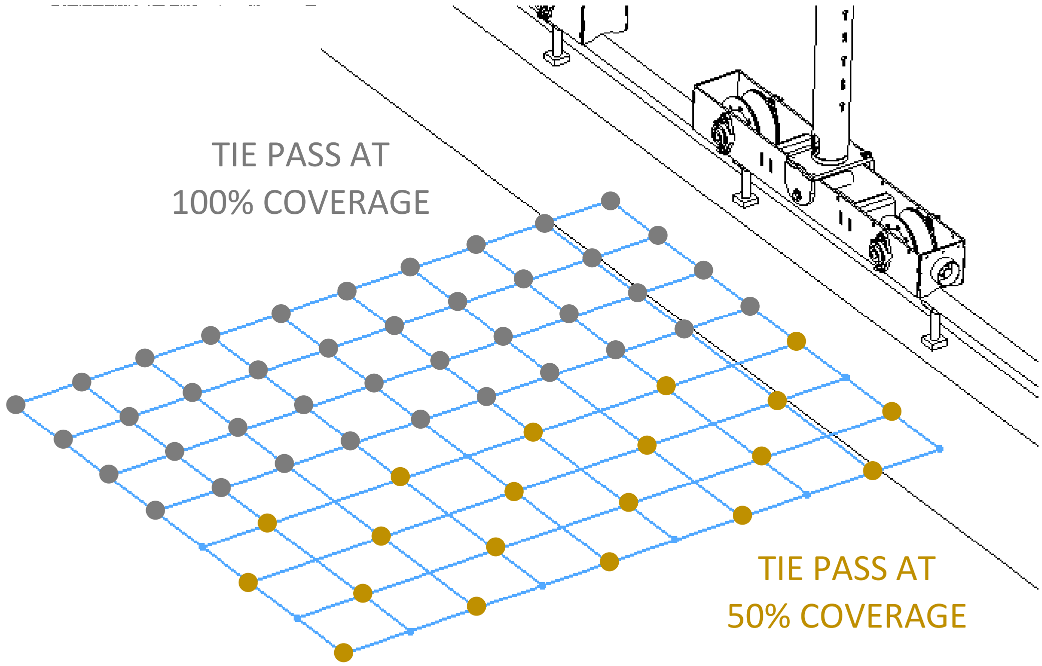



Figure 66: Tie Coverage Proportion Patterns

## Belly Box Maintenance

The Belly Box used to control the TyBOT unit should not be user-serviced in the event of breakage – contact the TyBOT Service and Support Department to resolve any issue that arises with the provided Belly Box. Only alert volume adjustments and routine battery changes should be undertaken by qualified TyBOT users. Alert volume is adjusted by rotating the black sound baffle on the Belly Box's side.

The Belly Box is powered by a refillable pack of three AA batteries. The primary pack and a spare pack are accessible on the underside of the Belly Box as illustrated in Figure 67. To remove a pack, unthread its retaining screw and lift the pack out of the Belly Box. The battery tray can then be slid out of the power pack and refilled.

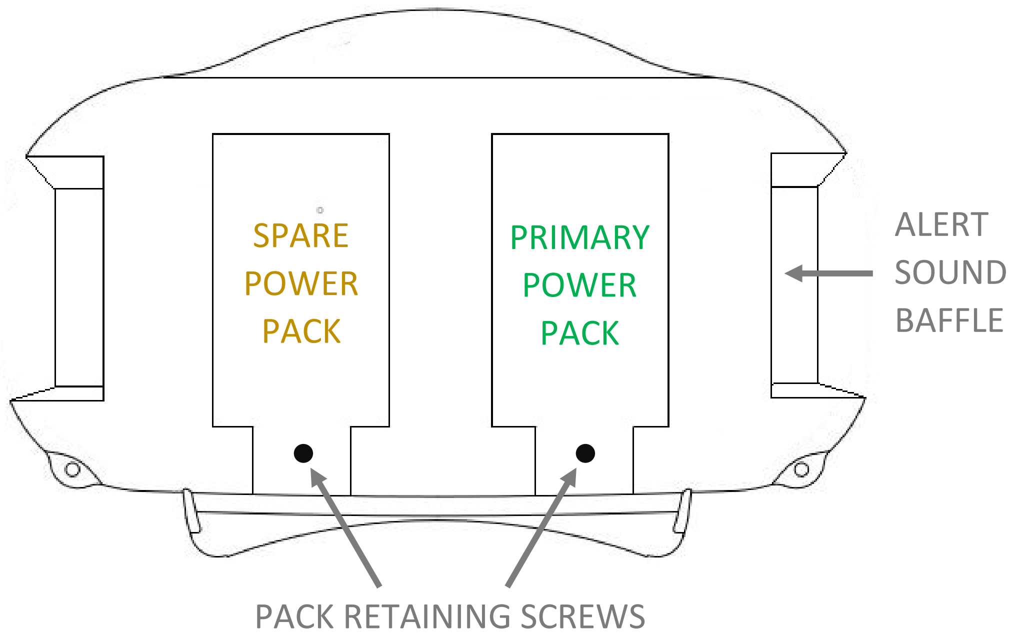



*Figure 67: Underside of Belly Box*

# V. TIE MODULE

## Tie Module Component Identification

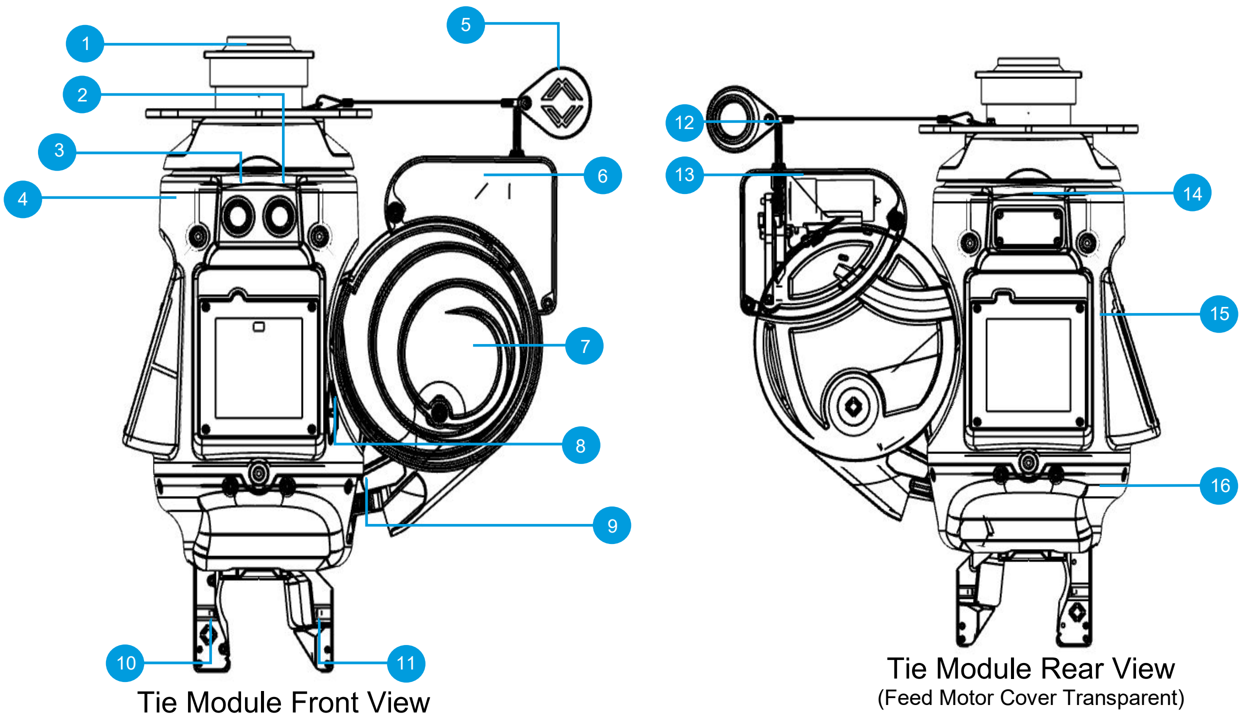
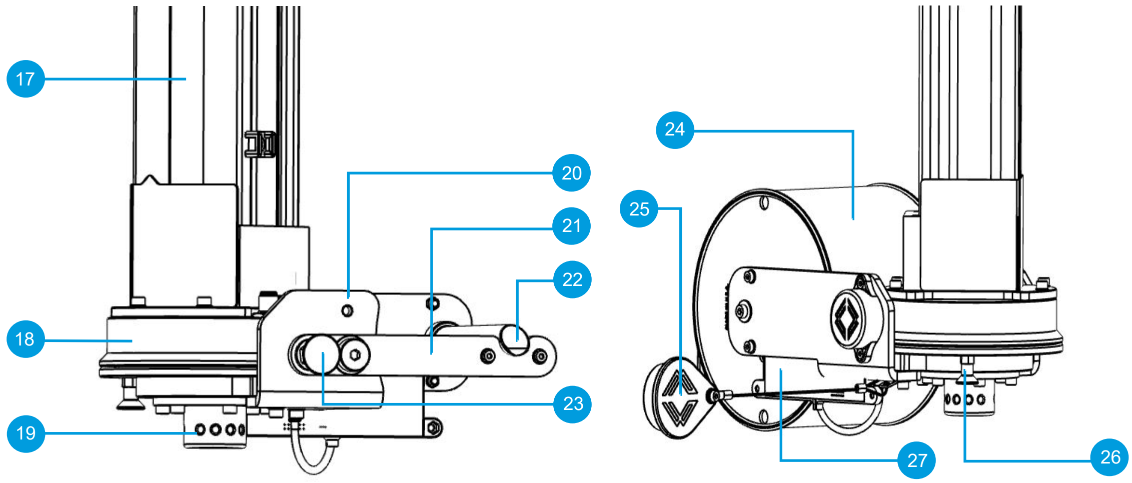



*Figure 68: Tie Module Components*

| Tie Module Component Identification | |
|---|---|
| **ID Number** | **Part Description** |
| 1 | Quick Release Female Hub |
| 2 | Green LED (Break Beam Status) |
| 3 | Red LED (Power Status) |
| 4 | Light Side Cover |
| 5 | Quick Release Blanking Cap |
| 6 | Feed Motor Cover |
| 7 | Reload Spool |
| 8 | Feed Motor Switch |
| 9 | Tie Wire Lock |
| 10 | Photo Sensor Emitter/Thrower Jaw |
| 11 | Photo Sensor Receiver/Receiver Jaw |
| 12 | Feed Tube |
| 13 | Feed Motor |
| 14 | Tie Module Data Plate |
| 15 | Backside Cover |
| 16 | Removeable Bottom Cover |




Z-Axis Linear Actuator Front View
(Tie Wire Spool Not Installed)

Z-Axis Linear Actuator Rear View

*Figure 69: Z-Axis Linear Actuator Tie Module Components*

| Tie Module Component Identification | |
|---|---|
| **ID Number** | **Part Description** |
| 17 | Z-Axis Linear Actuator |
| 18 | Indexing Manifold |
| 19 | Quick Release Male Hub |
| 20 | Spool Mounting Bracket |
| 21 | Spool Latch |
| 22 | Spool Bayonet |
| 23 | Spool Latch Pin |
| 24 | Tie Wire Spool |
| 25 | Quick Release Blanking Cap |
| 26 | Tie Module Indexing Knob |
| 27 | RFID Sensor (Reader) |

## Tie Module Installation, Removal, and Loading of Tie Wire

A Tie Module can be installed onto or removed from a TyBOT unit with or without the Generator power applied. While the Generator is running the Tie Module circuit electricity can be turned off by moving the Tie Module trigger toggle that is located on the Belly Box to the off position (see Figure 82, Step 1). If electrical power is not turned off prior to installation or removal of a Tie Module; a user may experience injury and/or damage to critical TyBOT unit components.

Tie Module installation, removal, and loading should be completed with the Tram actuators in the home position. The homing procedure can be referenced within Tie Module Advanced Operation in Section V. (see Figure 90).

Loading of the tie wire is to be completed with a Tie Module installed and powered on. Use the startup procedure located within TyBOT Operation Section IV. to properly power on the

Generator and Tie Module. Failure to apply power to the Tie Module during wire loading will result in an unsuccessful wire feed. Only TyBOT-provided tie wire should be used with the Tie Modules.

## Tie Module Installation

A Tie Module can be installed onto the TyBOT Z-axis linear actuator using the quick-release attaching system. Prior to attachment, remove and stow the blanking caps from the Tie Module and the Z-axis linear actuator. The locking collar on the quick-release female hub will need to be cocked prior to attaching the Tie Module to the TyBOT. This can be accomplished by pulling the lock collar down until it locks into the cocked position (see Figure 70).

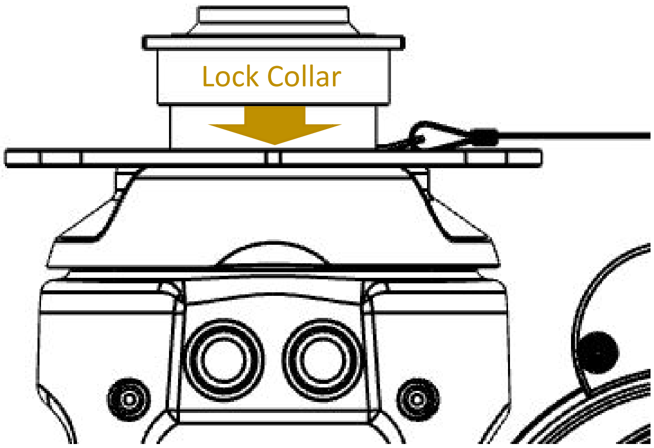



*Figure 70: Quick Release Lock Collar Cocking*

Tie Module attachment can be completed by connecting the female hub of the quick disconnect system which is located on top of the Tie Module to the male hub which is located on the bottom of the Z-axis linear actuator (see Figure 71).

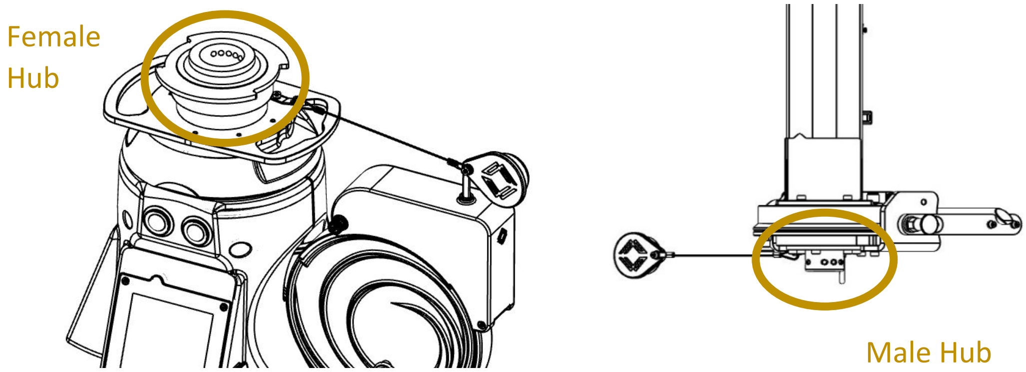



*Figure 71: Tie Module Quick Release Components*

Once the two ends have been successfully mated, rotate the Tie Module either clockwise or counterclockwise until the lock collar on the female hub snaps into the locked position (see Figure 72).

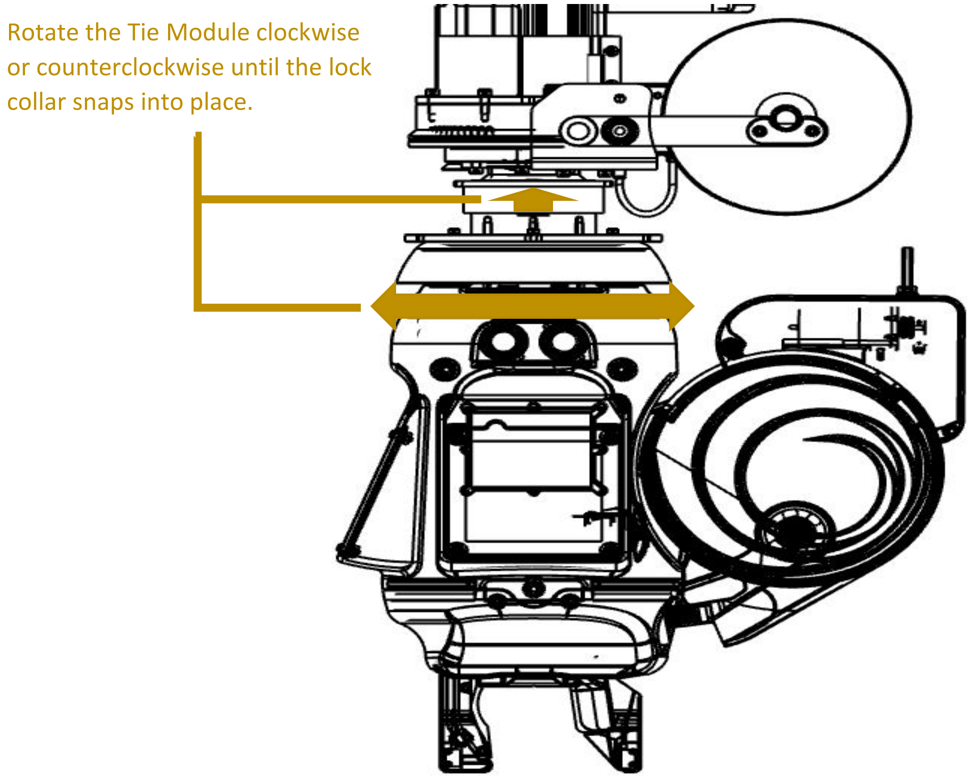



*Figure 72: Locking of the Tie Module Quick Release*

Failing to lock the quick disconnect can result in personal injury and/or damage to critical TyBOT components. If the locking collar prematurely springs to the locked position, the locking collar will have to be re-cocked, and the installation process will need to be repeated until the Tie Module can be successfully mated to the Z-axis linear actuator.

After successfully attaching a Tie Module to the TyBOT, power can be applied to the Tie Module by placing the Tie Module trigger toggle located on the Belly Box to the on position (see Figure 82, Step 1). The current number of Tie Module ties will be displayed on the Belly Box and the Tie Module will complete a power cycle.

## Tie Module Removal

Before removing a Tie Module, all wire will need to be removed from the module and pre-spool housing. With power applied the tie wire will need to be released from the Tie Module. This can be completed by depressing the tie wire lock, located between the Tie Module and the pre-spool housing (see Figure 73).

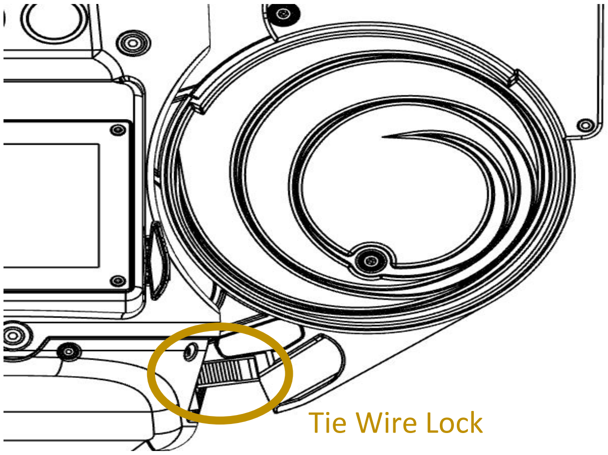



*Figure 73: Tie Module Wire Lock*

After the wire lock has been released, the tie wire can be pulled out of the Tie Module. Tie wire can become distorted following removal from the Tie Module; if this occurs the distorted portion of wire may be removed using a suitable wire cutting tool. All remaining wire can be removed from the pre-spool housing by pressing the up position of the pre-spool feed motor switch that is located behind the Aruco marker on the light side cover (see Figure 74).

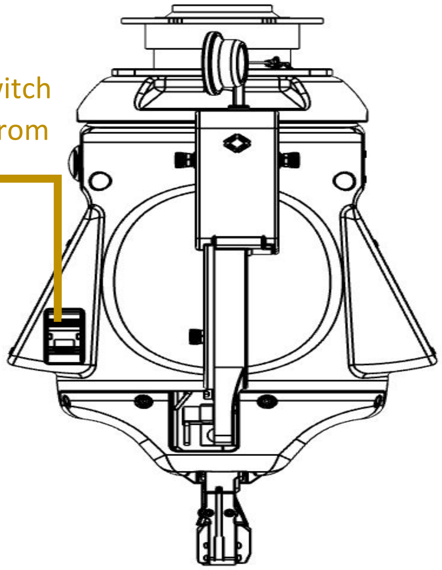



*Figure 74: Tie Module Feed Motor Switch*

All wire that was removed from the Tie Module and the pre-spool housing should be coiled up on the tie wire spool that is installed above the Tie Module.

Before detaching the Tie Module, it is recommended that the Tie Module power be turned off by placing the Tie Module toggle that is located on the Belly Box to the off position (see Figure 82, Step 1). The Tie Module can then be easily removed by using the quick-release detachment system. While supporting the top of the Tie Module with both hands, unlock the quick-release collar that is located on top of the Tie Module by using thumb pressure to push the quick disconnect lock collar down (see Figure 75).

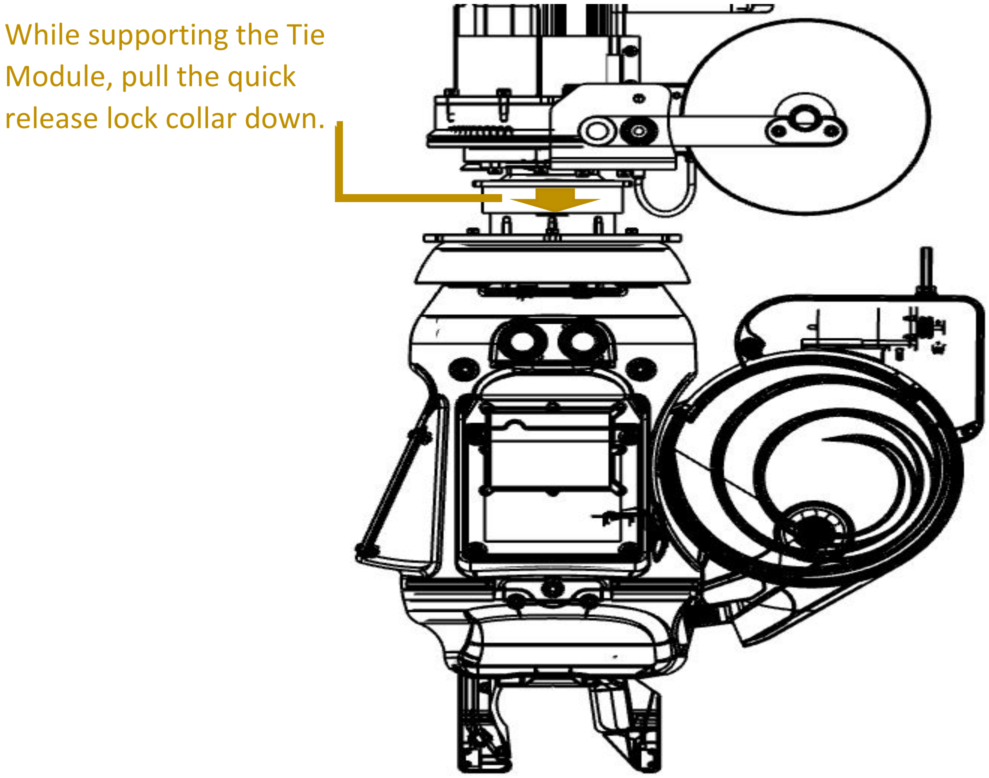



*Figure 75: Unlocking the Tie Module Quick Release*

Once the locking collar is depressed the Tie Module can be lowered off the male end of the quick-release system that is located on the Z-axis linear actuator. Following removal, install the blanking caps onto the Tie Module and the Z-axis linear actuator.

## Tie Wire Loading

Installation of a TyBOT tie wire spool can be completed with the TyBOT Generator power on or off. However, to complete loading of the tie wire spool, the TyBOT Generator will have to be powered on. Use the startup procedure located within TyBOT Operation Section IV. to properly power on the Generator and Tie Module.

Tie wire spools are to be installed on the spool bayonet which is mounted to the Z-axis linear actuator above the Tie Module. Installing a spool onto an empty bayonet can be accomplished by pulling out the spring-loaded spool latch pin that is located on the spool latch. Once the latch pin has been pulled out, the latch can be rotated downward. A spool can be installed onto the exposed bayonet.

Ensure that the spool is installed so that the wire is un-coiling off the top of the spool towards the Tie Module feed tube (see Figure 76). Following spool installation, release the latch pin from the stowed position and then rotate the latch upward until the spring-loaded latch pin is engaged in the locked position.

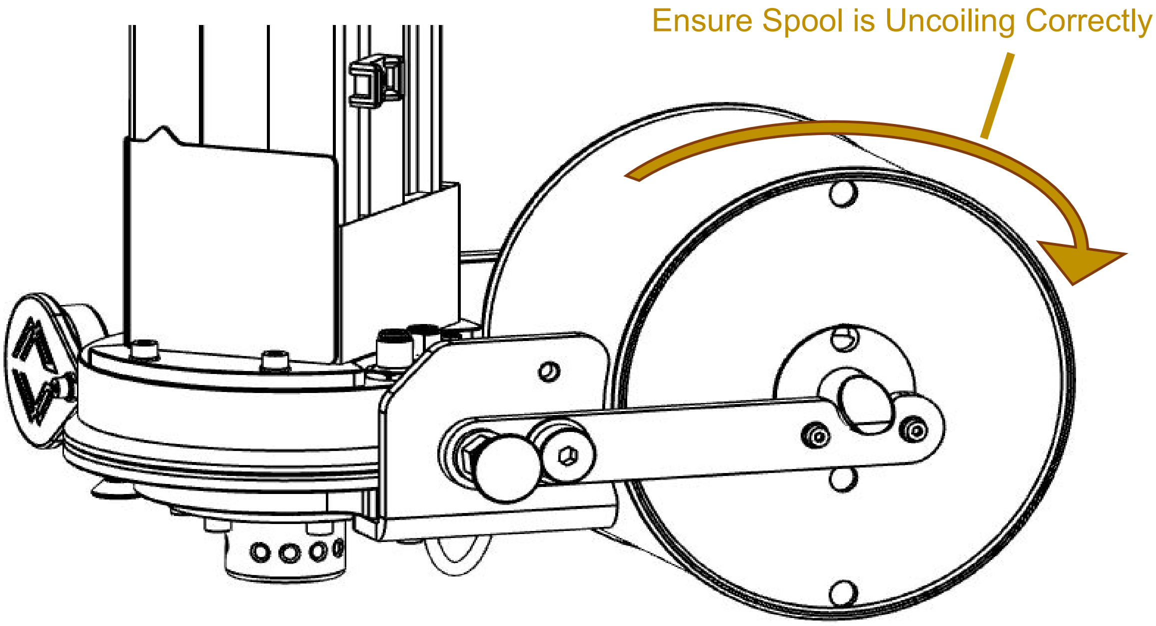



*Figure 76: Spool Orientation*

The TyBOT Generator power is required to be on and a Tie Module will need to be installed to complete the spool installation process. With power applied to the Tie Module, tie wire may be fed off the spool and inserted into the feed tube (see Figure 77). Press the down position of the pre-spool feed motor switch while applying slight pressure to the wire that has been inserted into the feed spool. Allow the external feed motor to engage the tie wire.

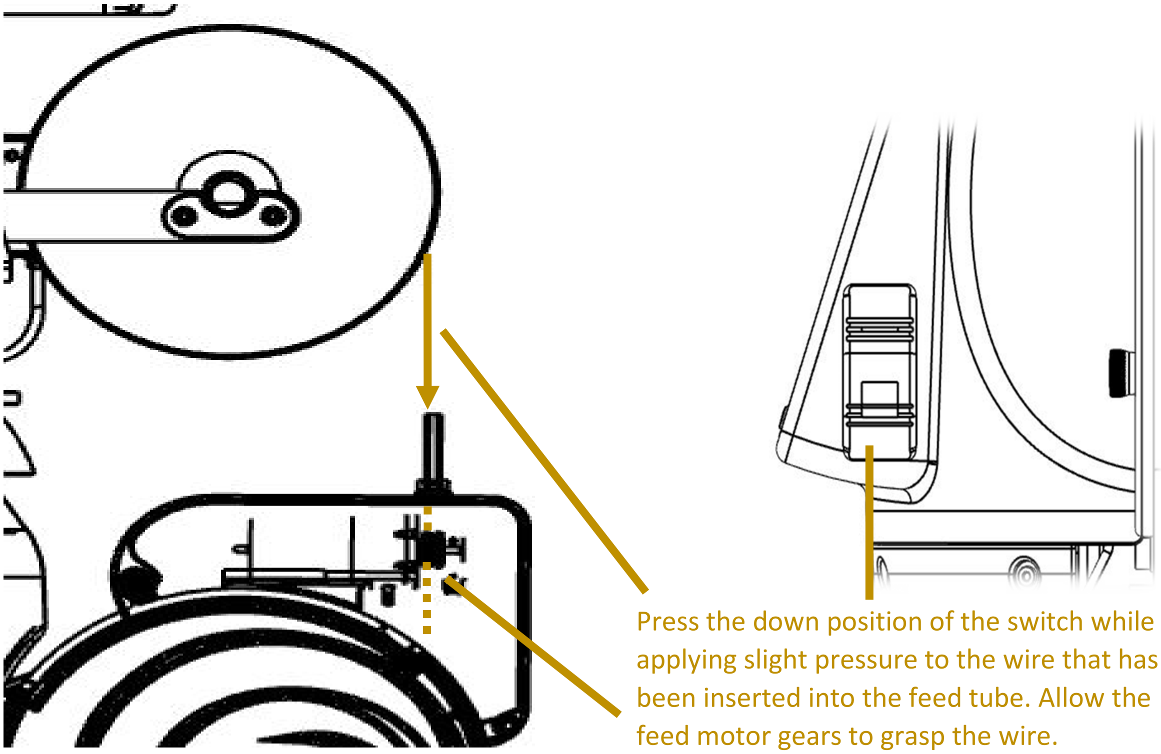



*Figure 77: Wire Feed Procedure*

After successfully feeding the tie wire into the external feed motor, continue to press and hold the down position of the pre-spool feed motor switch until the tie wire is fed to the Tie Module (see Figure 78). Release the pre-spool feed motor switch after the tie wire has reached the area between the pre-spool housing and the Tie Module.

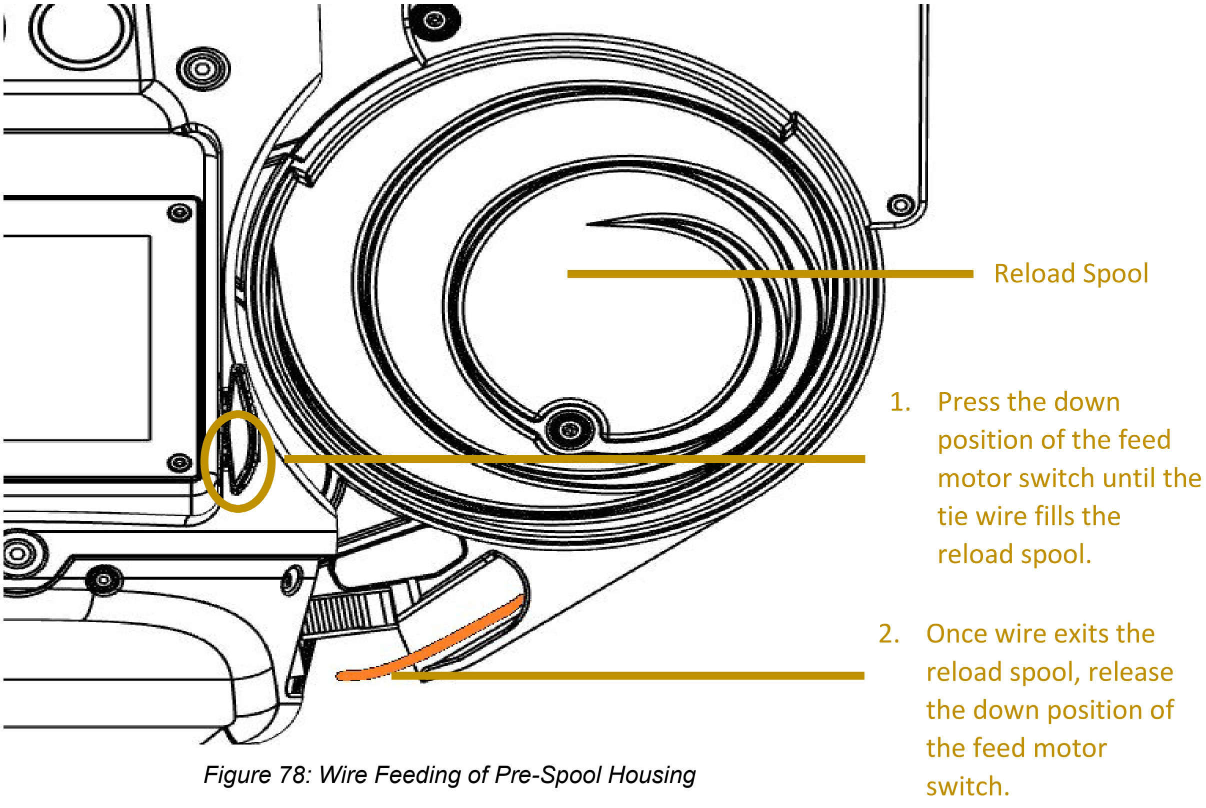



*Figure 78: Wire Feeding of Pre-Spool Housing*

The tie wire will then need to be inserted into the Tie Module. Ensure that the tie wire has been fully inserted into the Tie Module feed gears and lock the wire into place using the Tie Module lock button (see Figure 79).

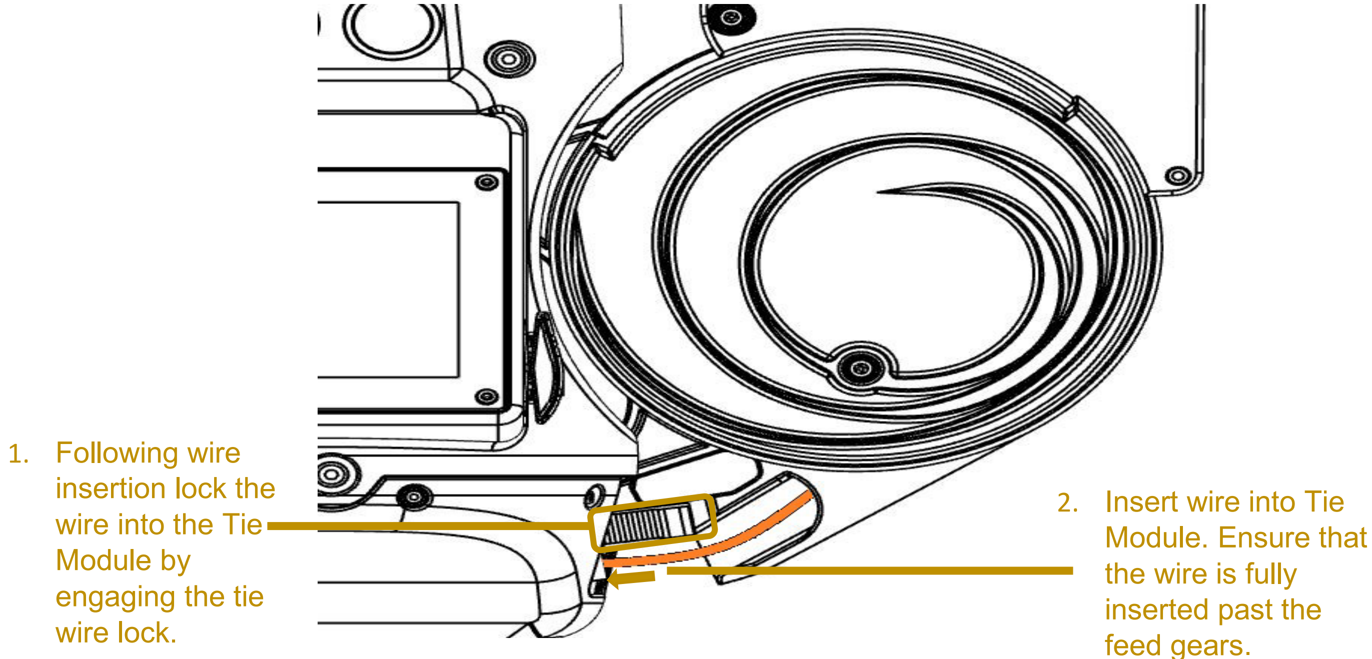



*Figure 79: Locking Tie Wire into Tie Module*

Depress the down position of pre-spool feed motor switch until the green LED illuminates on the switch (see Figure 80).

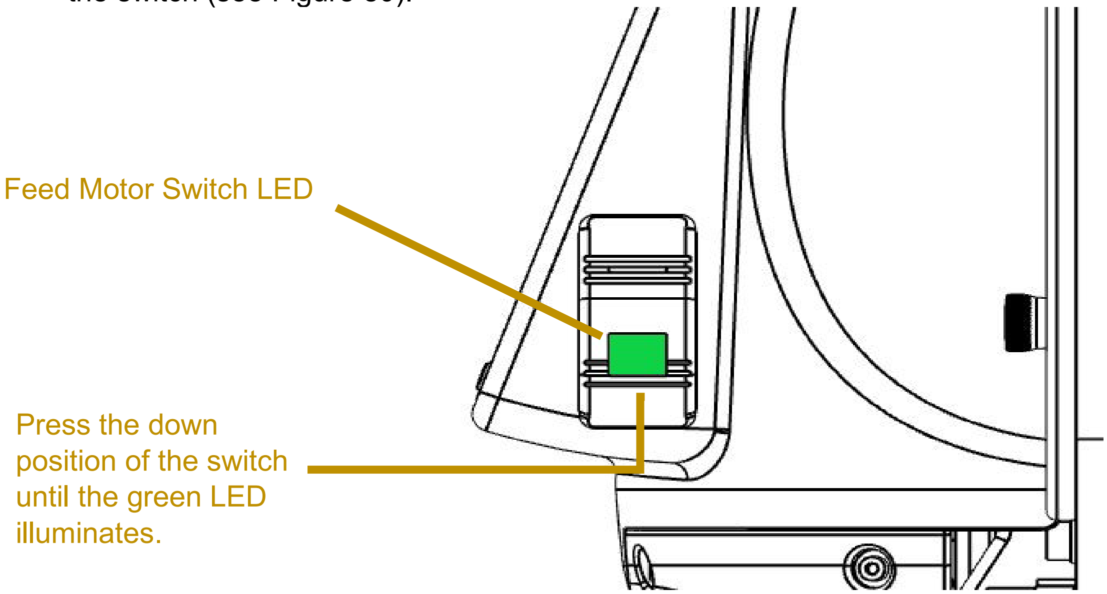
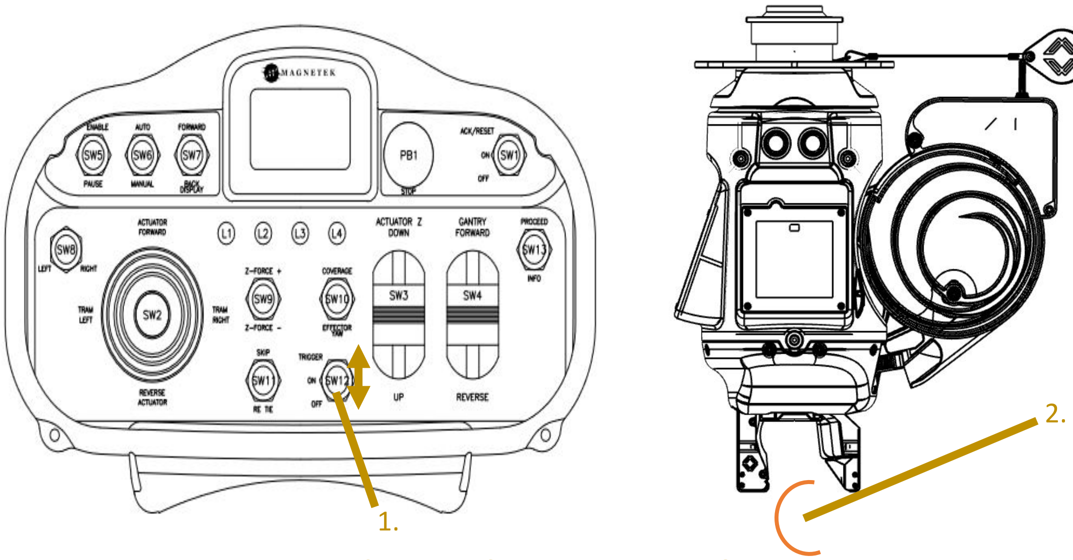



*Figure 80: Filling the Reload Spool*

An operational check of the Tie Module will need to be accomplished following the spool installation and loading process. Use the Belly Box to conduct the operational test by toggling the trigger toggle (SW12) to off and back to on (Figure 81). This will allow the Tie Module to complete a power cycle and produce a half-moon of tie wire if the tie wire spool is properly loaded.




1. Toggle SW12 to OFF then back to ON.
2. Tie Module should produce a half moon of wire

*Figure 81: Tie Module Operational Check*

If the wire is not produced or an abnormal noise can be heard, the tie wire will need to be removed and re-inserted into the Tie Module. After the wire is removed inspect the wire for deformities that may have been caused by the Tie Module. If the wire has been damaged during removal, the deformed portion of wire can be removed using a suitable wire-cutting tool. Repeat the Tie Module wire loading process until the Tie Module can perform a successful operational check. Following a successful operational check, the Tie Module can be used for autonomous tying operations.

## Tie Module Service and Maintenance

Proper care will be required to maintain the efficiency of the Tie Module. Performing field servicing and maintenance will prolong the service life of a Tie Module until the manufacturer's service intervals have been met. TyBOT recommends that the owners send Tie Modules to the TyBOT Service and Support Department when service intervals have been met and when a Tie Module is rendered unserviceable due to a defect that cannot be repaired in the field.

## Tie Module Service and Repair Tag

Owners are required to fill out the defective Tie Module serial number, current number of ties, the discrepancy or required servicing, and name and date (Figure 82). The fields in the lower half of the service tag do not need to be filled out by the owner.

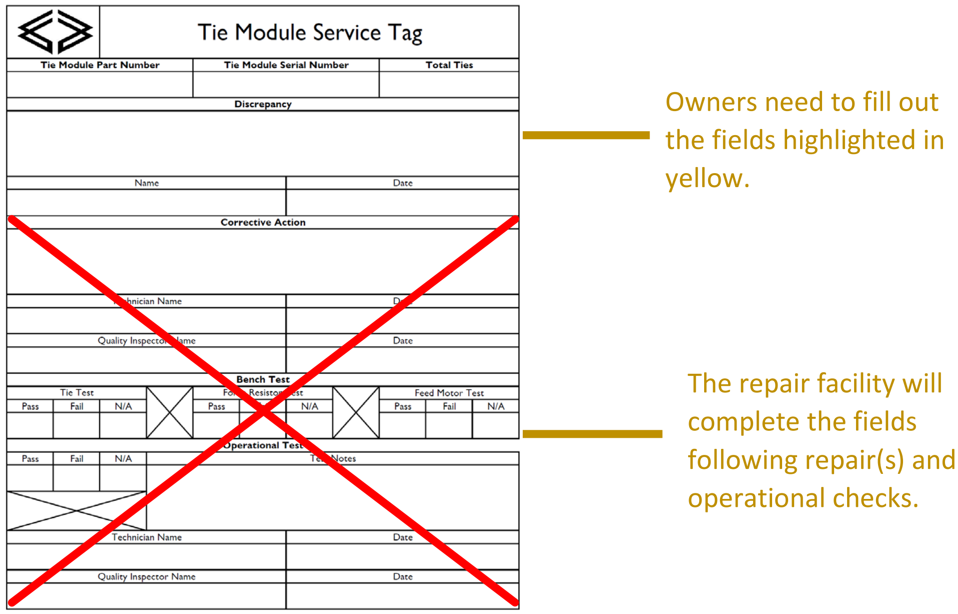



*Figure 82: Tie Module Service and Repair Tag*

A completed Tie Module service and repair tag will be attached to a Tie Module that requires service performance. The tag will be shipped with the Tie Module to the TyBOT Service and Support Department.

## Tie Module Service Intervals

Tie Modules should receive a manufacturer's servicing every 150,000 ties. Once a Tie Module reaches the 150,000 or 300,000 total tie count, it should be shipped to the TyBOT Service and Support Department in the provided Tie Module shipping container. TyBOT recommends that the Tie Modules be sent in for servicing at 150,000 +/- 15,000 ties or 300,000 +/- 30,000 ties to maintain optimum efficiency.

Only a certified Tie Module technician is to complete the servicing. Tie Module critical components can be damaged if the servicing is incorrectly performed.

### *Every 150,000 Ties (Phase A) Service*

A 150,000 tie inspection consists of a full unit teardown. All components will be inspected and cleaned. Any components that have been deemed unserviceable during the inspection will be replaced. The Tie Module fixed cutter will be rotated to lengthen the life cycle of the cutter.

### *Every 300,000 Ties (Phase B) Service*

A 300,000 tie inspection consists of a full unit teardown. All components will be inspected and cleaned. Any components that have been deemed unserviceable during the inspection will be replaced. The twister and cutter assemblies will be replaced as the components have reached their life limits.

## Tie Module Field Service

It is recommended that owners perform field various field servicing tasks on Tie Modules that are being utilized for autonomous tying operations. Completing the outlined tasks at the recommended intervals will prolong the service life of the Tie Module.

***Tie Module Air Purge*** – At the completion of each tying shift an air purge of the Tie Module should be completed. Complete the air purge by using compressed air to remove all built-up debris that has accumulated within the Tie Module's orifices (Figure 83). The air purge can be conducted with the Tie Module removed or installed on a TyBOT.

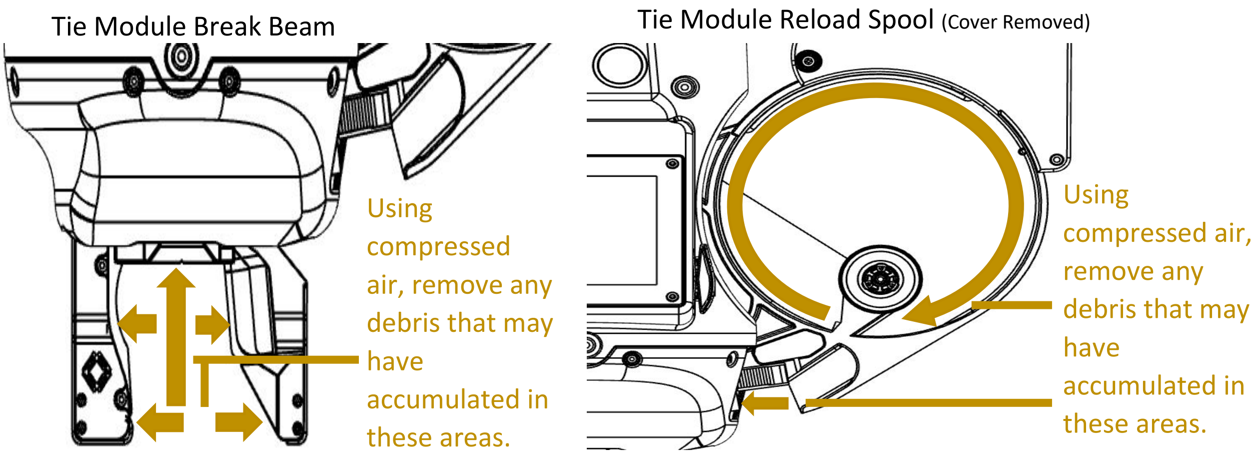



*Figure 83: Air Purge*

### *Tie Module Field Maintenance*

A Tie Module may exhibit signs of component failure during autonomous tying operations. Common component failures and remedies are listed below. Properly diagnosing component failures and issuing the appropriate corrective action will prolong the service life of the Tie Module.

***Excessive Wire Blockages (Jamming)*** – During tying operations, a dislodged wire may block the pathway for the twist motor to complete a tying cycle properly. The Belly Box may issue a "Wire Status" fault code if the Tie Module cannot complete a tying cycle. If this is encountered there are two remedies which are listed below:

- Use the Belly Box to clear the fault by cycling the trigger toggle (SW12) to off and back to on (Figure 84). This will allow the Tie Module to complete a power cycle and produce a half-moon of tie wire which clears the wire pathway of heavy debris. After a half-moon of wire is produced, momentarily toggle SW13 up to the proceed function which will place the TyBOT back into autonomous tying mode. If wire blockages and wire status warnings are continually issued, proceed to Step 2 of this section.

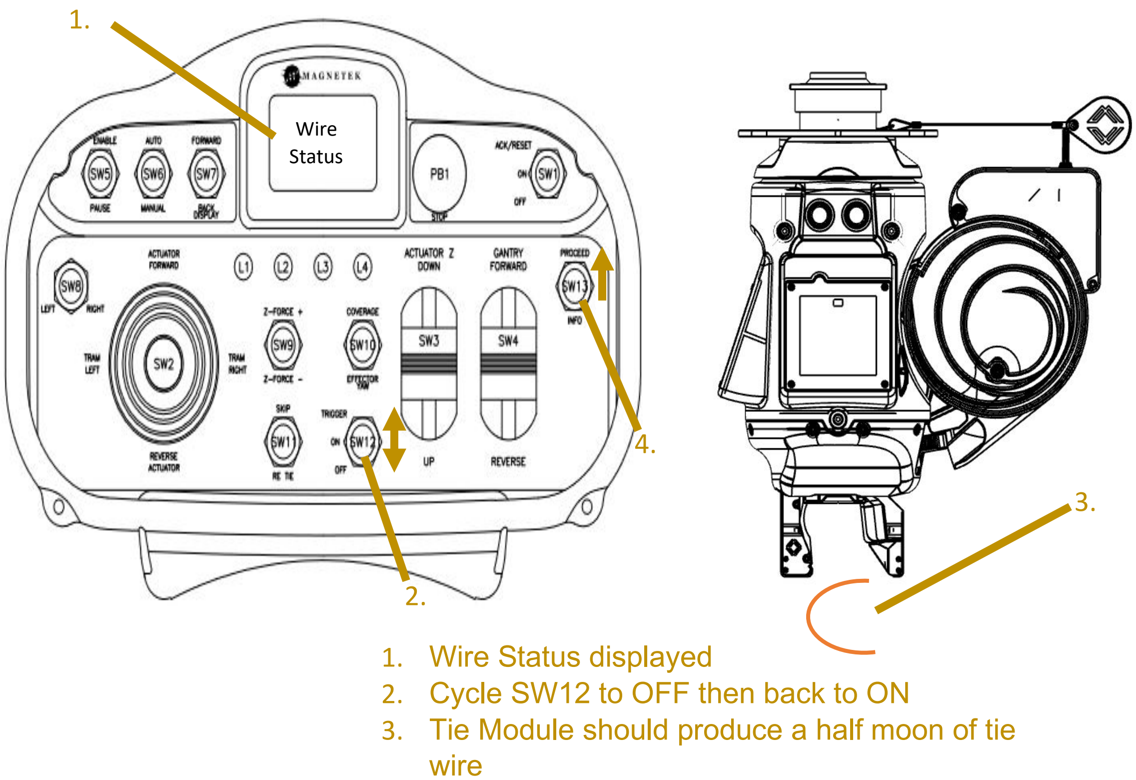



*Figure 84: Automatic Removal of Wire Blockages*

- Inspect the Tie Module for wire blockages within the Tie Module twist motor assembly and wire pathway (Figure 85). Remove any wire or debris that is present, using a suitable tool such as needle nose pliers. Complete Step 1 of this section once all debris has been cleared.

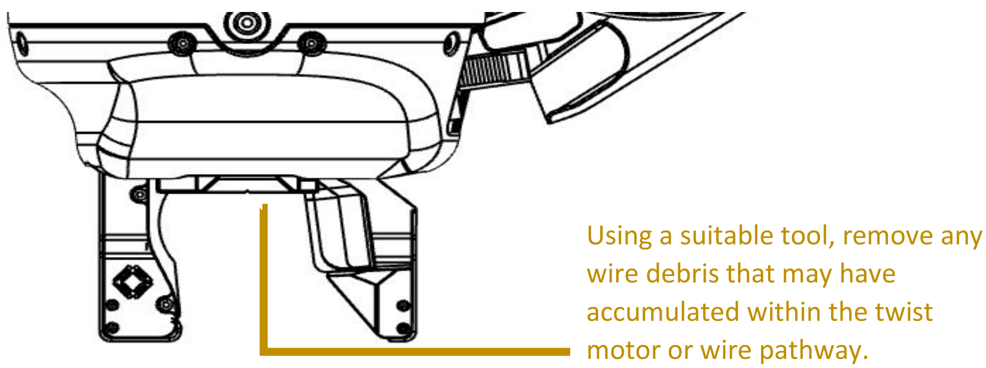



*Figure 85: Manual Removal of Wire Blockages*

If the remedies listed above do not improve the function of a Tie Module that is experiencing excessive wire blockages contact a TyBOT Service and Support representative.

***Break Beam Blocked*** – Each Tie Module is equipped with a sensor system known as the break beam. The break beam sensor notifies a TyBOT and TyBOT user that there is an obstruction in the critical pathway between the Tie Module's tying jaws. A rebar map fault code will be issued on the Belly Box display and the green LED on the Tie Module will be illuminated when a blockage has been detected between the sensors (Figure 86).

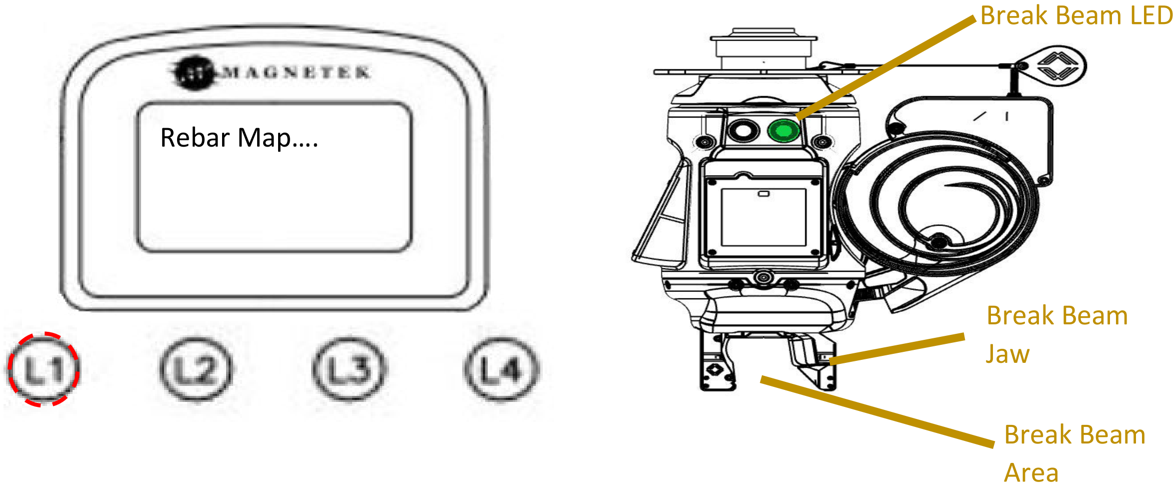



*Figure 86: Notification of Break Beam Blockage*

Autonomous tying operations will cease until the break beam is clear of any obstruction(s). The procedure outlined below outlines a potential remedy if this occurs.

1. Ensure that the TyBOT is paused – L2 will be illuminated yellow. Using compressed air remove any debris that has accumulated within the sensor area (Figure 87).

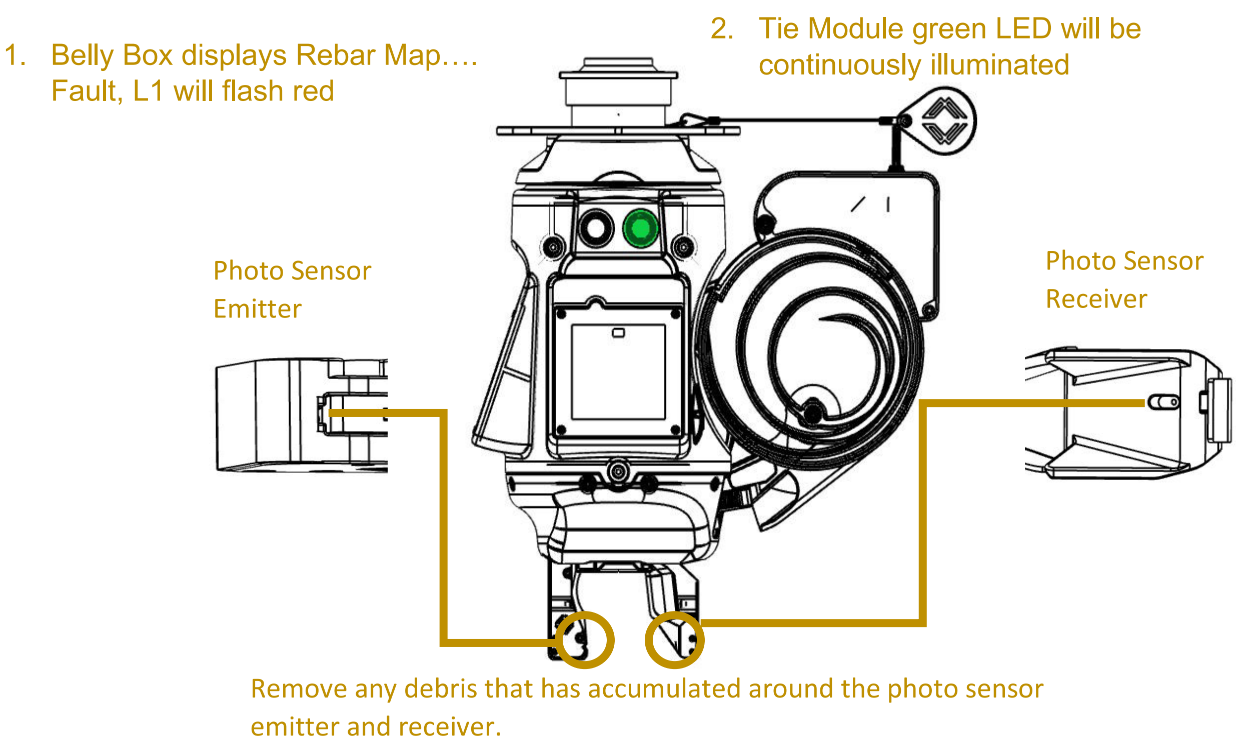
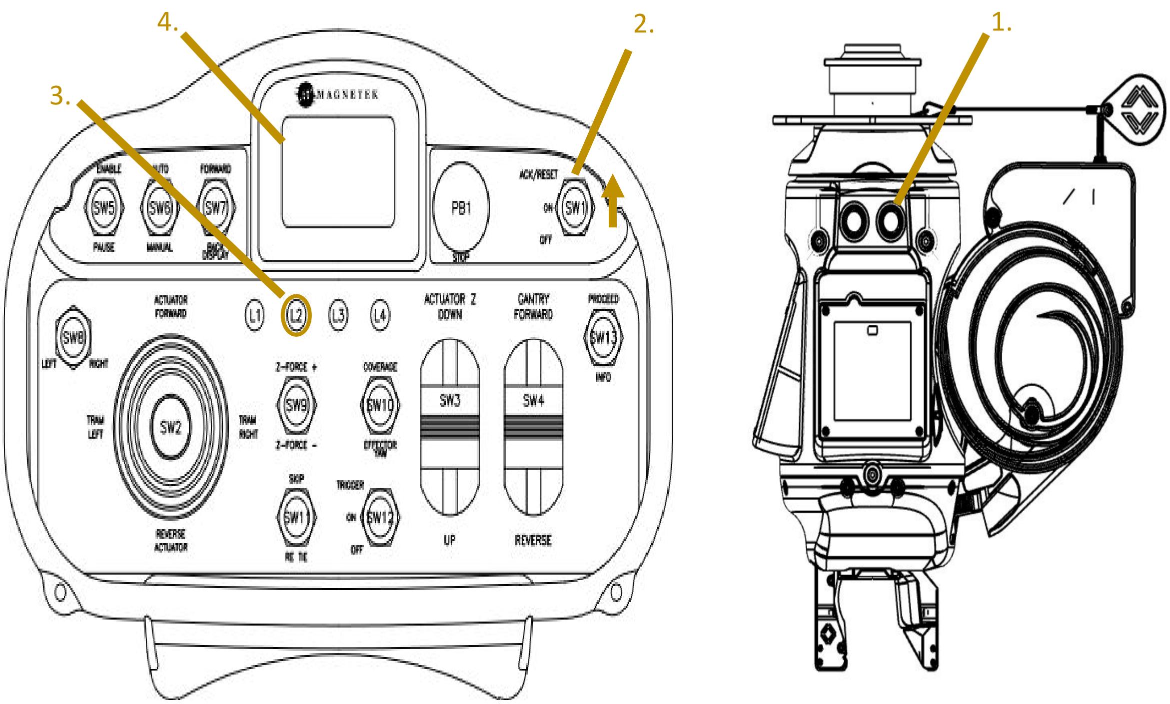



*Figure 87: Removal of Break Beam Blockage*

2. If the debris blocking the break beam sensor properly removed the green LED on the Tie Module will extinguish (Figure 88). The rebar map fault can be acknowledged by toggling SW1 to ACK/RESET on the Belly Box. After acknowledging, L1 (red) LED will extinguish and the TyBOT is ready for autonomous tying operation.

If the remedy listed above does not improve the function of a Tie Module that is experiencing a break beam blockage refer to Troubleshooting Section VI. or contact a TyBOT Service and Support representative.




1. Green LED on Tie Module should extinguish.
2. Toggle SW1 to ACK/RESET.
3. L1 (red) will extinguish and L2 (yellow) will remain illuminated.
4. Rebar Map Fault will clear from display.

*Figure 88: Acknowledging Break Beam Blockage Removal*

# Tie Module Advanced Operation

During manual and autonomous operation, a Tie Module may need to be positioned for installation, removal, wire loading, or configuration. This section outlines the advanced operation procedures a TyBOT user should follow while conducting manual or autonomous operations. Each advanced operation procedure is to be conducted using a TyBOT that is powered on and the corresponding Belly Box that is powered on.

## Homing the Tie Module

Homing the Tie Module allows the user to move the Tie Module to a raised/reverse position. This position gives the TyBOT user safe access to the Tie Module so that Tie Module removals, installations, Tie Module maintenance, and tie wire loading can be conducted. Also, a Tie Module should be placed into the home position anytime that a TyBOT is moved manually forward and/or reverse.

Moving a Tie Module into the home position can be completed by toggling SW5 to the pause position and holding SW5 in the pause position for 3 seconds. The TyBOT will then position the Z-axis linear actuator to the full up position and the Y-axis linear actuator to the full reverse position (Figure 89).

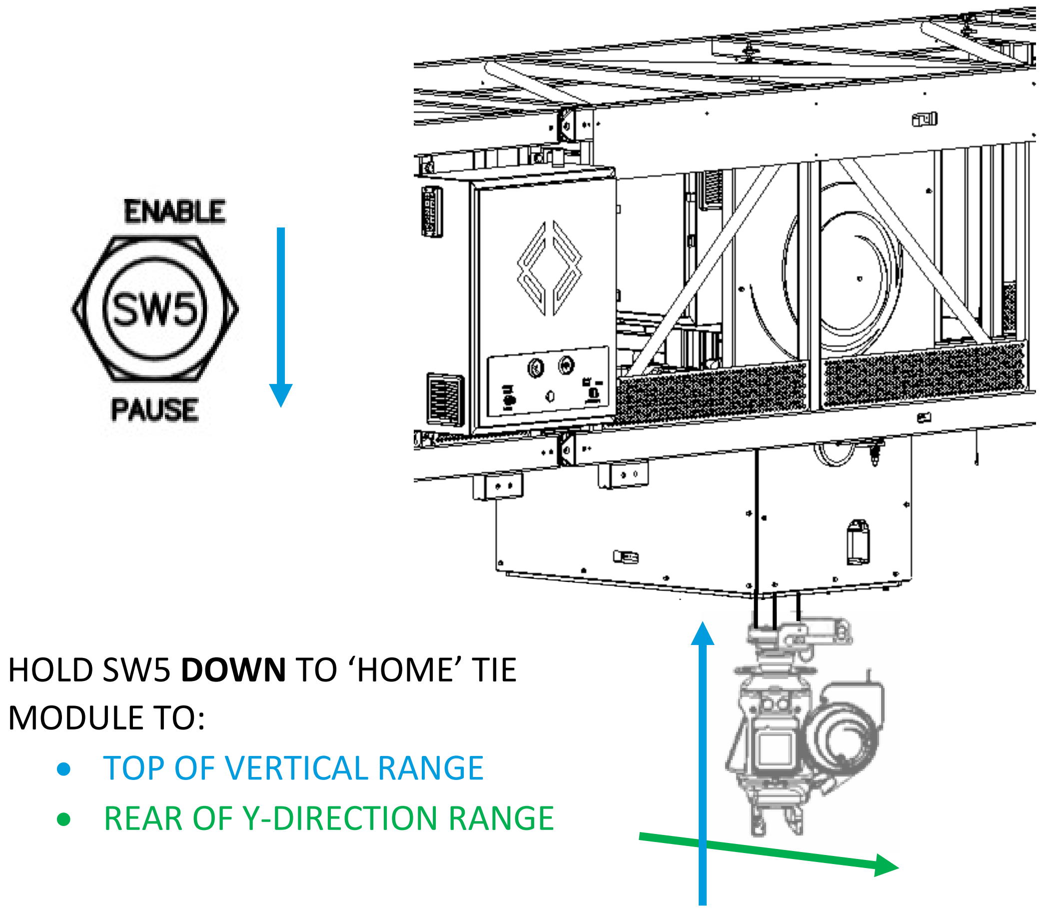



*Figure 89: Tie Module Homing*

After the TyBOT has moved the Tie Module to the home position, L2 will illuminate yellow notifying a TyBOT user that the TyBOT is in a paused state. Tie Module maintenance or wire loading can be conducted following the homing procedure.

## Tie Module Yaw Angle Adjustment

'Yaw angle' describes the orientation of the Tie Module break beam jaws relative to the rebar grid (X-Y plane). The yaw angle value is normalized (zeroed) to 45° from the Y-direction. This angle should be optimized during the setup process for greatest access to each rebar intersection.

The Tie Module must be in view of the camera to set the yaw angle. Manually lower the Tie Module in the Z-direction using SW3 until the Tie Module break beam jaws are about one inch above the rebar mat. Proceed to manually move the Tie Module forward in the Y-direction using SW2 until the Belly Box issues an audible warning tone and the yaw angle value is displayed on the Belly Box (Figure 90).

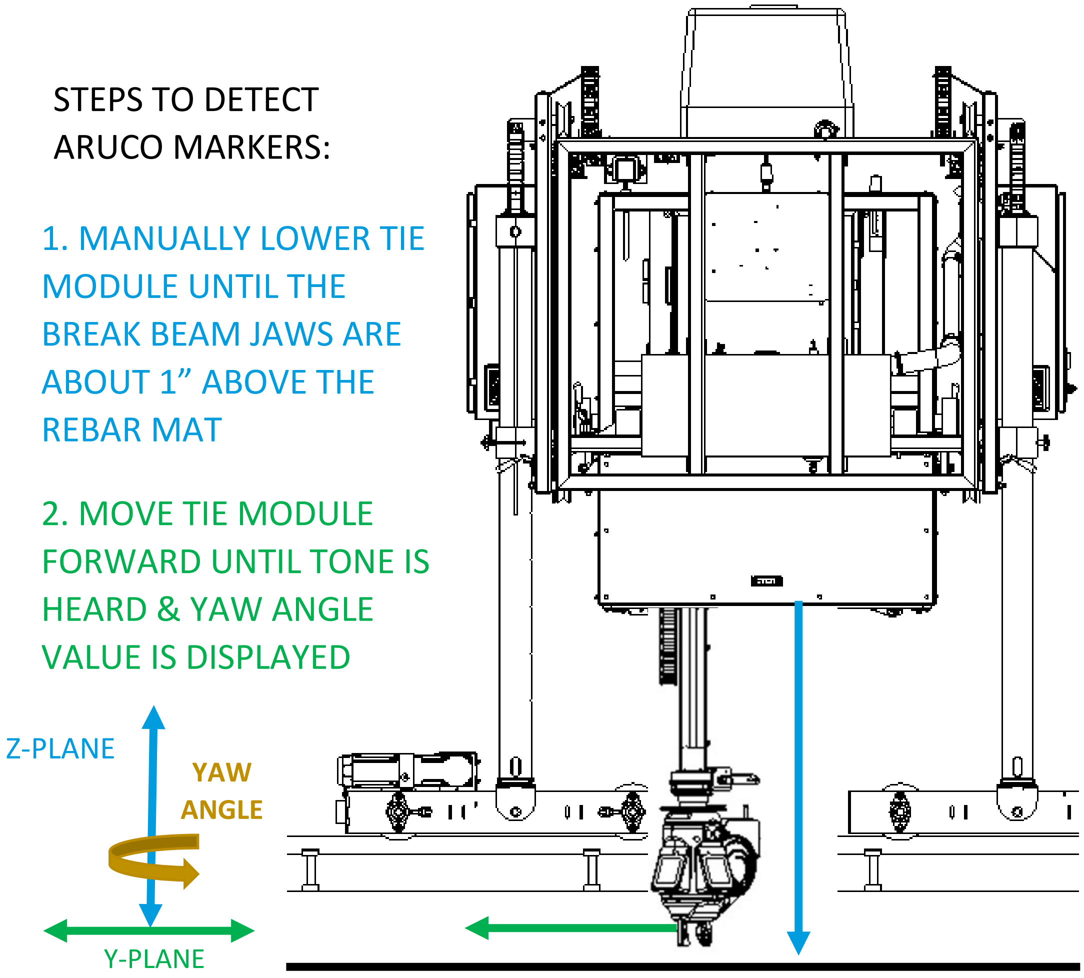



*Figure 90: Aruco Marker Detection*

Adjusting the yaw angle is accomplished by first pulling the adjustment pin from the indexing plate on the bottom of the Z-axis linear actuator (Figure 91). With the adjustment pin retracted, rotate the Tie Module left or right until the yaw angle displayed on the Belly Box shows a value of 0° +/- 2.5°. Release the adjustment pin and slightly rotate the Tie Module left or right until the pin locks into the indexing plate. The detents on the indexing plate are spaced at 5° increments.

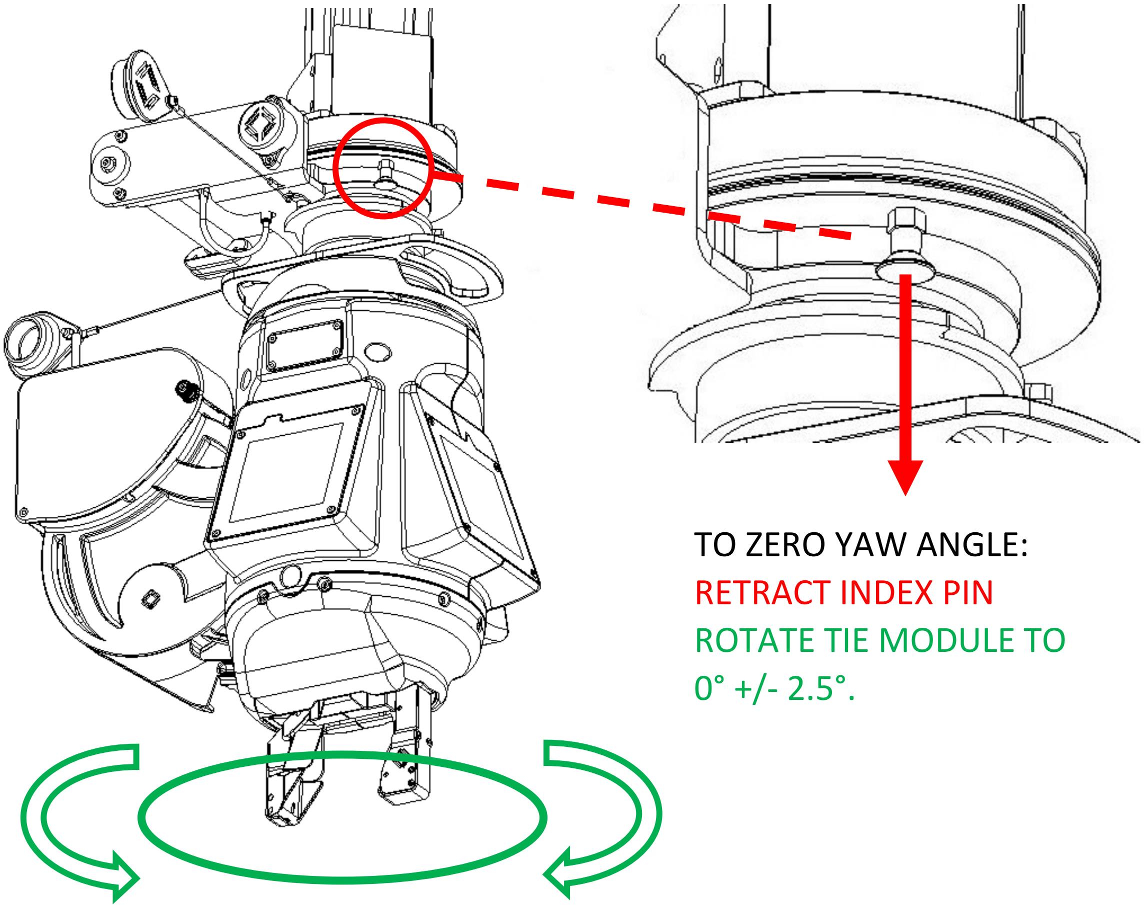



*Figure 91: Yaw Angle Zeroing*

Skewed/unconventional rebar mats may require further adjustment of the yaw angle value to allow optimal access to each rebar intersection. As needed, lower the Tie Module close to the rebar mat and adjust the yaw value until the break beam jaws bisect the intersections (see Figure 92).

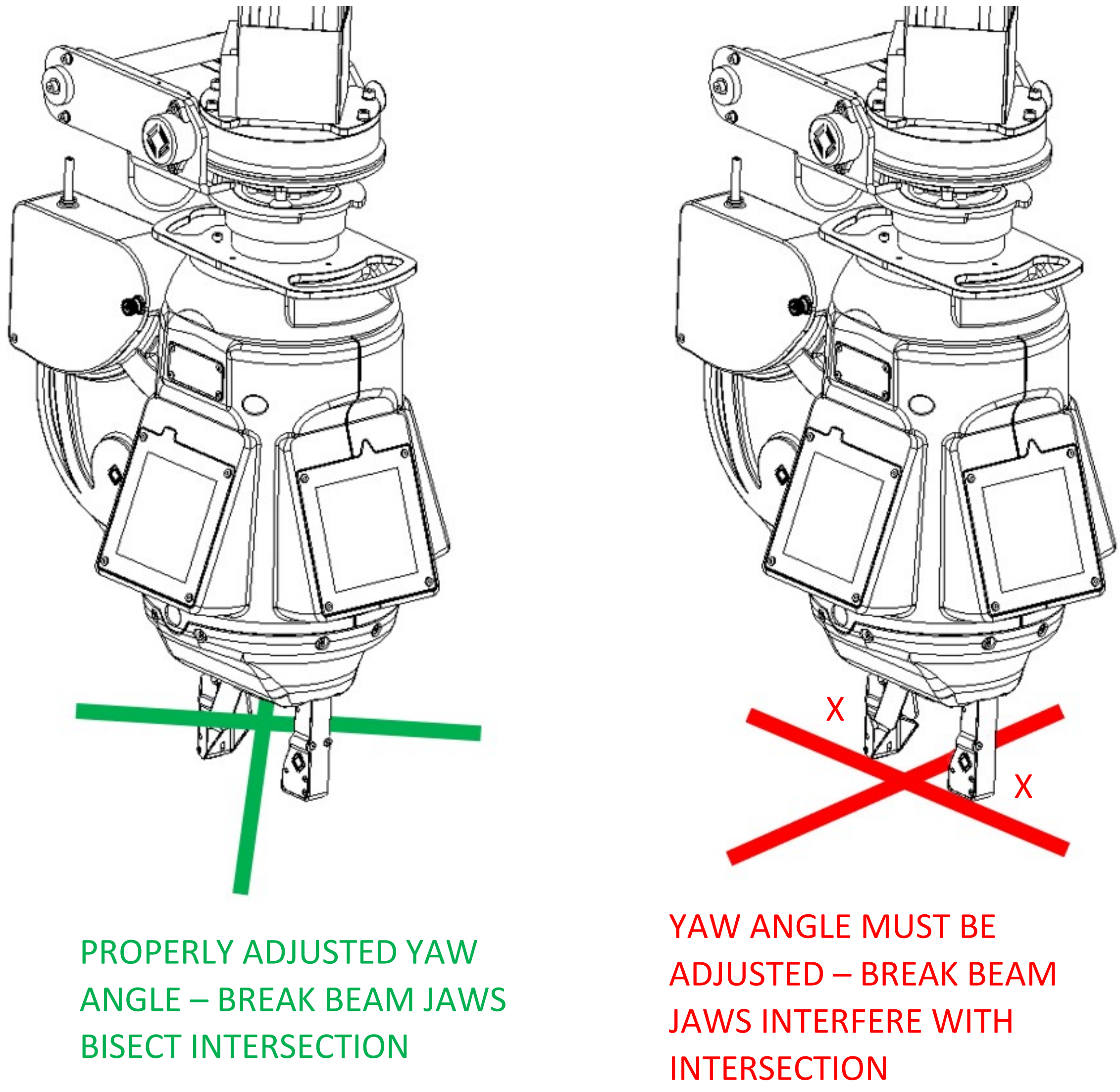



*Figure 92: Optimizing Yaw Angle*

Once the correct yaw angle has been set, acknowledge the displayed angle by toggling SW1 to ACK/RESET on the Belly Box. This will clear the yaw angle from the Belly Box's status display. A Tie Module's yaw angle can be re-displayed by holding SW12 to the trigger position for 3 seconds.

## Tie Module 90° Yaw Angle Adjustment

During autonomous tying operations, a break beam blockage rebar map fault code may be issued. If no debris is present within the break beam sensors (see Break Beam Blockage – Page 70), the Tie Module may need to be rotated 90°. By rotating the Tie Module 90°, it will reduce the amount of glare that is creating a break beam blockage.

Prior to adjusting the Tie Module, display the yaw angle by holding SW12 to the trigger position for 3 seconds. Once the yaw angle is displayed on the Belly Box, adjust the yaw angle by pulling and holding the adjustment knob out of the indexing plate that is located on the bottom of the Z-axis linear actuator. While holding the adjustment knob, rotate the Tie Module left or right until the yaw angle that is displayed on the Belly Box shows a value that is increased or decreased 90° from the previously established yaw angle. Once the correct angle is met, release the adjustment knob. If the adjustment knob does not lock into place slightly rotate the Tie Module left or right until the adjustment knob locks into the indexing plate.

## Tie Module Tie Count Accumulation

A Tie Module accumulates the number of ties during autonomous tying operations. Each tie is counted and can be accessed for data collection. Collecting accurate tie counts for each Tie Module is important for maintenance-related tasks and for determining production rates.

Cumulative tie count is the total number of attempted ties and can be found on the Belly Box. This tie count is utilized to determine when a servicing interval has been met on a Tie Module or the Tie Module experiences a maintenance-related issue. To populate the tie count, the TyBOT will need to be in a paused state. Once the TyBOT has been paused, cycle the trigger toggle (SW12) that is located on the Belly Box to off and back to on (Figure 55). This will allow the Tie Module to complete a power cycle and the updated Tie Module tie count will be populated on the Belly Box display. Warning: the tie count only updates once the Tie Module is powered on. The trigger will have to be manually toggled each time a cumulative tie count needs to be viewed. Cumulative tie counts are to be entered into the total tie field of the Tie Module Service and Repair Tag (Figure 82).

# VI. MAINTENANCE AND TROUBLESHOOTING

## Scheduled Maintenance

Performance of scheduled maintenance is required to maintain the serviceability of the TyBOT. Completing the scheduled maintenance tasks at the appropriate intervals will prolong the service life of the TyBOT. Tie Module scheduled maintenance tasks are outlined in Tie Module Section V.

### TyBOT 1.5 Unit Routine Maintenance Tasks and Intervals

TyBOT operational hours will be used to determine when a service interval has been met. The hour meter that is located on the Gantry Driver Electronics Box displays the TyBOT operational hours (see Figure 93).

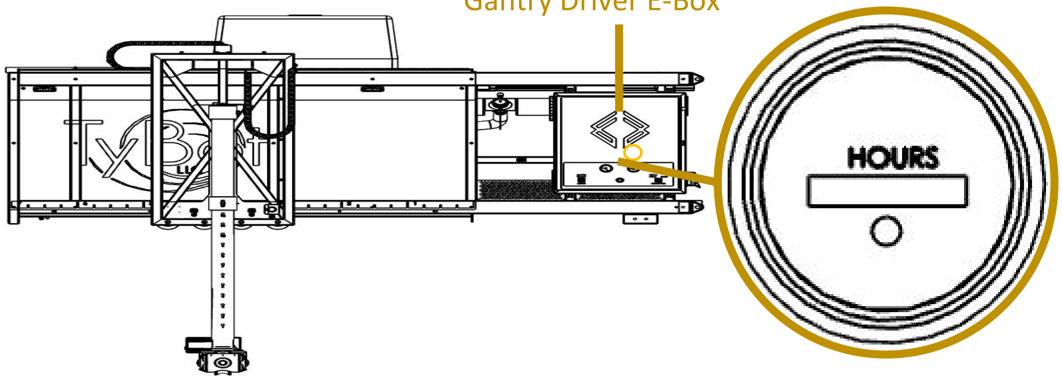



*Figure 93: TyBOT Hour Meter*

Use the hour meter reading to establish when the appropriate service interval has been met. The table below outlines routine maintenance tasks with the appropriate service interval.

| Maintenance Task | Service Interval |
|---|---|
| TyBOT Inspection | 150 Hours |
| Gantry System Bogie Bearing Lubrication | 150 Hours* |
| Tram Idler Shaft Bearing Lubrication | 150 Hours* |
| Tram Drive Shaft Lubrication | 150 Hours* |
| Gantry Stop Inspection | 150 Hours |
| Tram Stop Inspection | 150 Hours |
| **Note(s):** *Denotes that lubrications should be performed more often when operating in dusty or salty environments.<br><br>For Generator service tasks and intervals refer to the Cummins Onan 5.5HGJAD Operators Manual. Generator service tasks include but are not limited to Generator Inspection, Engine Oil Level Check, Generator Battery Cleaning and Check, Clean Spark Arrester, Engine Oil & Oil Filter Changes, Air Filter Replacement, Cleaning of Engine Cooling Fans, Spark Plug Replacement, Fuel Filter Replacement, and Adjustment of Valve Lash. | |

Table 1: Routine Maintenance Tasks.

## TyBOT Inspection

The TyBOT inspection consists of a visual and an operational inspection. It is recommended that the visual inspection be accomplished with the TyBOT Generator powered off. Generator power will need to be applied to the TyBOT to perform the operational portion. Adhere to all safety guidelines while conducting the TyBOT Inspection.

***TyBOT Visual Inspection* –** A visual inspection should be performed on a TyBOT at 150-hour intervals. This visual inspection will aid the TyBOT user in identifying electrical, mechanical, and safety defects that may inhibit the operational performance of the TyBOT. TyBOT inspection zones are displayed below (see Figure 94) and zone inspection criteria are listed in Table 2. If any mechanical defects are identified refer to the TyBOT Illustrated Parts Catalog (IPC) for replacement part information or contact the TyBOT Service and Support Department.

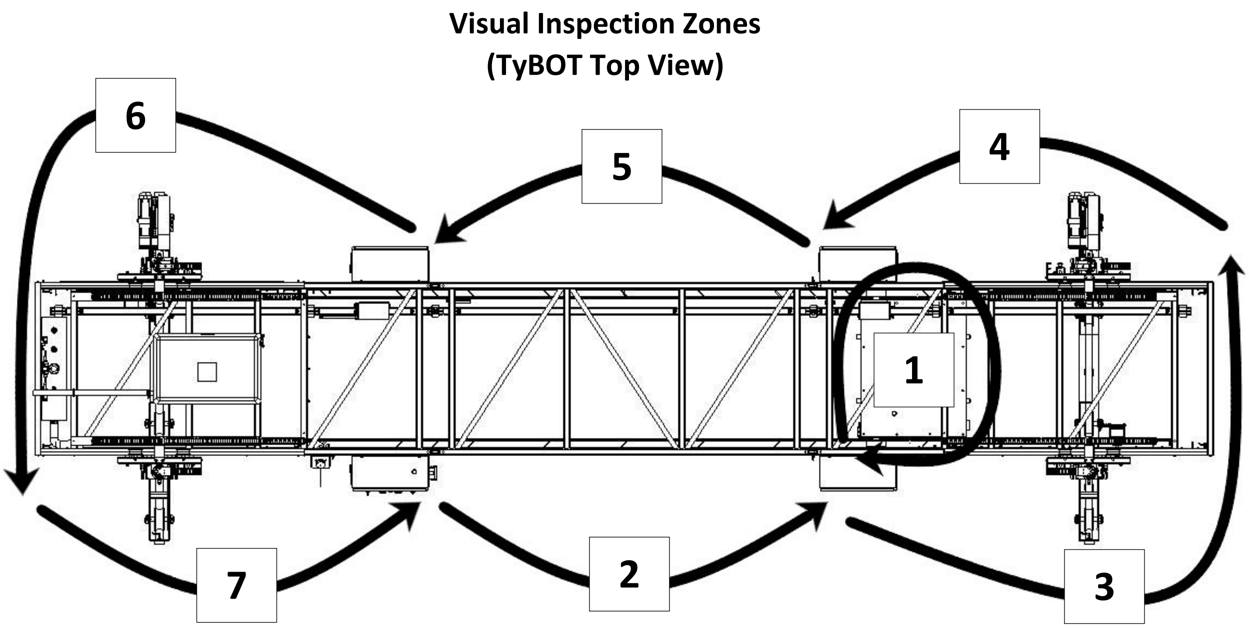
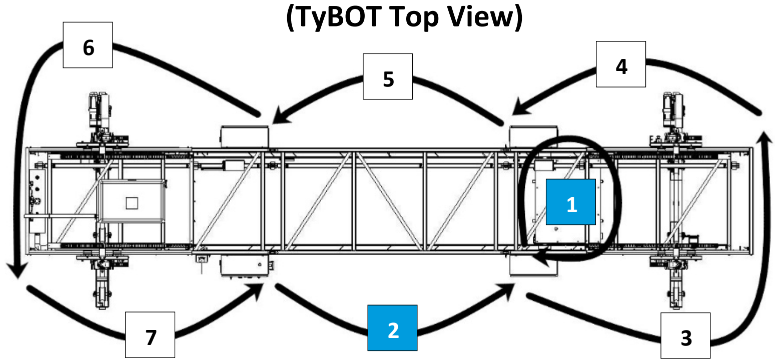
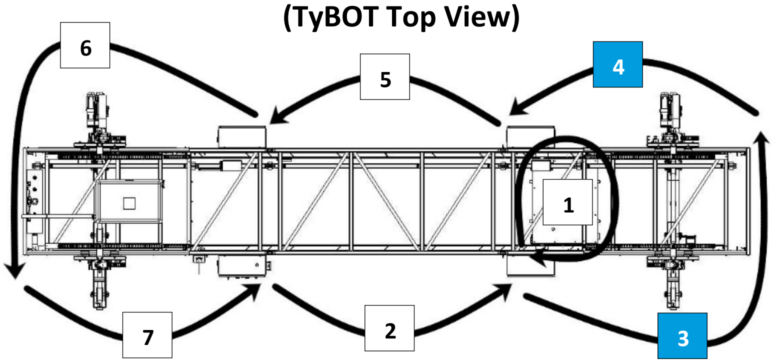



*Figure 94: TyBOT Visual Inspection Zones*




| |
|---|
| ***Zone 1: Tram and Tie Module***<br>• *Tram Drive Shaft – drive motor security, Condition of motor, shaft, and Wheels x2*<br>• *Tram Electronics Box – latches locked and overall box condition*<br>• *Tram Shipping Lock – condition and function*<br>• *Tram Spring Wheel x2 – security and wheel condition*<br>• *Running Lights x2 – condition*<br>• *Tram Idler Shaft – encoder security, Condition of encoder, shaft, and wheels x2*<br>• *Tram Power Box – latches locked and overall box condition*<br>• *Cover Panels – security and cleanliness*<br>• *Camera x2 – security and condition, Inspect for internal moisture*<br>• *Z-Axis Linear Actuator – motor/gearbox security and condition, Actuator security and condition*<br>• *Y-Axis Linear Actuator – motor/gearbox security and condition, Actuator security and condition*<br>• *Tie Module Indexing Mount – indexing pin spring, rotation of the indexing plate, spool latch pin spring, rotation of the spool latch, dust cap condition, and the condition of the spool bayonet*<br>• *Tie Module – quick disconnect components condition and security, Tie Module condition* |
| ***Zone 2: Truss Middle Section(s) (negative side)***<br>• *Gantry Weldment(s) – condition*<br>• *Tram Wheel Track – free of obstruction(s)*<br>• *Cover Panel(s) – security and cleanliness*<br>• *Running Light(s) – condition*<br>• *Attachment Pins – condition of lanyards, pins fully installed and condition* |

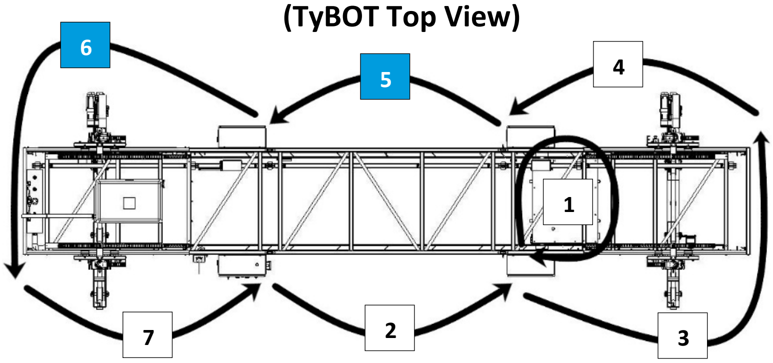
*Table 2: Visual Inspection*




| Zone 3: Passenger Section (negative side) |
|---|
| • Spare Box – latches locked and overall box condition<br>• Gantry Weldment(s) – condition<br>• Tram Wheel Track – free of obstruction(s)<br>• Cover Panel – security and cleanliness<br>• Electrical Wiring – condition of wiring<br>• Running Lights x2 – condition<br>• Skew Sensors x2 – condition<br>• Attachment Pins – lanyard condition, pins fully installed and condition<br>• Gantry Leg Tube – condition, pin fully installed and condition<br>• IGUS Chains x2 – condition<br>• Gantry Leg Interface – condition of weldments and wheels x6<br>• Gantry Leg Locks x2 – condition and function<br>• Emergency Stop – condition and function<br>• Idler Bogie – condition of bogie, wheels x2 and Leg base bracket |
| **Zone 4: Passenger Section (positive side)** |
| • Passenger Power Box – latches locked and box condition<br>• Gantry Weldment(s) – condition<br>• Power Rail – condition<br>• Electrical Wiring – condition of wiring, security and condition of junction boxes x2<br>• Tram Wheel Track – free of obstruction(s)<br>• Cover Panel – security and cleanliness<br>• Running Lights x2 – condition<br>• Skew Sensors x2 – condition<br>• Attachment Pins – lanyard condition, pins fully installed and condition<br>• Gantry Leg Tube – condition, pin fully installed and condition<br>• IGUS Chains x2 – condition<br>• Gantry Leg Interface – condition of weldments and wheels x6<br>• Gantry Leg Locks x2 – condition and function<br>• Emergency Stop – condition and function<br>• Drive Bogie – condition of bogie, motor/gearbox, wheels x2, and Leg base bracket |

*Table 2: Visual Inspection* - continued

**Visual Inspection Zones**
**(TyBOT Top View)**



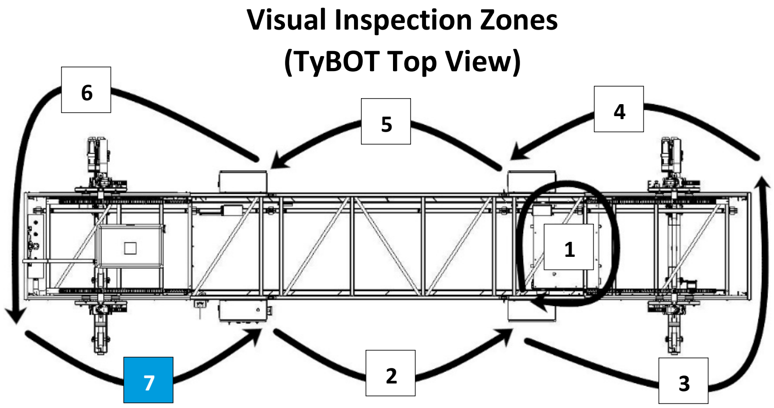

***Zone 5: Truss Middle Section(s) (positive side)***

- *Gantry Weldment(s) – condition*
- *Power Rail(s) – condition*
- *Electrical Wiring – condition of wiring, security and condition of junction box(es)*
- *Tram Wheel Track – free of obstruction(s)*
- *Cover Panel(s) – security and cleanliness*
- *Running Light(s) – condition*
- *Attachment Pins – condition of lanyards, pins fully installed and condition*

***Zone 6: Driver Section (positive side)***

- *Driver Power Box – Latches locked and box condition*
- *Gantry Weldment(s) – condition*
- *Power Rail – condition*
- *Electrical Wiring – condition of wiring, security and condition of junction boxes x2*
- *Tram Wheel Track – free of obstruction(s)*
- *Cover Panel – security and cleanliness*
- *Generator – access door locked, Generator secured to the Gantry System*
- *Exhaust Pipe – condition*
- *Fuel Lines – condition*
- *WIFI Antenna and Fuel Pump Plate – condition of components and plate, security of plate to the Gantry System Frame*
- *Fuel Tank – condition*
- *Running Lights x2 – condition*
- *Skew Sensors x2 – condition*
- *Attachment Pins – pins fully installed and condition*
- *Gantry Leg Tube – condition, pin fully installed and condition*
- *IGUS Chains x2 – condition*
- *Gantry Leg Interface – condition of weldments and wheels x6*
- *Gantry Leg Locks x2 – condition and function*
- *Emergency Stop – condition and function*
- *Drive Bogie – condition of bogie, motor/gearbox, wheels x2 and Leg base bracket*

*Table 2: Visual Inspection - continued*




| |
|---|
| ***Zone 7: Driver Section (negative side)***<br>• *Driver Electronics Box – latches locked and overall box condition*<br>• *Gantry Weldment(s) – condition*<br>• *Tram Wheel Track – free of obstruction(s)*<br>• *Cover Panel – security and cleanliness*<br>• *Fuel Filler and Fuel Line – condition of components and filler cap lanyard condition*<br>• *Electrical Wiring – condition of wiring*<br>• *Running Lights x2 – condition*<br>• *Skew Sensors x2 – condition*<br>• *Attachment Pins –pins fully installed and condition*<br>• *Gantry Leg Tube – condition, pin fully installed and condition*<br>• *IGUS Chains x2 – condition*<br>• *Gantry Leg Interface – condition of weldments and wheels x6*<br>• *Gantry Leg Locks x2 – condition and function*<br>• *Emergency Stop – condition and function*<br>• *Idler Bogie – condition of bogie, wheels x2 and Leg base bracket* |

*Table 2: Visual Inspection - continued*

***TyBOT Operational Inspection –*** An operational inspection should be performed on a TyBOT at 150-hour intervals. The operational inspection will aid the TyBOT user in identifying electrical, mechanical, and safety defects that may inhibit the operational performance of the TyBOT. The TyBOT operational inspection is outlined in Table 3.

| |
|---|
| ***Operational Check: Step 1 Generator Startup (Refer to Operation Section IV., Startup Procedure)***<br>• *Insert the TyBOT key into the key slot (Located on the Gantry Driver Electronics Box) and turn the key to the ON position*<br>  ○ *Master Enable light illuminates*<br>  ○ *Fuel Gauge backlight illuminates*<br>  ○ *Hour Meter backlight illuminates*<br>  ○ *Fuel Gauge needle moves to show the correct fuel level*<br>• *Move and hold the Generator Switch (Located on Gantry Driver Electronics Box) to the PRIME position for 3 to 5 seconds*<br>  ○ *Generator Switch will illuminate while held in the PRIME position*<br>  ○ *After releasing the Generator switch the light will extinguish*<br>• *Move and hold the Generator Switch (Located on Gantry Driver Electronics Box) to the START position until the Generator starts*<br>  ○ *Generator Switch will blink until the Generator has started*<br>  ○ *After releasing the Generator switch the light will remain illuminated*<br>  ○ *After 30 seconds Gantry Running Lights will illuminate and remain solid*<br>  ○ *After 1 to 2 minutes the Tram Running Lights and Perception Lighting will illuminate and remain solid*<br>  ○ *If installed, the Tie Module will perform a power cycle* |

*Table 3: Operational Inspection*

***Operational Check: Step 2 Manual Movement Validation (Refer to Operation Section IV. - Machine Operation-Manual Operation)***

- *Ensure that the TyBOT is properly set up for machine operation (Operation Section IV.)*
- *Adjust the Tram and Gantry stops to accommodate short-distance movements, place the Tram stops so that a Tram travels 3 to 4 feet LEFT and RIGHT, place the Gantry stops so that the Gantry travels 3 to 4 feet FORWARD and REVERSE*
- *Use the Belly Box to move each TyBOT Axis through its full range of travel*
    - *Use SW3 to move the Z-Actuator UP and DOWN, Observe for any mechanical or electrical defects, Ensure that the actuator has a full range of travel, the downward travel limit may not be reached, Do not try to reach the downward limit if the rebar mat or ground becomes an obstacle*
    - *Use SW2 to move the Y-Actuator FORWARD and REVERSE, observe for any mechanical or electrical defects, ensure that the actuator has a full range of travel,*
    - *Use SW2 to move the Tram LEFT and RIGHT, observe for any mechanical or electrical defects, ensure that the Tram has a full range of travel, and stops when the Tram stops are detected*
    - *Use SW4 to move the Gantries FORWARD and REVERSE, observe for any mechanical or electrical defects, ensure that the Gantries have a full range of travel and stops when the Gantry stops are detected*
    - *Use SW8 in conjunction with SW4 to move the Driver Gantry in FORWARD and REVERSE independently of the Passenger Gantry, observe for any mechanical or electrical defects, ensure that the Driver Gantry has a full range of travel and stops when the Gantry stops are detected*
    - *Use SW8 in conjunction with SW4 to move the Passenger Gantry in FORWARD and REVERSE independently of the Driver Gantry, observe for any mechanical or electrical defects, ensure that the Passenger Gantry has a full range of travel and stops when the Gantry stops are detected*

***Operational Check: Step 3 Emergency Shutdown Validation***

- *Startup the TyBOT (Refer to Operation Section IV. Startup Procedure)*
- *Setup the TyBOT for Machine Operation (Operation Section IV.)*
- *Setup the TyBOT for Autonomous Operation (Operation Section IV.)*
- *While running the TyBOT Autonomously depress PB1 – Stop Button on the Belly Box*
    - *TyBOT tying should cease*
    - *TyBOT motions should cease*
- *Pull out PB1 – Stop Button on the control*
- *Move SW1 to the OFF position*
- *Move SW1 to the ON position*
    - *Belly Box should power on*
- *Locate an emergency stop (located on Gantry Leg interface) and depress the stop button*
    - *The Generator should shutdown*
    - *Master Enable light is OFF with the TyBOT key in the ON position*
- *Release the depressed emergency stop button by rotating the button counterclockwise a quarter turn*
    - *Master Enable light is ON with the TyBOT key in the ON position*

***Operational Check: Step 4 Tie Module***

- *Refer to Tie Module Section V.  for Tie Module operational check(s)*

*Table 3: Operational Inspection- continued*

***Gantry Bogie Bearing Lubrication –*** Lubrication of the TyBOT Gantry bogie bearings should occur at 150-hour intervals. There are two bearings attached to each TyBOT bogie wheel assembly (see Figure 95). Each bearing is equipped with a grease fitting. Use a suitable tool such as a grease gun to purge general-purpose lithium-based grease through each bearing.

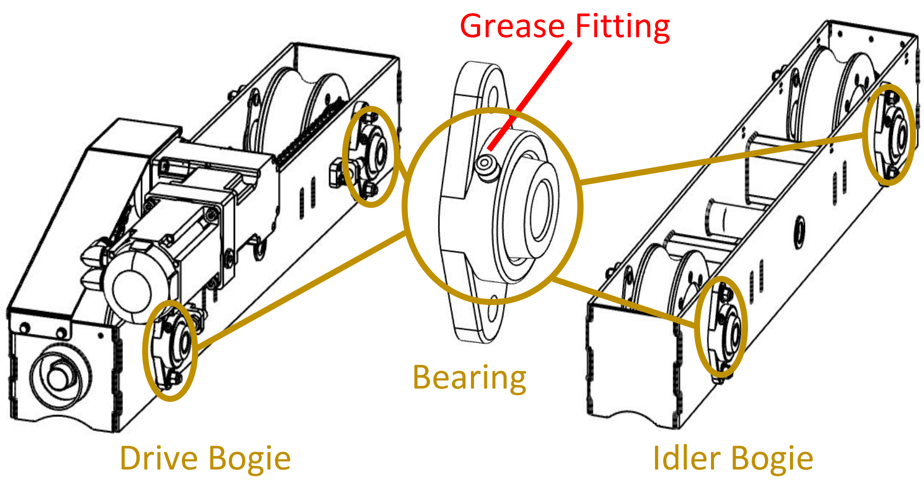



*Figure 95: Gantry Bogie Lubrication Points*

**Note: There are two drive bogies and two idler bogies installed on each TyBOT.**

***Tram Idler Shaft Bearings Lubrication –*** Lubrication of the TyBOT Tram idler shaft bearings should occur at 150-hour intervals. There are two bearings attached to the TyBOT idler shaft (see Figure 96). Each bearing is equipped with a grease fitting. Use a suitable tool such as a grease gun to purge general-purpose lithium-based grease through each bearing.

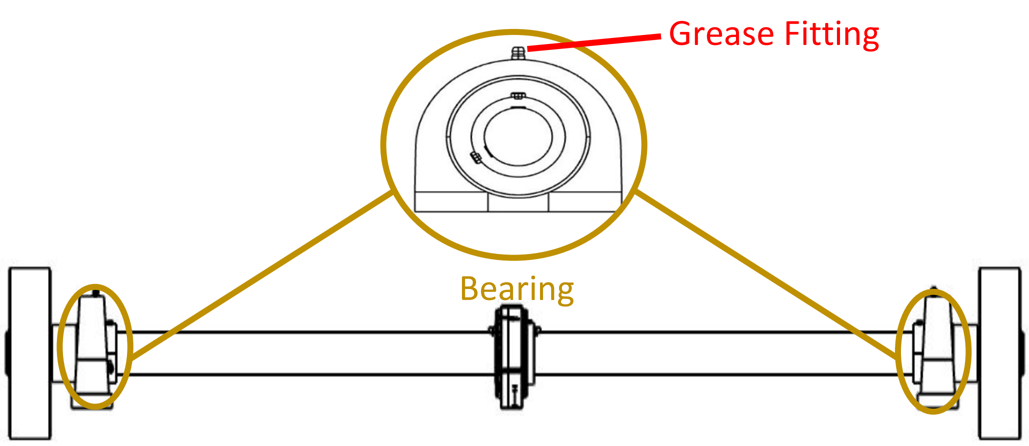



*Figure 96: Tram Idler Shaft Bearings Lubrication Points*

***Tram Drive Shaft Bearings and Gearbox Lubrication –*** Lubrication of the TyBOT Tram drive shaft bearings and gearbox should occur at 150-hour intervals. There are two bearings attached to the TyBOT idler shaft (see Figure 97). Each bearing and the gearbox are equipped with a grease fitting. Use a suitable tool such as a grease gun to purge general-purpose lithium-based grease through each bearing.

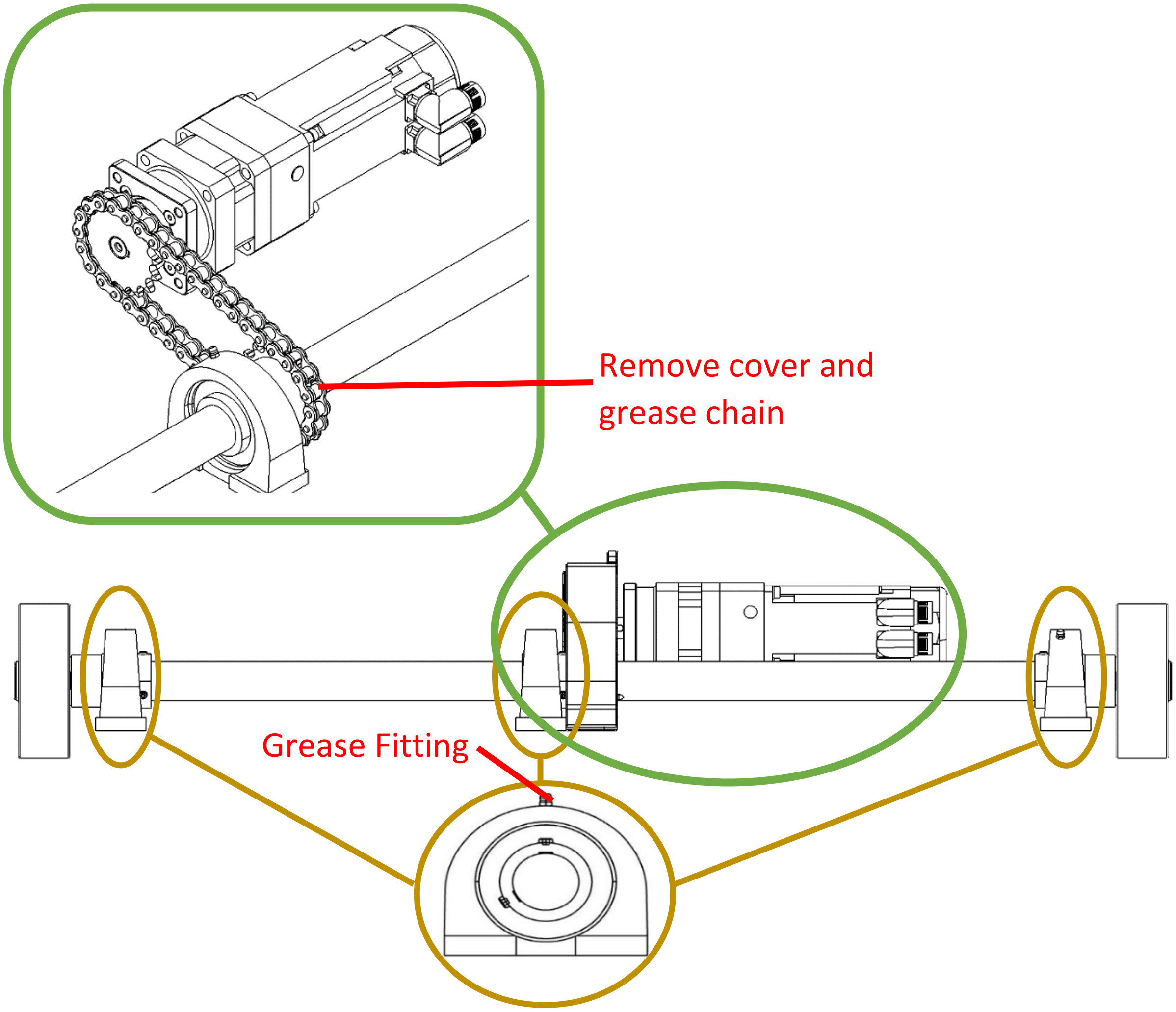



*Figure 97: Tram Driveshaft Lubrication Points*

***Gantry Stop Inspection –*** Inspection of the Gantry stops should occur at 150-hour intervals. Ensure that the TyBOT is equipped with four Gantry stops (see Figure 98). Inspect each Gantry stop for any distortion or cracked welds, and ensure that the four magnets are attached to the underside of each stop.

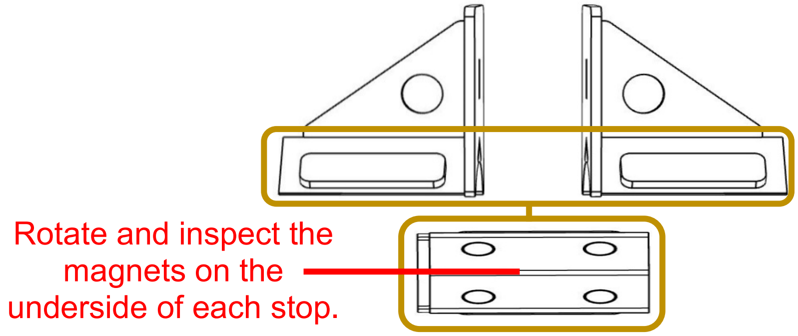



*Figure 98: Gantry Stop Inspection*

***Tram Stop Inspection –*** Inspection of the Tram stops should occur at 150-hour intervals. Ensure that the TyBOT is equipped with two Tram stops (see Figure 99). Inspect each Tram stop for any distortion or worn parts. Ensure that each of the Tram stop springs deflects.

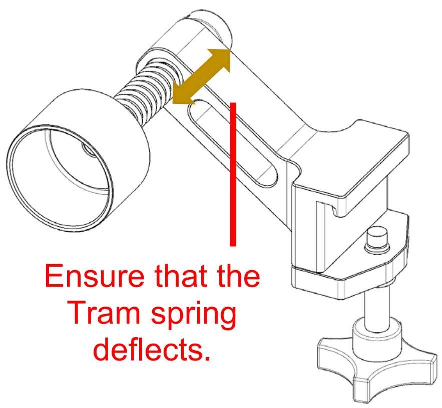



*Figure 99: Tram Stop Inspection*

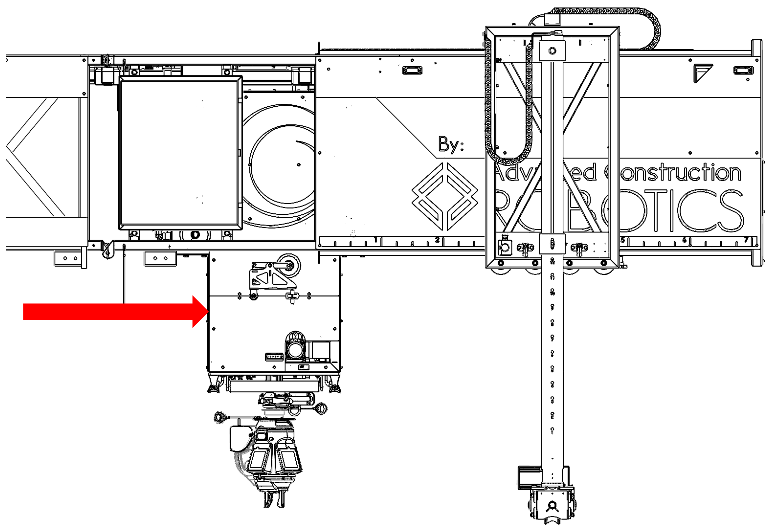
***Camera Calibration –*** Calibration of the camera should occur on an as-needed basis when tie performance appears to be decreasing. Perform camera calibration sequence by manually moving the Tie Module down just above the rebar mat using the Z-actuator down paddle. Then move the Tie Module forward and backward and forward using the Y-actuator FWD/REV paddle. Monitor the Belly Box display screen for the lower-case “fb” and watch for lower-case to transition to upper-case “FB.” Once an upper-case “FB” is displayed the cameras have been correctly calibrated.

# TyBOT 1.5 Unit Trailering Prep, Cleaning, and Long-Term Storage

***TyBOT Preparation for Trailering –*** Prior to trailering TyBOT, the machine should be prepared to minimize risk of damage to components during transport. Steps required are outlined in Table 4.

***Step 1: Stow TyBOT Tram in Passenger Truss***

- *Position Tram within Passenger Side Gantry*
- *Secure Tram lock before lifting*




***Step 2: Home Z-Axis and Remove Tie Module***

- *Move Z-Axis to Home Position*
- *Remove Tie Module and Store in provided case*

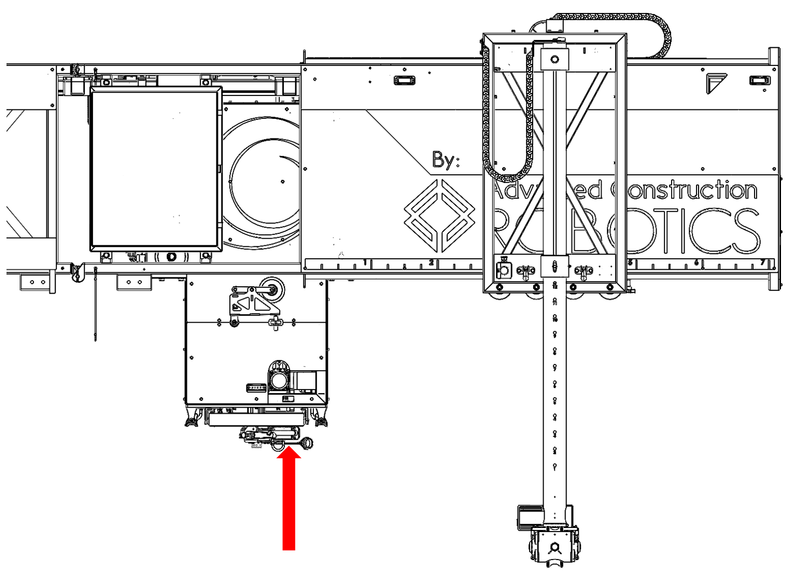



*Table 4 – TyBOT Trailering Prep*

***Step 3: Remove Stereo Cameras***

- *Remove both TyBOT cameras that are located on the undercarriage of the Tram and store in provided cases*
- *Install covers over all exposed camera cable connectors*

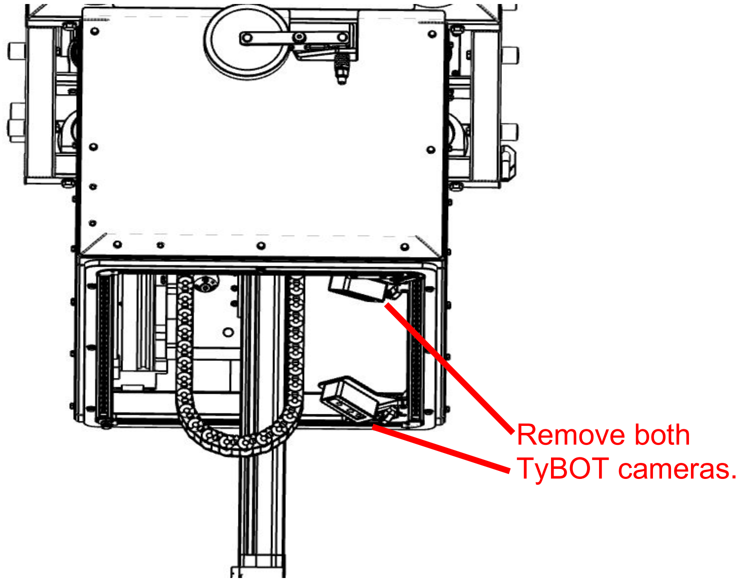
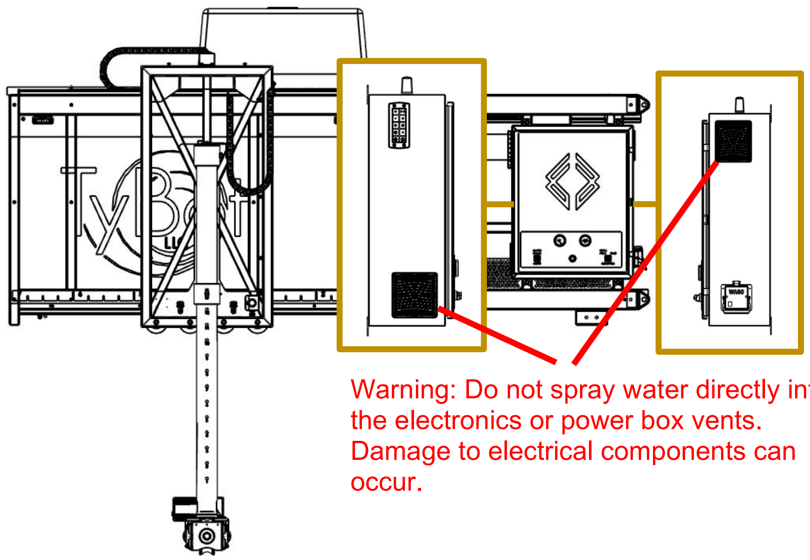



Table 4 - TyBOT Trailering Prep- continued

***TyBOT Unit Cleaning –*** Cleaning of the TyBOT should be performed whenever practicable. It is recommended that a TyBOT unit be cleaned upon returning to its home location, when the TyBOT has been transported during freezing conditions, exposure to salt, and/or prior to being stored long-term. The cleaning procedure is outlined in Table 5.

***Step 1: TyBOT Unit Cleaning Hazards***

- *Remove all power from the TyBOT unit while cleaning is being performed*
- *Avoid spraining water directly into the electronics and power box vents, electrical equipment can become damaged if water is introduced inside the boxes*




***Step 2: TyBOT Unit Cleaning***

- *TyBOT recommends using a heavy-duty degreaser*
- *Water should be applied to the TyBOT followed by the degreaser using a suitable tool such as a soft bristle cleaning brush*
- *Using water rinse all degreaser off the TyBOT*

*Table 5 - TyBOT Cleaning Procedure*

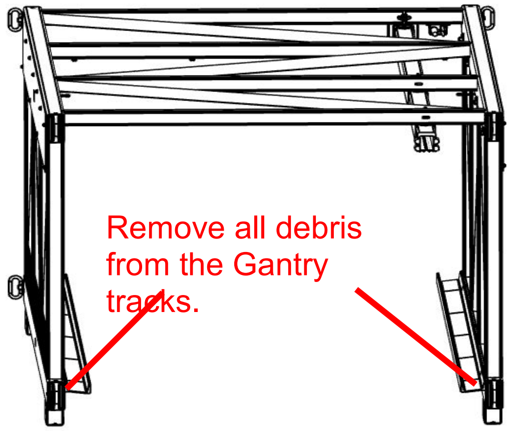
| |
|---|
| ***Step 3: Gantry Track Debris Removal***<br>• *Remove all debris from the Gantry tracks with the degreaser or by hand*<br>• *Rinse the Gantry tracks if necessary*<br> |

*Table 5 - TyBOT Cleaning Procedure- continued*

***TyBOT 1.5 Unit Long-Term Storage –*** Periods may exist when a TyBOT has to be stored without use. If a TyBOT is stored for more than 30 consecutive days, it is recommended that a TyBOT owner completes the tasks outlined in the long-term storage procedure. Completing the tasks outlined in the procedure will prolong the lifetime of the TyBOT. The long-term storage procedure is outlined in Table 6.

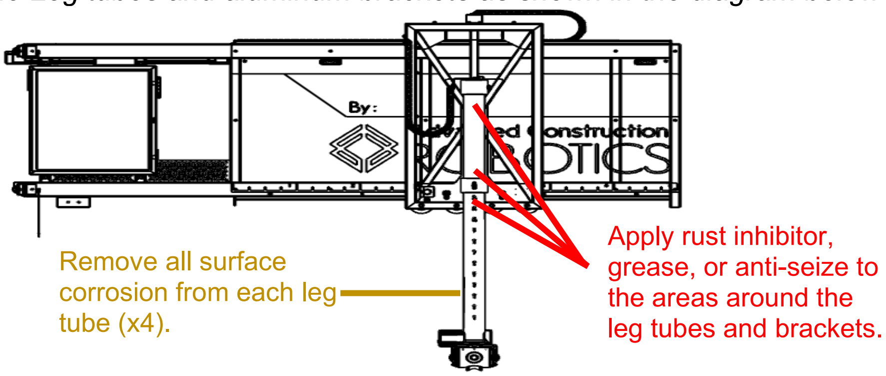
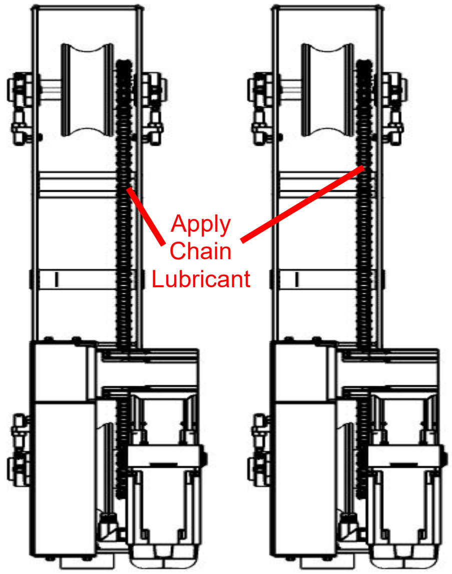
| |
|---|
| ***Step 1: Clean the TyBOT unit***<br>• *Follow the procedure outlined within Maintenance and Troubleshooting; TyBOT Cleaning* |
| ***Step 2: Leg Tube Corrosion Treatment***<br>• *Using a light abrasive pad remove all surface corrosion that has accumulated on the TyBOT Leg tubes as shown on the diagram below in yellow*<br>• *Apply a rust inhibitor, multi-purpose grease, or anti-seize to the areas near the interface of the Leg tubes and aluminum brackets as shown in the diagram below in red*<br> |

*Table 6 - TyBOT 1.5 Unit Long-Term Storage Procedure*

### *Step 3: Drive Bogie Chain Lubrication*

- *Apply chain lubricant to both Gantry Drive Bogie Chains as shown below*




### *Step 4: Bearing Collar Corrosion Treatment*

- *Using a light abrasive pad remove all surface corrosion that has accumulated on all Tram and bogie-bearing collars as indicated below*
- *Apply a rust inhibitor to all Tram and bogie bearing collars as shown below indicated in red*

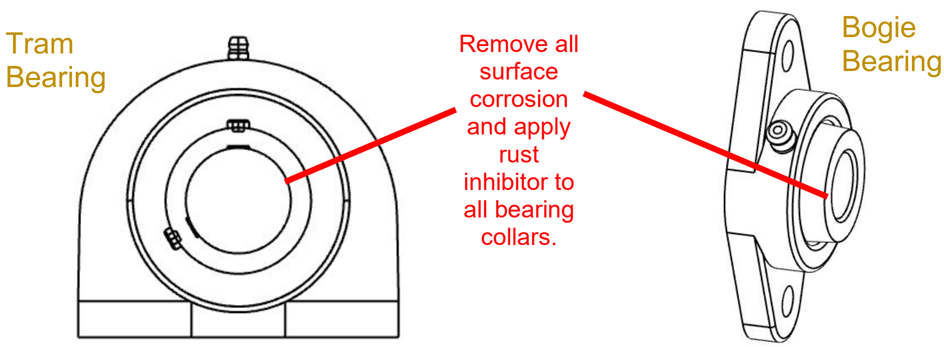
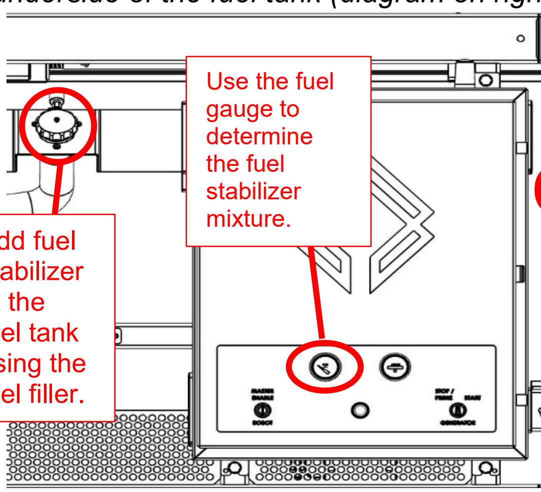


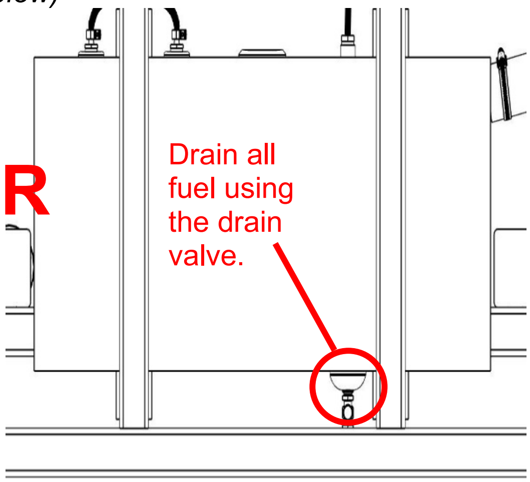

*Table 6 - TyBOT 1.5 Unit  Storage Procedure- continued*

### *Step 5: Fuel Maintenance*

- *Add a fuel stabilizer to the fuel tank via the fuel filler cap (diagram on left below), use the fuel gauge to determine the proper amount of fuel stabilizer to be added; if no fuel additive is available, completely drain the fuel tank using the drain valve that is located on the underside of the fuel tank (diagram on right below)*




OR




### *Step 6: Remove Stereo Cameras*

- *Remove both TyBOT cameras that are located on the undercarriage of the Tram and store in provided cases*
- *Install covers over all exposed Truss harnesses and camera cable connectors*

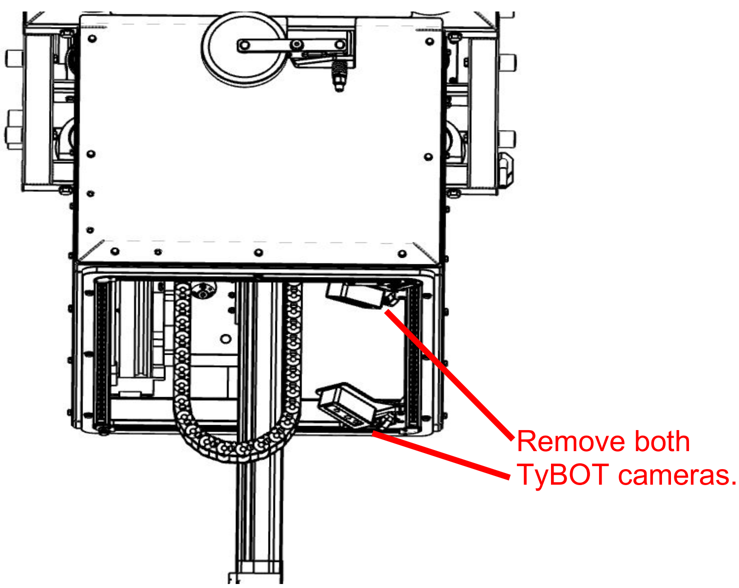



*Table 6 - TyBOT 1.5 Unit  Storage Procedure - continued*

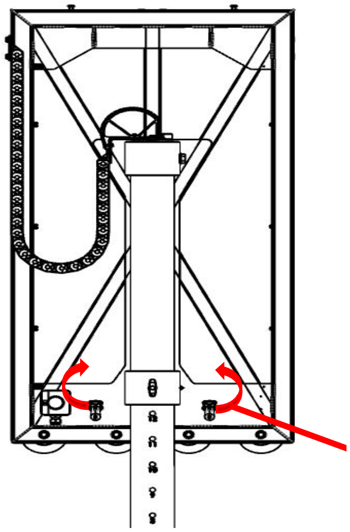
| ***Step 7: Unlock Leg Interfaces and Loosen Securing Straps (if installed)*** |
|---|
| • *Upon arriving at a storage location unlock all (4) Leg interface toggle clamps by pulling the handles upward*<br>• *If a TyBOT is to be stored on a trailer top, loosen all ratchet straps*<br><br> |

*Table 6 - TyBOT 1.5 Unit Storage Procedure- continued*

## TyBOT Troubleshooting

***Troubleshooting*** – For any troubleshooting occurrences refer to the TyBOT Troubleshooting Manual Document 50-004-0003 Rev. D located in the Reference Section.

## TyBOT Service and Support Department

The TyBOT Service and Support Department is staffed with professional service personnel who are available to provide both pre-deployment support as well as on-the-job technical assistance whenever needed. Below is the contact list for the TyBOT Service and Support Department. If the on-call technician cannot be reached, please send an email with a brief description of the technical issue, name, and phone number to service@constructionrobots.com.

**Office Phone: 412-756-3360, Option 2**
**Email: service@constructionrobots.com**
**Address: 3812 William Flinn Hwy**
**Building 3H**
**Allison Park, PA 15101**

# TyBOT Middle Sections Charts

ACR PN: 50-004-0017-A

## TyBOT 1.5

Skew Angle (degrees)

Rail-to-Rail (ft)

| 1 | 0 | 2.5 | 5 | 7.5 | 10 | 12.5 | 15 | 17.5 | 20 | 22.5 | 25 | 27.5 | 30 | 32.5 | 35 | 37.5 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 1 | 1 | 1 | 1 | FALSE | FALSE | FALSE | FALSE | 1 | 1 | 1 | 1 | 1 | 1 | 1 | FALSE | FALSE |
| 22.5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | FALSE | FALSE |
| 25 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | FALSE | 1 | 1 | FALSE | FALSE |
| 27.5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | FALSE | 2 | 2 | FALSE | FALSE |
| 30 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | FALSE | 2 | FALSE | FALSE |
| 32.5 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | FALSE | 2 | FALSE | FALSE |
| 35 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | FALSE | 3 | FALSE | FALSE |
| 37.5 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | FALSE | FALSE | FALSE | FALSE |
| 40 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | FALSE | FALSE | FALSE |
| 42.5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | FALSE | FALSE | FALSE |
| 45 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | FALSE | 4 | FALSE |
| 47.5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | FALSE | 4 | FALSE | 4 | FALSE |
| 50 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | FALSE | 5 | FALSE |
| 52.5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | FALSE | 5 | FALSE |
| 55 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | FALSE | FALSE | FALSE | FALSE |
| 57.5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | FALSE | 5 | FALSE | FALSE |
| 60 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | FALSE | 6 | FALSE | FALSE |
| 62.5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | FALSE | 6 | FALSE | FALSE |
| 65 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 6 | FALSE | FALSE |
| 67.5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 6 | FALSE | 6 | 7 | FALSE | FALSE |
| 70 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | FALSE | 7 | 7 | FALSE | FALSE |
| 72.5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 7 | FALSE | FALSE | FALSE |
| 75 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | FALSE | FALSE | FALSE |
| 77.5 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 8 | FALSE | FALSE | FALSE |
| 80 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | FALSE | FALSE | FALSE |
| 82.5 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | FALSE | FALSE | FALSE | FALSE |
| 85 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | FALSE | FALSE | FALSE | FALSE |
| 87.5 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | FALSE | FALSE | FALSE | FALSE | FALSE |
| 90 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | FALSE | 9 | FALSE | FALSE | FALSE |
| 92.5 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 10 | FALSE | FALSE |
| 95 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | FALSE | FALSE |
| 97.5 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | FALSE | FALSE |
| 100 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 11 | FALSE | FALSE |

# in cell = # of 3m Middle Sections | 0 (1m Middle) | 1 (1m Middle) | 2 (1m Middle)

# TyBOT 2.0

Skew Angle (degrees)

Rail-to-Rail (ft)

| 1 | 0 | 2.5 | 5 | 7.5 | 10 | 12.5 | 15 | 17.5 | 20 | 22.5 | 25 | 27.5 | 30 | 32.5 | 35 | 37.5 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 1 | 1 | 1 | 1 | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | 1 | 1 | 1 | 1 | FALSE | FALSE | FALSE |
| 22.5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | FALSE | 1 | 1 | FALSE | FALSE | FALSE |
| 25 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | FALSE | FALSE | 1 | FALSE | FALSE | FALSE |
| 27.5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | FALSE | FALSE | 2 | FALSE | FALSE |
| 30 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | FALSE | FALSE | 2 | FALSE | FALSE |
| 32.5 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | FALSE | 2 | FALSE | FALSE |
| 35 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | FALSE | FALSE | FALSE | FALSE |
| 37.5 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | FALSE | FALSE | FALSE | FALSE |
| 40 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | FALSE | 3 | FALSE | FALSE | FALSE | FALSE |
| 42.5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | FALSE | 3 | 3 | FALSE | FALSE | FALSE |
| 45 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | FALSE | 4 | FALSE | FALSE | FALSE |
| 47.5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | FALSE | 4 | FALSE | FALSE | FALSE |
| 50 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | FALSE | 4 | FALSE | FALSE | FALSE |
| 52.5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | FALSE | FALSE | FALSE | FALSE |
| 55 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | FALSE | FALSE | FALSE | FALSE |
| 57.5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | FALSE | 5 | FALSE | FALSE | FALSE | FALSE |
| 60 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | FALSE | 5 | FALSE | FALSE | FALSE | FALSE |
| 62.5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | FALSE | 6 | FALSE | FALSE |
| 65 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | FALSE | 6 | FALSE | FALSE |
| 67.5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 6 | FALSE | FALSE | 7 | FALSE | FALSE |
| 70 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | FALSE | 7 | FALSE | FALSE | FALSE |
| 72.5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | FALSE | 7 | FALSE | FALSE | FALSE |
| 75 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | FALSE | 7 | 7 | FALSE | FALSE | FALSE |
| 77.5 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | FALSE | 7 | 8 | FALSE | FALSE | FALSE |
| 80 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 8 | FALSE | FALSE | FALSE | FALSE |
| 82.5 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | FALSE | FALSE | FALSE | FALSE |
| 85 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | FALSE | FALSE | FALSE | FALSE |
| 87.5 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | FALSE | FALSE | FALSE | FALSE | FALSE |
| 90 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | FALSE | FALSE | FALSE | FALSE | FALSE |
| 92.5 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | FALSE | FALSE | FALSE | FALSE | FALSE |
| 95 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | FALSE | 9 | 10 | FALSE | FALSE | FALSE |
| 97.5 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | FALSE | FALSE |
| 100 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 11 | FALSE | FALSE |

# in cell = # of 3m Middle Sections | 0 (1m Middle) | 1 (1m Middle) | 2 (1m Middle)

# TyBOT Tie Wire Certificate of Origin

ACR PN: 50-006-0002

| | | |
|---|---|---|
| TyBOT, LLC<br>3812 William Flinn Hwy #3H<br>Allison Park, PA 15101<br>412-756-3360 | **Title:** Plastic Coated Coil Wire | |
| | **Doc No.** 50-006-002 | **Origin Date:** 7/3/19 |
| | **Product:** TyBOT Plastic Coil Wire | |

## STANDARD REQUIREMENTS:

TyBOT, LLC Plastic Coated Coil Wire is drawn, annealed, coated, coiled, and packaged in the USA and complies with "Buy American" and "Buy America" standards. TyBOT, LLC Plastic Coated Coil Wire conforms to the ASTM A853 specification and to the ASTM A775 specification, appendix section X1.3.13. (The AASHTO designation M-284M/M 284 has been superseded by ASTM A775). TyBOT, LLC Plastic Coated Coil Wire also conforms to the requirements of "American Iron and Steel (AIS)" as outlined in provisions P.L. 113-76, the Consolidated Appropriations Act, 2014.

## CHEMICAL REQUIREMENTS:

TyBOT, LLC Plastic Coated Coil Wire is produced using C1006 or C1008 grade of steel as specified in ASTM A510 and A1040.

## PHYSICAL REQUIREMENTS:

**Core Wire** – The core wire used to produce TyBOT, LLC Plastic Coated Coil Wire is annealed in a "dead soft" annealing cycle. The wire used is annealed to a tensile range of 40,000psi to 54,000psi. The final tensile range after processing and plastic coating will be 40,000psi to 60,000psi.

**Core Wire Diameter:**

| 16.5 Gauge | |
|---|---|
| Min. | Max. |
| 0.057" | 0.059" |

**Coating** – TyBOT, LLC Plastic Coated Coil Wire is coated with a bonded HDPE (High-Density Polyethylene). Polyethylene is considered a dielectric material with a dielectric constant of 2.25. The thickness of the coating is 7 mils +/-2.

**Overall Diameter:**

| 16.5 Gauge | |
|---|---|
| Min. | Max. |
| 0.070" | 0.074" |

## PACKAGING REQUIREMENTS:

TyBOT, LLC Plastic Coated Coil Wire is supplied in 15-pound coils. There are 4 coils packaged in a box for a total weight of 60 pounds per carton.

Additional technical questions in regard to TyBOT, LLC Plastic Coated Coil Wire products can be directed to:

TyBOT, LLC
3812 William Flinn Hwy #4B
Allison Park, PA 15101
412-756-3360

## TyBOT® Command Quick Reference

ACR PN: 50-004-0002-A

| Command | Switches | Duration | Other Conditions | Remarks |
|---|---|---|---|---|
| **Remote Power Down** | RC Off | Immediate | Hold Pause & Manual | Power down is delayed 5 sec |
| **SW Reset** | Start/Reset | 8 sec | Pause Mode | All LEDs on indicates complete |
| **Acknowledge Feedback** | Start/Reset | Immediate | Feedback displayed | Only applies to feedback line actively displayed on RC |
| **Manual Home** | Pause | 2.5 sec | Pause Mode | |
| **Toggle Skew Limits** | EffectorYaw | Immediate | Proceed | Feedback indicates active mode |
| **Hold Fault** | Start/Reset | Immediate | Hold Proceed | Stops persistently intermittent fault cycle by holding fault on |
| **Tie Tension Adjust** | Force (+/-) | Immediate | Hold Trigger | Text feedback indicates new level |
| **Auxiliary Text Display** | Info | Momentary | Aux text exists | Only applies to feedback line actively displayed on RC |
| **Reverse Ops Toggle** | Coverage | Immediate | Hold Pause & Auto | Feedback indicates ON or OFF |
| **Tie Module Warmup** | Trigger | 5 sec | None | Turn Tie Module off to cancel |

## TyBOT® Command Quick Reference

ACR PN: 50-004-0002-A

| Command | Switches | Duration | Other Conditions | Remarks |
|---|---|---|---|---|
| **Obs Avoidance Toggle** | Skip + Force(-) | Immediate | Hold Pause | Feedback indicates active mode |
| **Gantry Differential Control Toggle** | Info | Immediate | Hold Pause | Feedback indicates active mode |
| **Mock Tying Mode** | Skip + Trigger | Immediate | None | Feedback indicates active mode |
| **Snapshot** | EffectorYaw + Force(-) | Immediate | None | Feedback shows timestamp |
| **Data Collection Toggle** | Coverage + Force(+) | 2 sec | None | Feedback indicates active mode |
| **Fast Log Transfer** | Start/Reset | Immediate | Hold Proceed | Robot is **not** operational during fast transfers, shows x/+ spinner |
| **Cancel Log Transfer** | Start/Reset | Immediate | Hold Pause | Transfer progress must be showing on RC display |
| **Set Chair Orientation** | Right + ReTie | Immediate | None | Feedback indicates active mode |

TyBOT® Operation Quick Reference ACR PN: 50-004-0001-A

| Pre-operational | |
|---|---|
| **Power On** | Release all E-Stops and turn key for master enable, hold start switch until Power Generator starts |
| **Connect RC** | Clear RC M-Stop, switch on RC, press reset after boot to connect |
| **Rail Parameters** | At prompts, use paddles/joystick to adjust and press acknowledge to set rail parameters<br>***Width:*** Z paddle adjusts Gantry Legs and Bogies, Gantry System paddle adjusts inches<br>***Radius:*** Driver's side rail radius, joystick down zeros radius for straight rails, press joystick in direction of curve (right/left) to apply the proper sign, paddles (course and fine) adjust value |
| **Position Gantry** | Press enable, jog Gantry System to starting location on bridge |
| **Tram Stops** | Jog Tram left and right to validate Tram stop locations |
| **Wire Supply** | Check wire supply and reload if necessary |
| **Set Coverage** | Default is 100%, switch to 50% if desired |
| **Op Direction** | Default is forward, switch to Reverse Operations if needed |
| **Position Tram** | Jog Tram to starting location |

TyBOT® Operation Quick Reference ACR PN: 50-004-0001-A

| | |
|---|---|
| **Manual Home** | Hold Pause 3 sec to trigger homing process, wait for complete |
| **Effector Yaw** | Jog Tie Module down and to center until effector yaw is displayed on RC, acknowledge effector yaw |
| **Operational** | |
| **Engage Auto** | Press Auto to engage auto mode (must be enabled) |
| **Tram Direction** | At prompt, use Left/Right switch to indicate go right or left |
| **Z Force** | Monitor operation to ensure Z Force is adequate (colder temperatures require higher Z Forces, toggle if necessary) |
| **Effector Yaw** | Monitor operation to ensure Tie Module is rotated optimally, frequent retries indicates adjustment may be necessary |
| **Operator Intervention** | TyBOT will request clearance to advance the Gantry System, ensure area is safe and press Proceed to confirm |
| **Wire Resupply** | RS must monitor for the out of wire condition, move Y and Z axes fully up and back, change spool, re-engage auto |
| **QC** | Monitor for missed intersections and tie manually as necessary |

# Troubleshooting Guide

## 1. General Problems

| Problem | Possible Causes(s) | Action |
|---|---|---|
| **Can't start Generator** | • Dead battery<br>• Out of fuel<br>• Fuel pump lost prime<br>• Fuel pump failure<br>• Engine failure | See Figure 1 |
| **Can't get Master Enable** | • E-Stop depressed<br>• E-Stop circuit fuse blown<br>• Dead battery<br>• E-Stop circuit cable harness broken<br>• Master Enable lamp burnt out | See Figure 2 |
| **Tie module frequently retracting/ pausing** | • Dirty camera lens<br>• Condensation on camera lens<br>• Camera too far from rebar | See Figure 3 |
| **Robot frozen in auto mode** | • Targeting unreachable intersection<br>• Unidentified software bug | See Figure 4 |
| **RC unit will not connect to robot** | • Out of range<br>• Wrong RC unit | Verify RC and robot serial numbers match, move next to the robot, verify receiver (CAN2) is powered on |
| **TyBOT continuously reties the same intersection** | • Bad tie module<br>• Software Bug | Skip intersection, if problem persists, replace tie module, if problem persists with new module, call tech support |
| **Cannot move TyBOT due to a fault persistently interrupting movement** | • Persistently intermittent fault, meaning a fault that clears and re-fires almost immediately after fault acknowledgment | Place the fault on hold by acknowledging the fault with the Proceed switch held forward |
| **Frequent inaccuracy causing reposition attempts, especially if deck is sloped (grade or superelevation)** | • X-axis slip or overshoot<br>• Tie module sagging due to slope | Rotate tie module to a tying orientation that results in the wire spool being upslope |

## 2. Fault Codes

| Fault Code | Description | Possible Causes | Action |
|---|---|---|---|
| **xxxxxx_9999** | Software module stopped reporting status (possibly crashed) | • Transient software timing<br>• Unidentified software bug | Soft reset if it doesn't clear after a few seconds |
| **Vision_0010/ FrtVis_0010/ BckVis_0010** | No camera data, never had comms with camera module | • Camera not connected<br>• Bad camera IP<br>• Bad camera cable<br>• Bad camera | See Figure 5 |
| **Vision_0020/ FrtVis_0020/ BckVis_0020** | Camera data stopped, had comms then didn't | • Driver/Camera crash<br>• Camera failure<br>• Camera cable failure | See Figure 6 |
| **Vision_0030/ FrtVis_0030/ BckVis_0030** | Wrong camera resolution, received data with unexpected image resolution | • Transient comms problem with camera<br>• Bad camera | Power cycle, if problem persists replace camera |
| **Vision_0040/ FrtVis_0040/ BckVis_0040** | Missing image calibration data | • Bad camera initialization<br>• Bad camera | Power cycle, if problem persists replace camera |
| **Vision_0100/ FrtVis_0100/ BckVis_0100** | Image Obscured | • Obstacle/Operator blocked camera view<br>• Camera lens condensation<br>• Camera lens dirty | Move out of camera view; check camera imagery and clean or replace camera as necessary |
| **RbrMap_0001** | Unavoidable Obstacle, obstacle that cannot be safely traversed over | • Obstacle around tram<br>• Tram stop too close to parapet or leg assembly | Remove obstacles near tram, manually home to clear internal obstacle map, if occurring frequently at end of tram motion, move tram stop inward |
| **RbrMap_0002** | Break beam sensor persistently blocked | • Sensor view blocked by dirt or debris<br>• Sensor blinded by sun<br>• Sensor or cable broken | See Figure 7 |
| **WiComm_9999** | Comms between tram and gantry broken | • Wireless interference<br>• Wireless multiple dead spot<br>• Antenna damage<br>• Radio failure<br>• Network cable failure or damage<br>• Software module crash | See Figure 8 |

| | | | |
|---|---|---|---|
| **RcCtlr_0050** | Comms failure with RC unit | • Wireless interference<br>• RC unit out of range<br>• RC unit power failure<br>• RC malfunction<br>• RC receiver (CAN2) failure<br>• RC receiver (CAN2) power loss<br>• Mismatch RC unit and receiver<br>• RC unit on wrong channel | See Figure 9 |
| **RcCtlr_0010** | Switch Input Error (conflicting states) | • Transient input problem<br>• Bad RC unit | Power cycle RC unit, if persistent replace/repair RC unit |
| **RcCtlr_0011** | Joystick Input Error (conflicting states) | • Transient input problem<br>• Bad RC unit | Power cycle RC unit, if persistent replace/repair RC unit |
| **TrCtlr_0010** | Trio Comms Initialization Failure, never had comms | • Trio power failure<br>• Trio cable harness broken<br>• Trio wrong IP address<br>• Trio failure<br>• Computer port failure | See Figure 10 |
| **TrCtlr_0020** | Trio Comms Failure, had comms and then didn't | • Trio power failure<br>• Trio cable harness failure<br>• Trio system crash | See Figure 11 |
| **TrCtlr_0050** | Trio Internal Fault, Trio thread heartbeat stopped updating | • Transient thread delay<br>• Trio execution thread crash | If persistent for more than a few seconds power cycle |
| **TrCtlr_0060** | Tram X axis limit switch fault | • Bad limit switch<br>• Tram on limit and stuck due to slip | Manually check X-axis limit switch(s), replace switch(s) if necessary |
| **TrCtlr_0070** | Trio Firmware version incompatible with autonomy software version | • Trio software too old<br>• Bad software upgrade | Call technical support, software update problem |
| **TrCtlr_0080** | Detected Y or Z axis slip | • Worn or loose hardware<br>• Faulty actuator limit switch or switch wiring harness | If problem reoccurs check for loose or worn axis hardware, check for proper functionality of the limit switches |
| **TrCtlr_0100** | Z axis is snagged, using max allowable force but not moving (specifically up) | • Uncut tie wire<br>• Tie module mechanical coupling to deck (jaw under shear stud)<br>• Z-axis mechanical friction/binding | See Figure 12 |
| **GtCtlr_0110/ GtCtlr_0111** | Gantry drive configuration failed (Driver-0110, Passenger-0111) | • CAN message failure<br>• Invalid configuration<br>• Wrong drive installed | See Figure 13 |

| | | | |
|---|---|---|---|
| **GtCtlr_0210/ GtCtlr_0211** | Gantry drive communications failed (Driver-0210, Passenger-0211) | • CAN bus failure (noise or harness)<br>• Drive power loss<br>• Drive failure<br>• Drive rotary switch set wrong (drive ID) | See Figure 14 |
| **GtCtlr_0310/ GtCtlr_0311** | Failed to configure gantry drive rotational limits (Driver-0310, Passenger-0311) | • CAN message failure<br>• Invalid configuration<br>• Wrong drive installed | See Figure 15 |
| **GtCtlr_0410/ GtCtlr_0411** | Gantry drive unrecoverable fault (Driver-0410, Passenger-0411) | • Limitation of motor drive<br>• Bad motor drive | Power cycle the system, if problem persists, call tech support |
| **GtCtlr_0510/ GtCtlr_0511** | Gantry drive stuck (Driver-0510, Passenger-0511) | • Loss of synchronization with motor drive | Pause system then try to resume, if problem persists, power cycle, if problem persists after power cycle, call tech support |
| **TGCtlr_0010/ TMCtlr_0010** | Tie Module (TM) communications failure | • TM cables unplugged or not seated<br>• TM cable damage/failed<br>• TM failure<br>• COM port misconfigured<br>• Cable plugged into wrong COM port<br>• Software configure for wrong COM port | See Figure 16 |
| **TMCtlr_0020/ TMCtlr_0020** | Tie Module (TM) internal electrical failure | • TM internal wiring failure | Power cycle TM, if problem persists replace TM |
| **TMCtlr_0030** | Tie Module command failure (only applies to units with gen4 tie modules), Tie Module did not respond to command | • TM failure<br>• TM communications noise (RF environment, pogo pins degradation, etc) | Replace TM, if problem persists clean pogo pins, if problem persists after cleaning, system service is necessary |
| **TrSyMn_0010/ GnSyMn_0010** | Tram(Tr) or Gantry (Gn) System free disk space is low | | Remove/Purge log data |
| **TrSyMn_0011/ GnSyMn_0011** | Tram(Tr) or Gantry (Gn) System free disk space is critically low | | Remove/Purge log data |
| **TrSyMn_0020/ GnSyMn_0020** | Tram(Tr) or Gantry (Gn) System free memory is low | | No action required |
| **TrSyMn_0021/ GnSyMn_0021** | Tram(Tr) or Gantry (Gn) System free memory is critically low | | Power cycle system |
| **TrSyMn_0030/ GnSyMn_0030** | Tram(Tr) or Gantry (Gn) System computer overheating | | |

| | | | |
|---|---|---|---|
| **TrSyMn_0031/ GnSyMn_0031** | Tram(Tr) or Gantry (Gn) System computer critically hot | | |
| **TrSyMn_0091/ GnSyMn_0091** | Tram(Tr) or Gantry (Gn) System failed to monitor disk | | Power cycle, if persistent call technical support |
| **TrSyMn_0092/ GnSyMn_0092** | Tram(Tr) or Gantry (Gn) System failed to monitor memory | | Power cycle, if persistent call technical support |
| **TrSyMn_0093/ GnSyMn_0093** | Tram(Tr) or Gantry (Gn) System failed to monitor temperature | | Power cycle, if persistent call technical support |
| **SplMn_0001** | The RFID module is not readable | • RFID module failure<br>• RFID module cables unplugged or damaged<br>• RFID module plugged into wrong port | Inspect RFID module and cables for loose connections or damage, if the problem persists, call technical support |
| **SplMn_0002** | The wire spool RFID tag has failed basic verification | • Use of unsupported wire spools<br>• Damage to the wire spool RFID tag | Replace the current wire spool with a new TyBOT-provided spool, if the problem persists, call technical support |
| **SplMn_0003** | The wire spool is empty due to recent consumption failing verification | • Use of unsupported wire spools<br>• Damage to the wire spool RFID tag | Replace the current wire spool with a new TyBOT-provided spool, if the problem persists, call technical support |
| **SplMn_0004** | The wire spool is empty due to the consumption exceeding the programmed capacity | • Use of unsupported wire spools<br>• Damage to the wire spool RFID tag | Replace the current wire spool with a new TyBOT-provided spool, if the problem persists, call technical support |
| **SplMn_0005** | The RFID module is not writable | • RFID module failure<br>• RFID module cables unplugged or damaged<br>• RFID module plugged into wrong port | Inspect RFID module and cables for loose connections or damage, if the problem persists, call technical support |

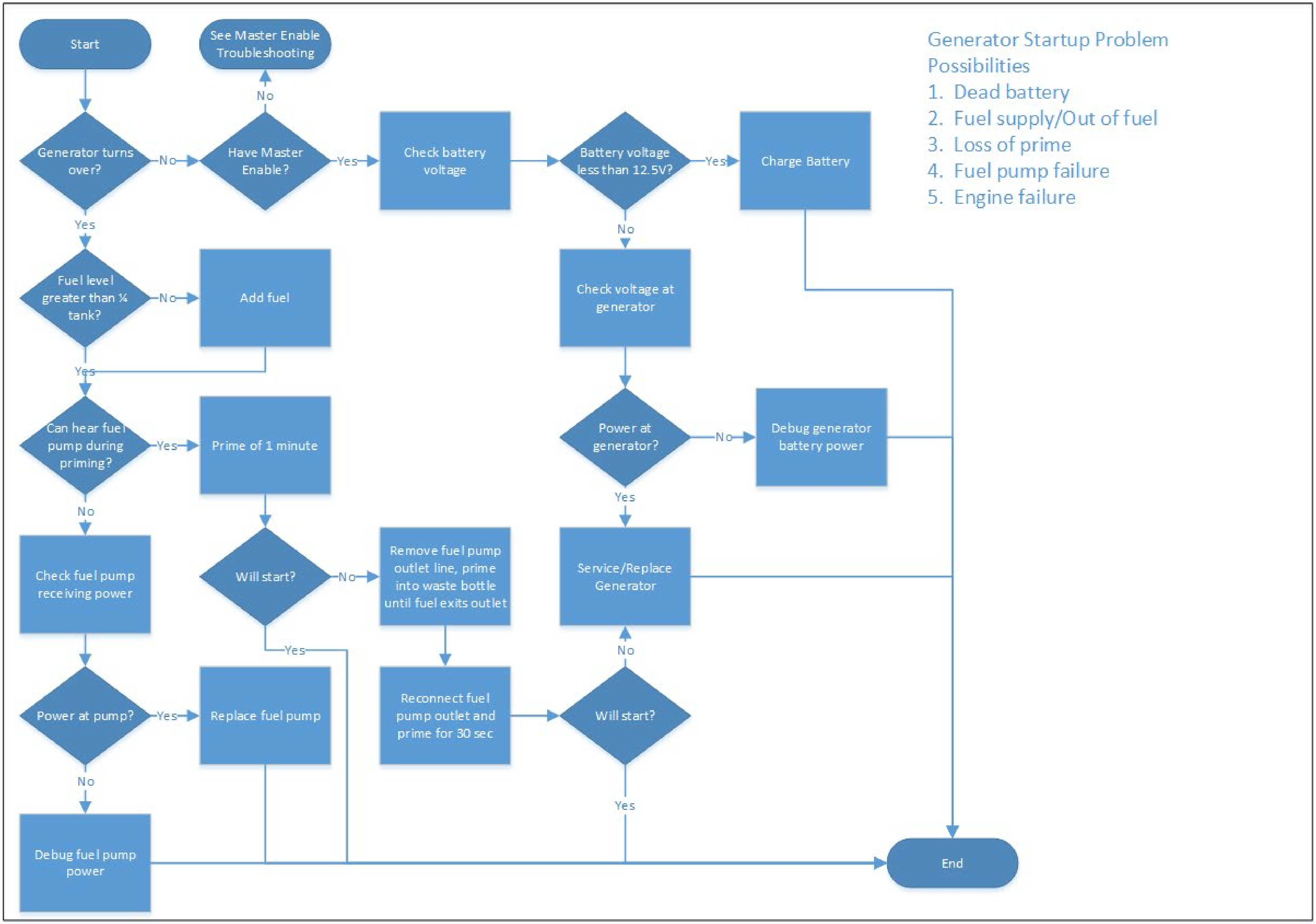



*Figure 1 – Generator Startup Problem*

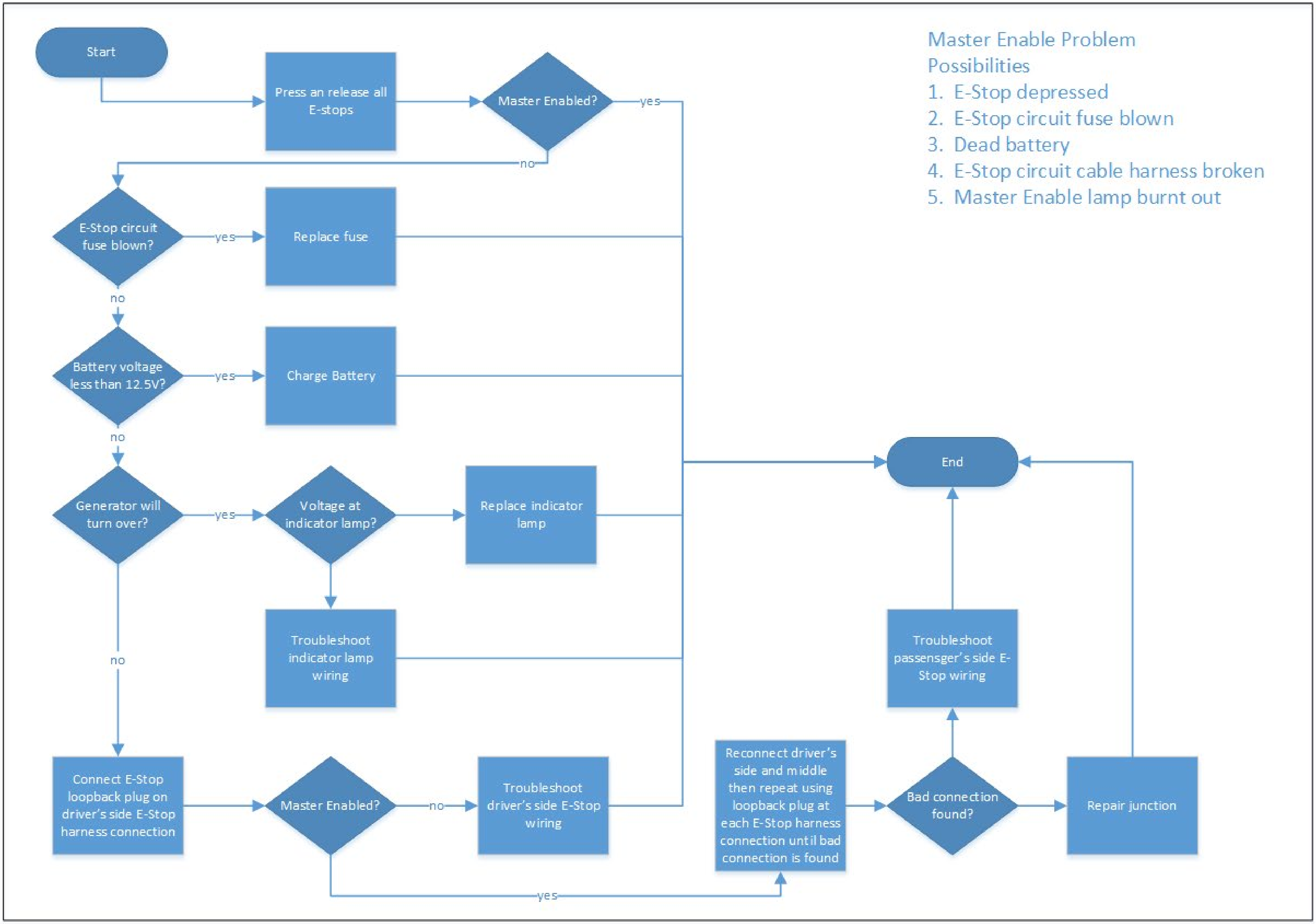



*Figure 2 – Master Enable Problem*

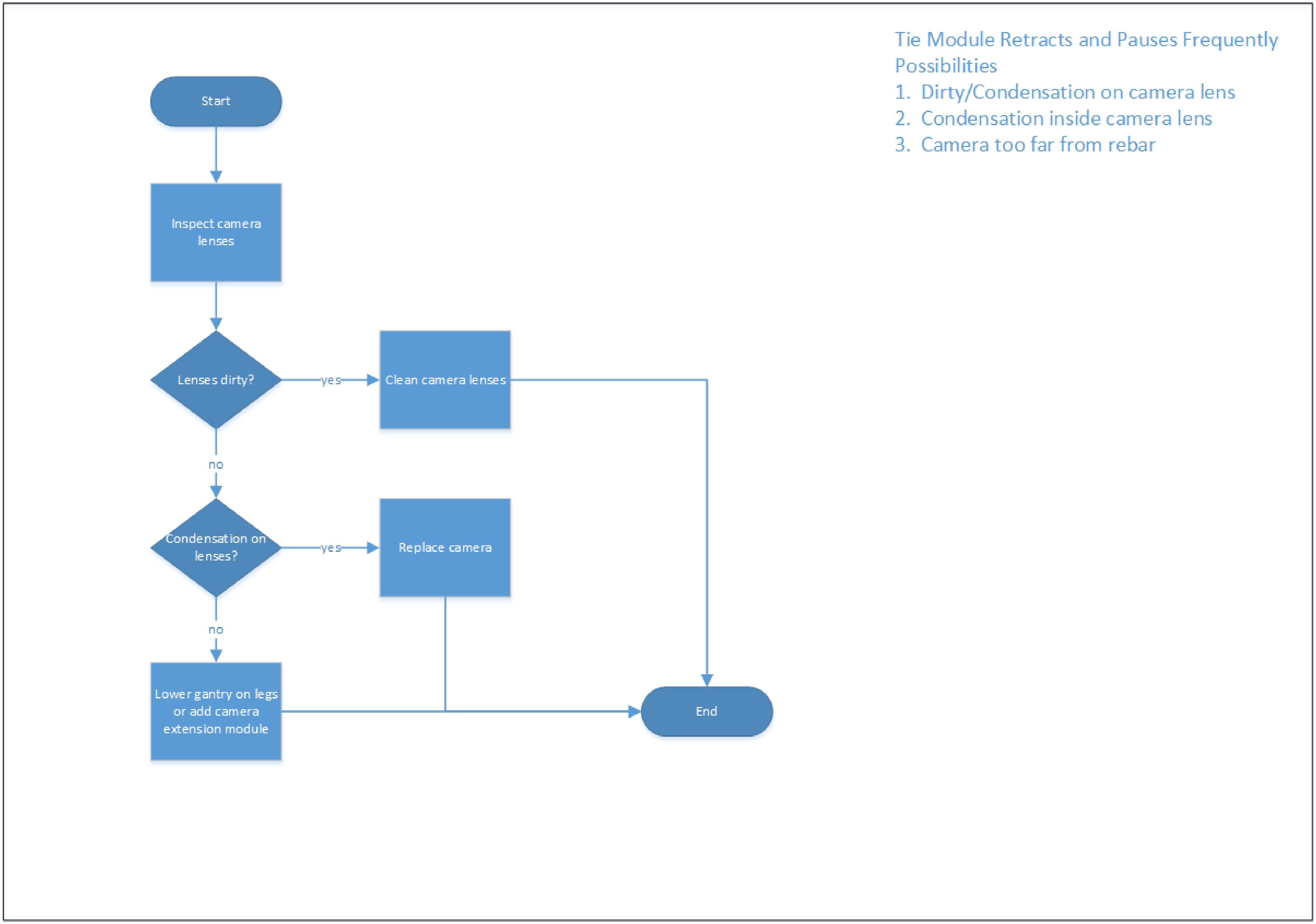



*Figure 3 – Tie Module Retracts and Pauses Frequently*

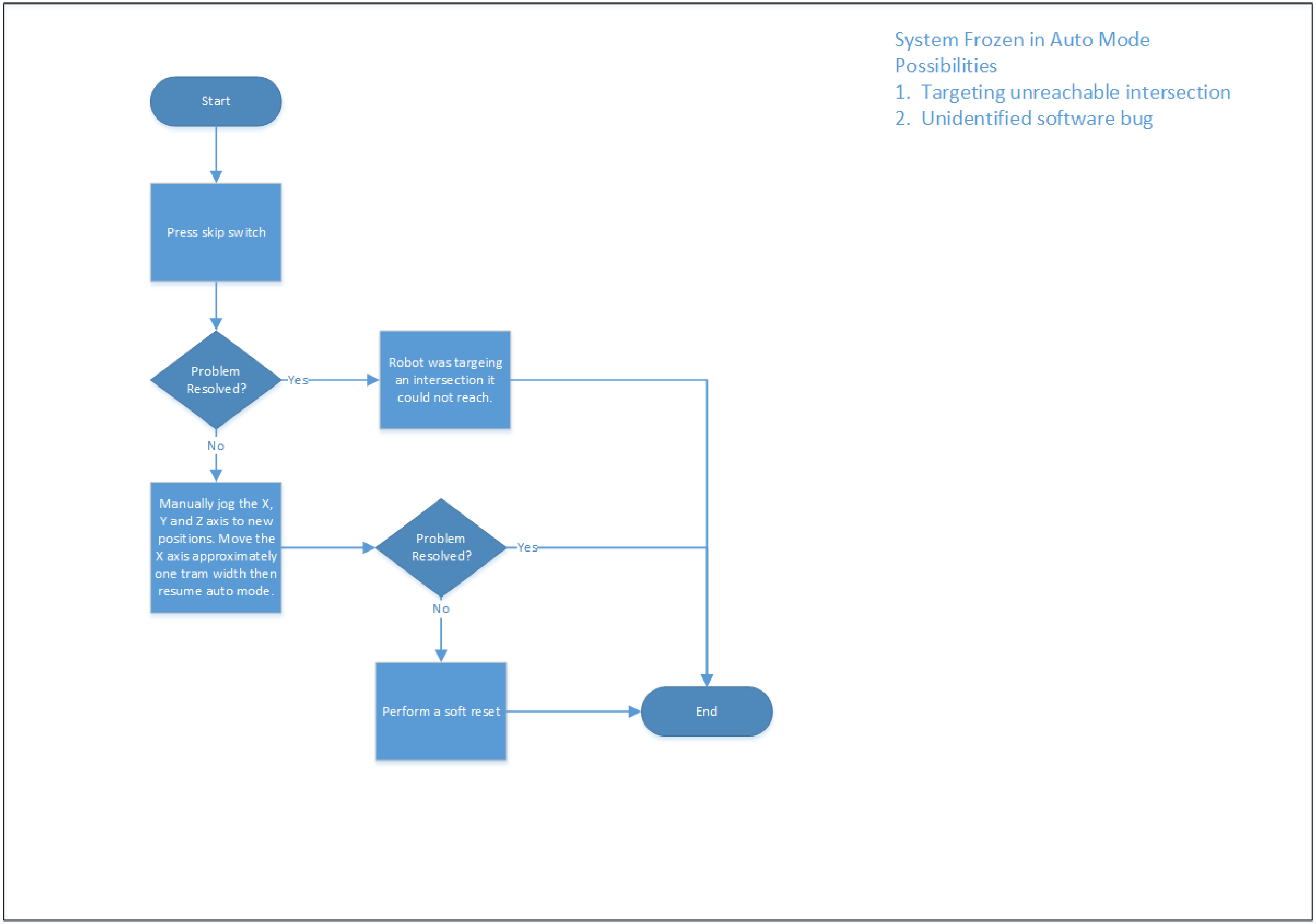



*Figure 4 – System Frozen in Auto Mode*

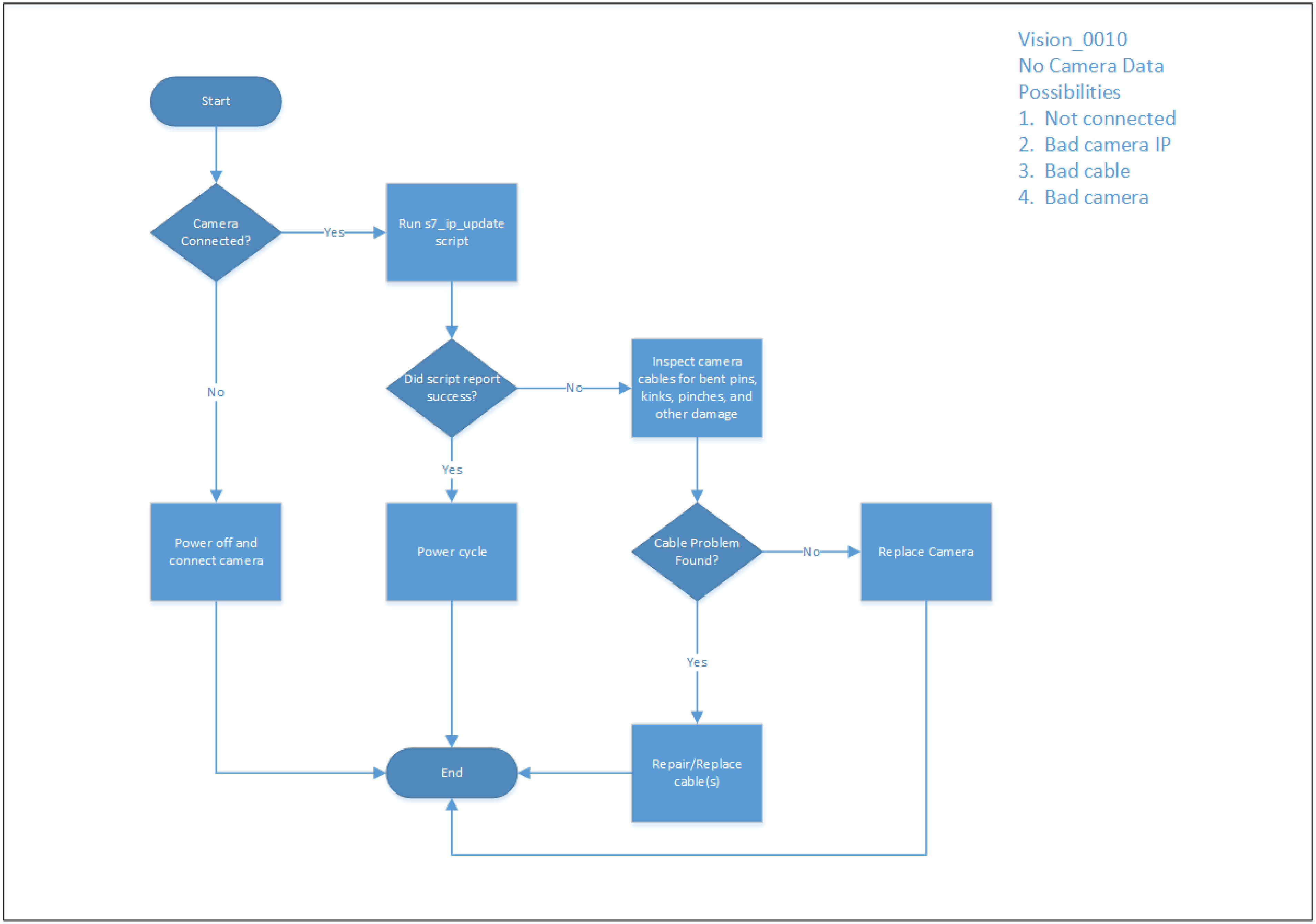



*Figure 5 – Vision_0010 No Camera Data*

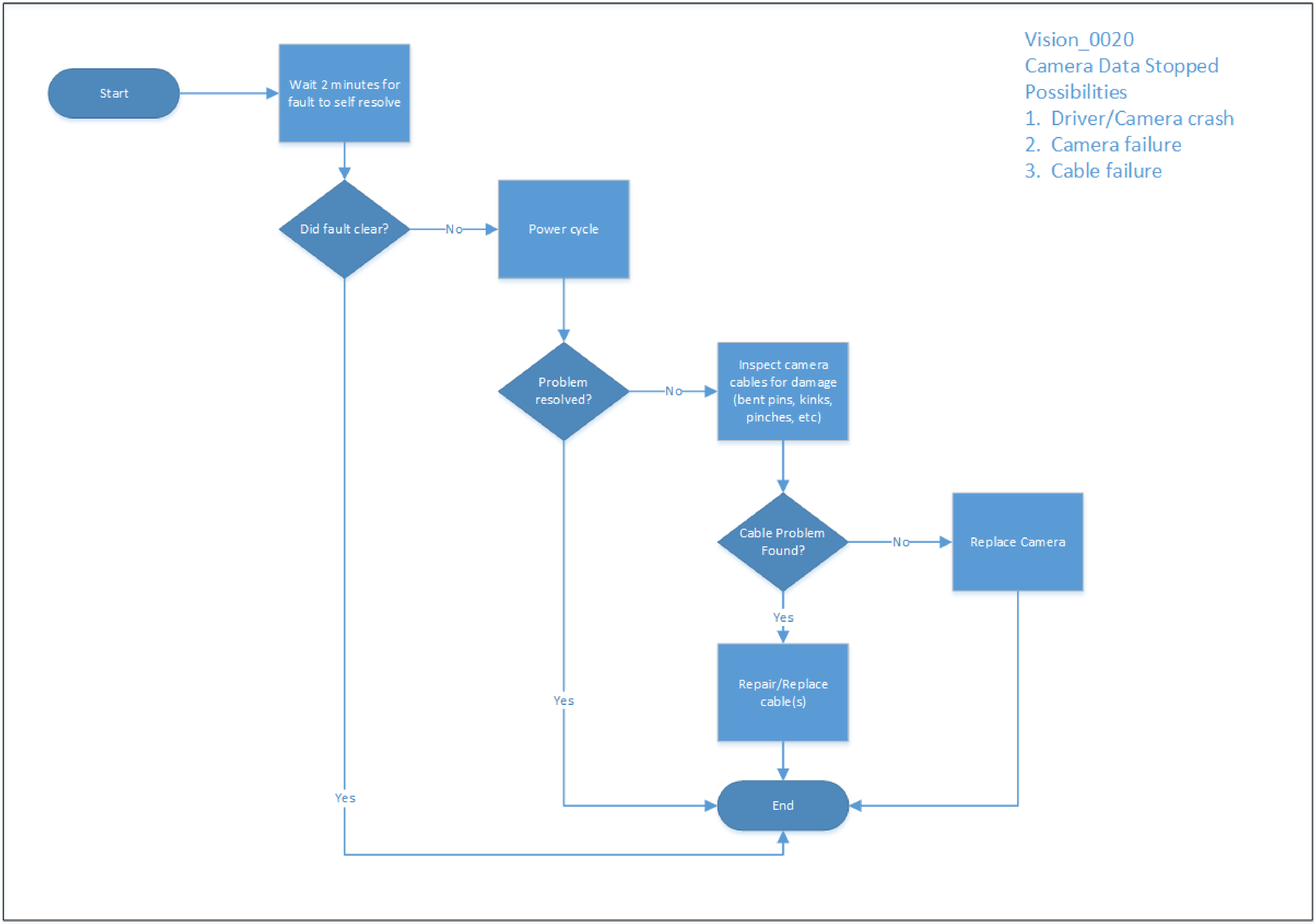



*Figure 6 – Vision_0020 Camera Data Stopped*

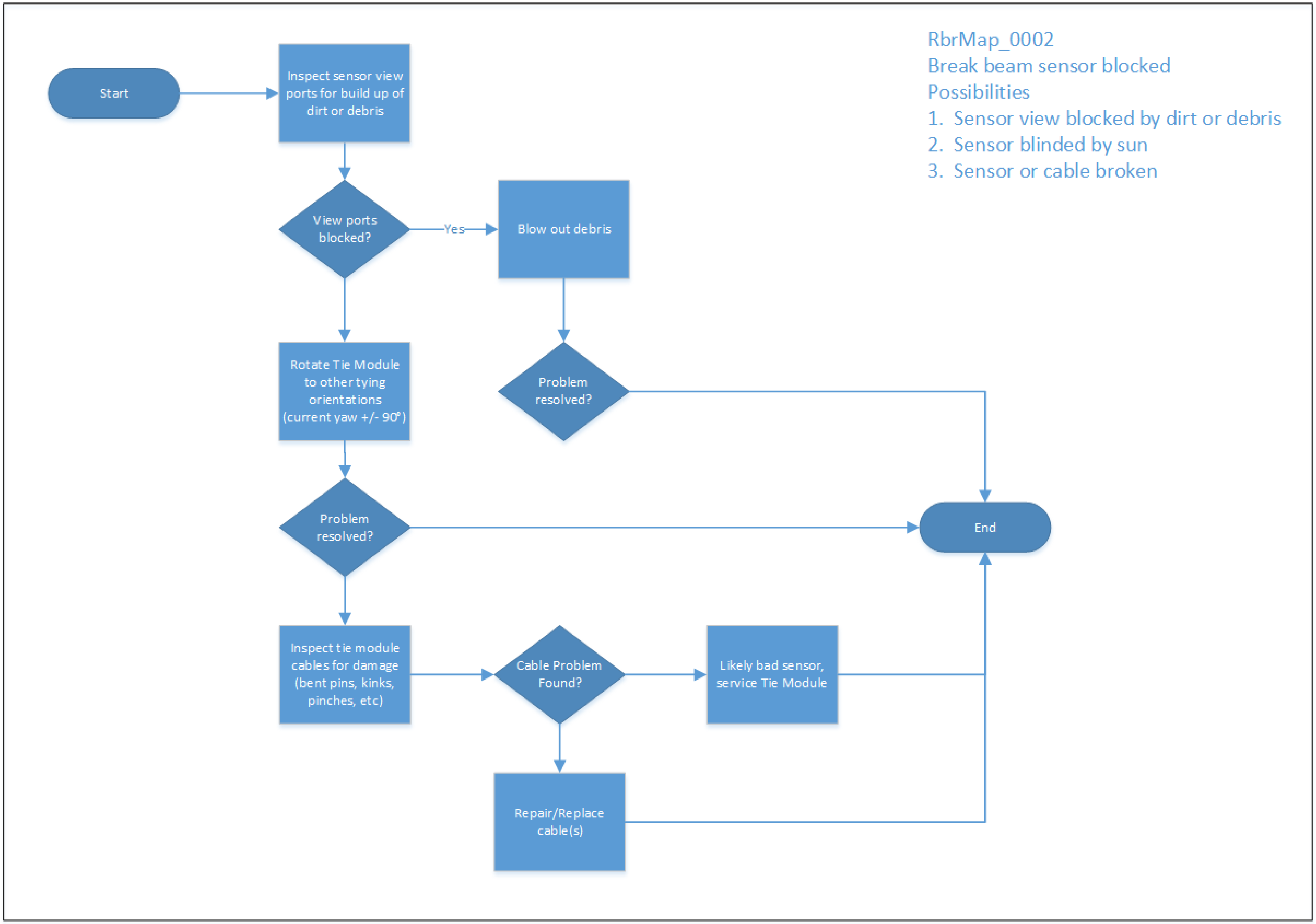



*Figure 7 – RbrMap_0002 Break Beam Sensor Blocked*

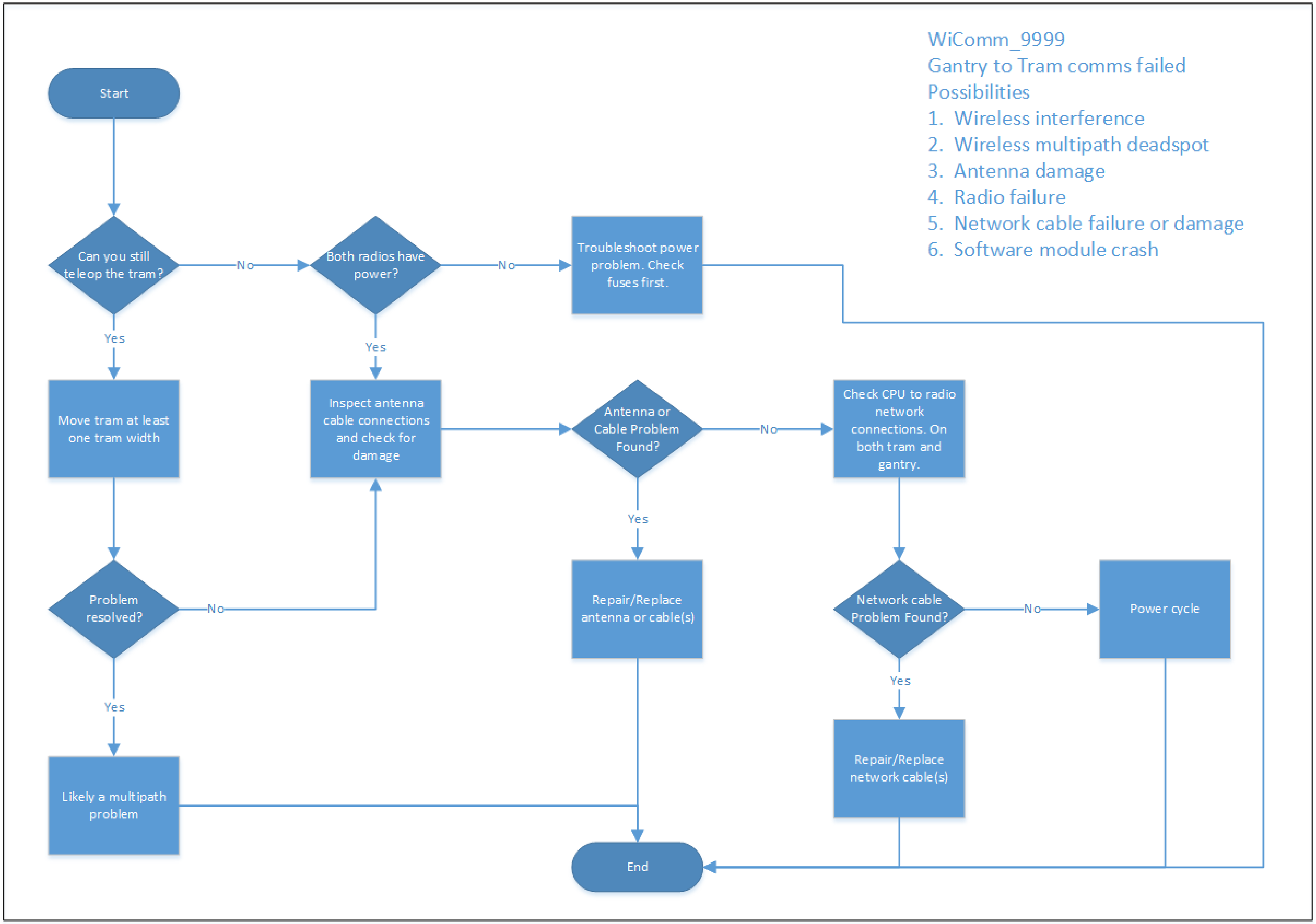



*Figure 8 – WiComm_9999 Gantry to Tram Comms Failed*

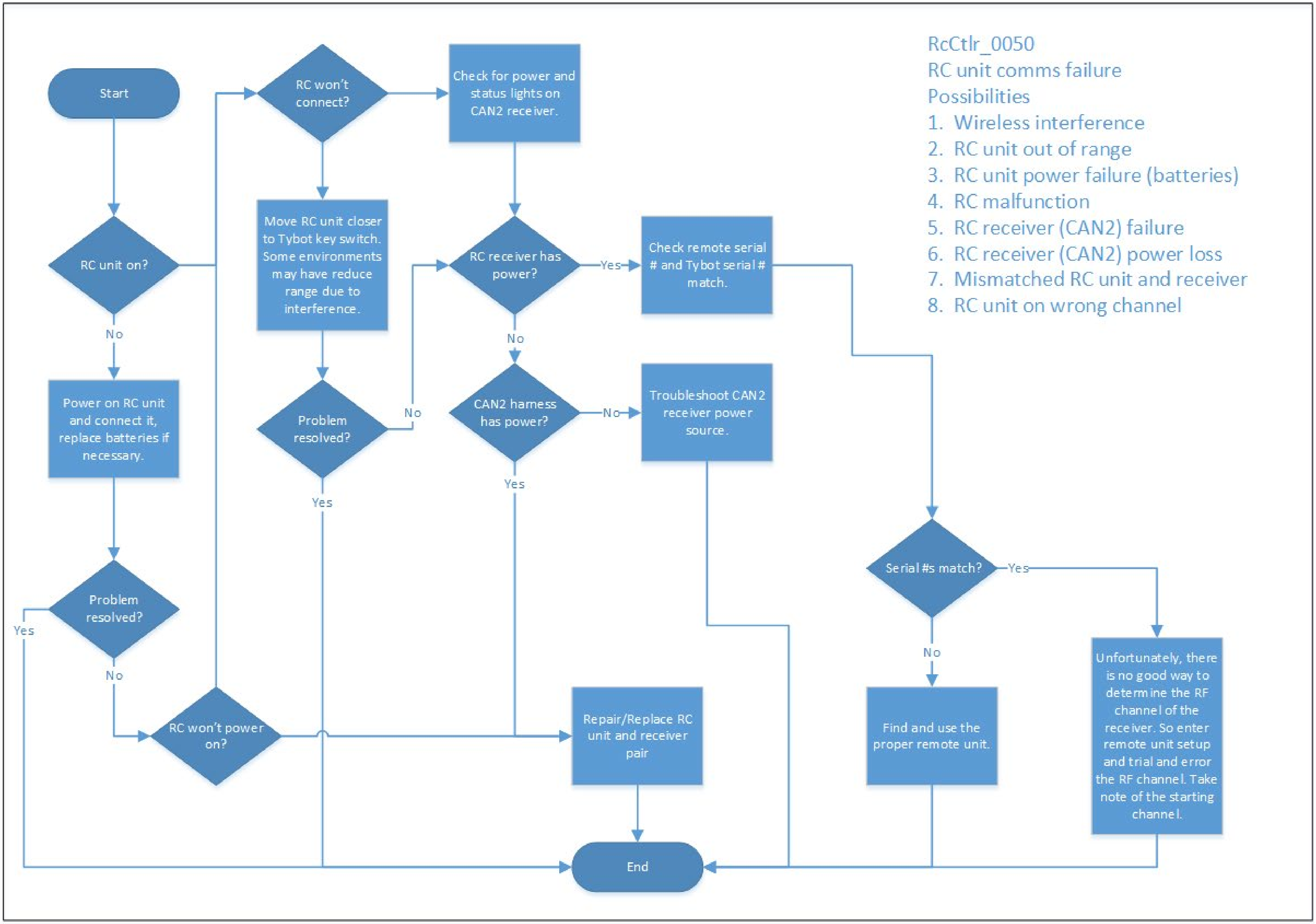



*Figure 9 – RcCtlr_0050 RC Unit Comms Failure*

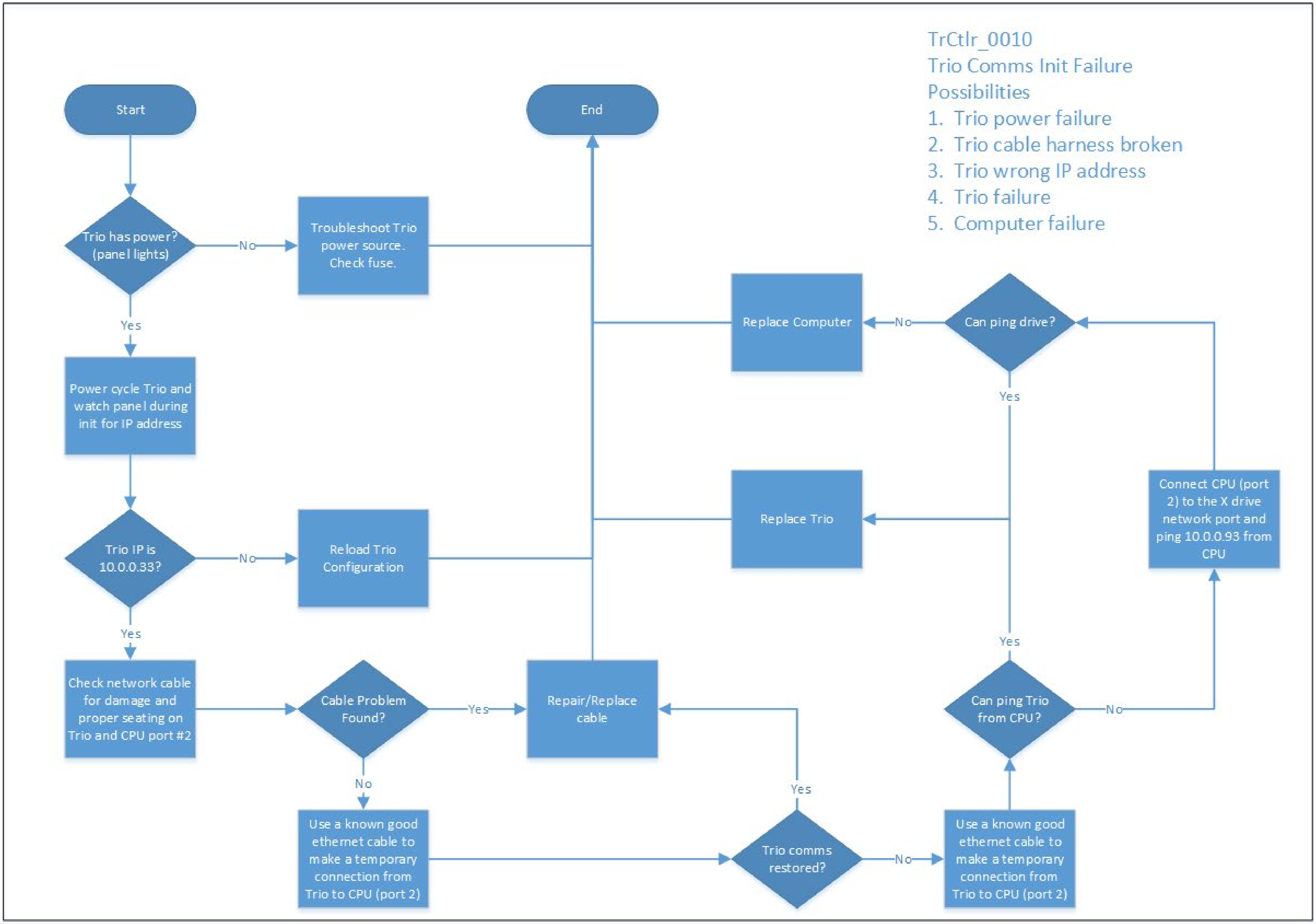



*Figure 10 – TrCtlr_0010 Trio Comms Init Failure*

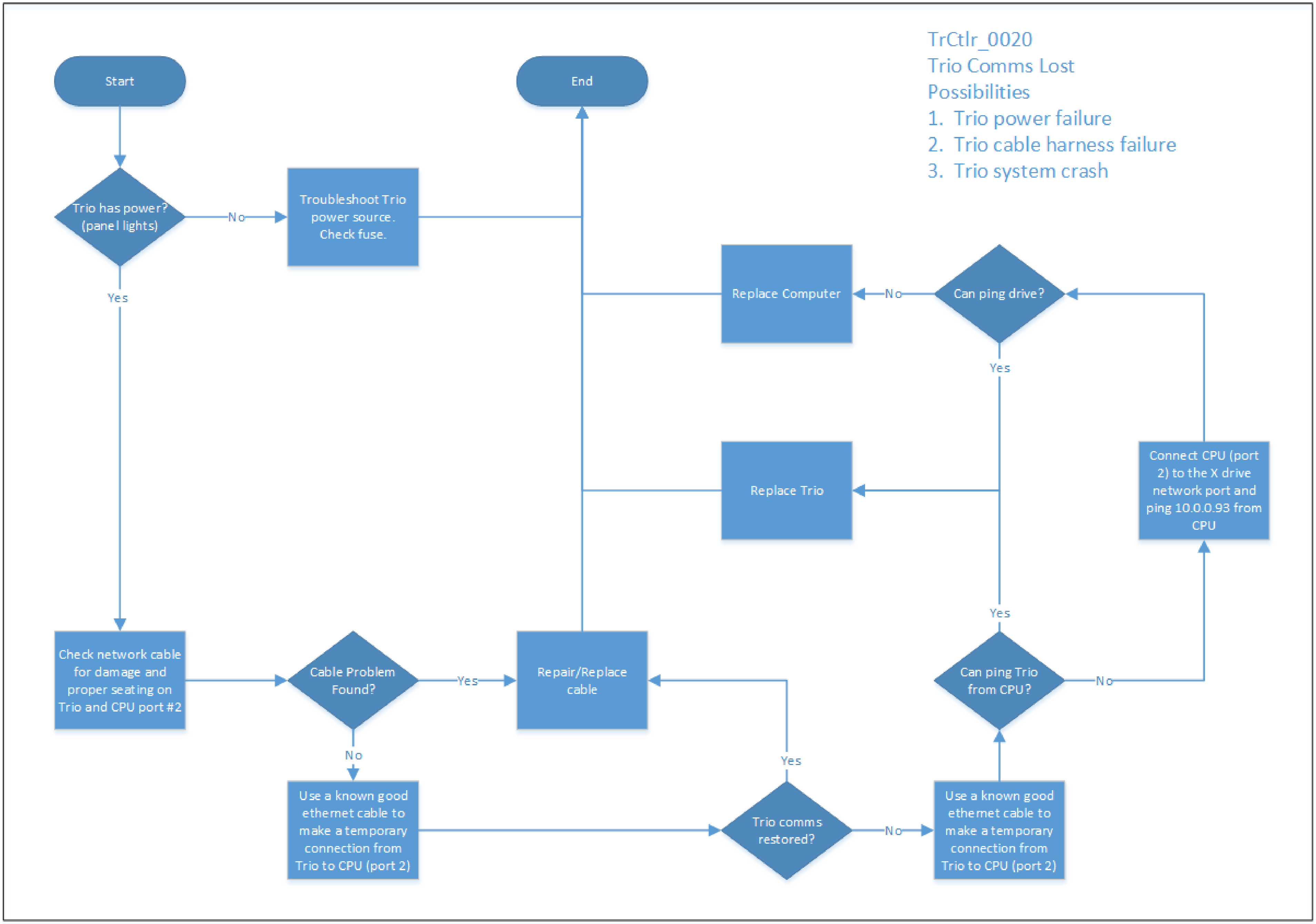



*Figure 11 – TrCtlr_0020 Trio Comms Lost*

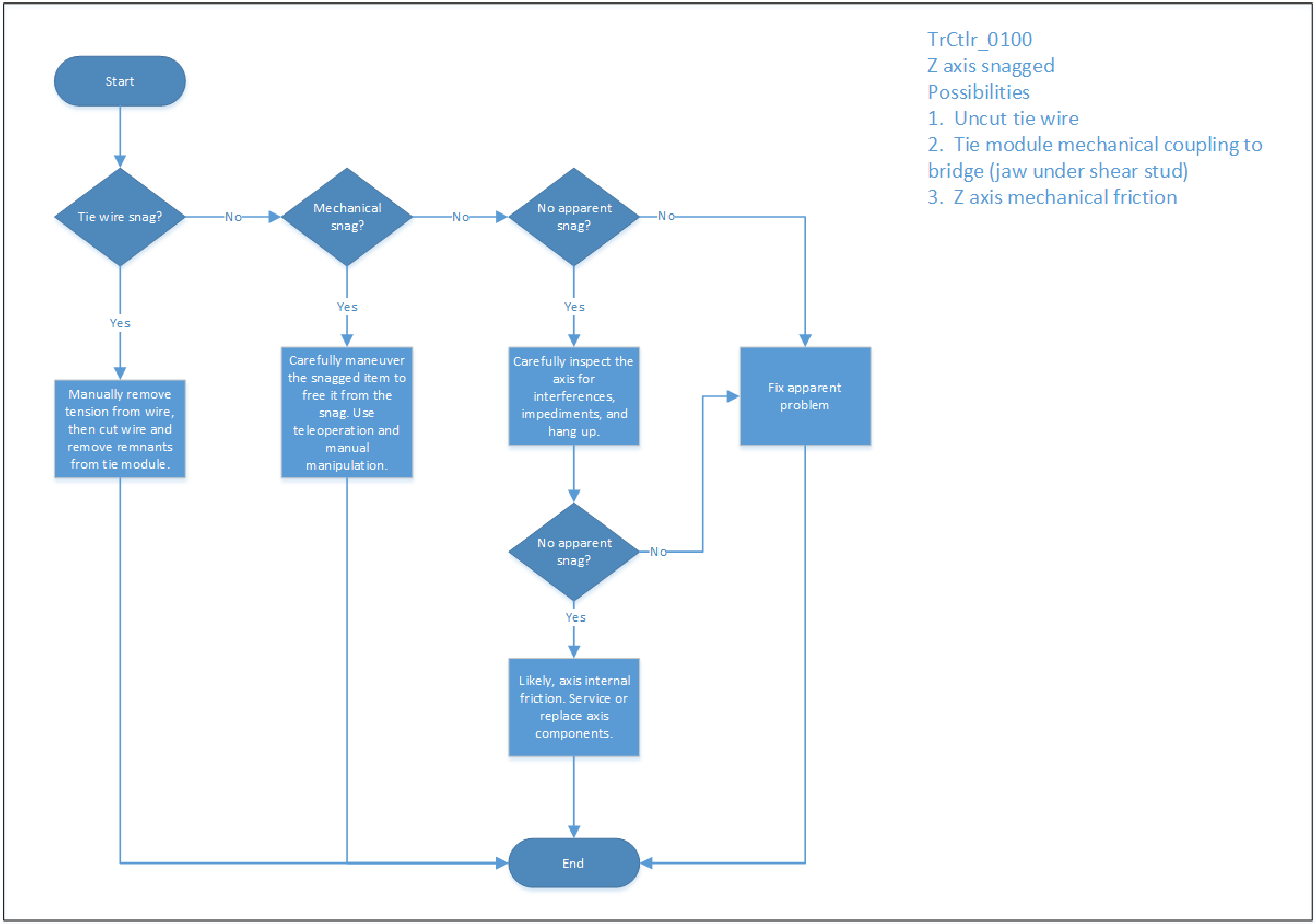



*Figure 12 – TrCtlr_0100 Z-axis Snagged*

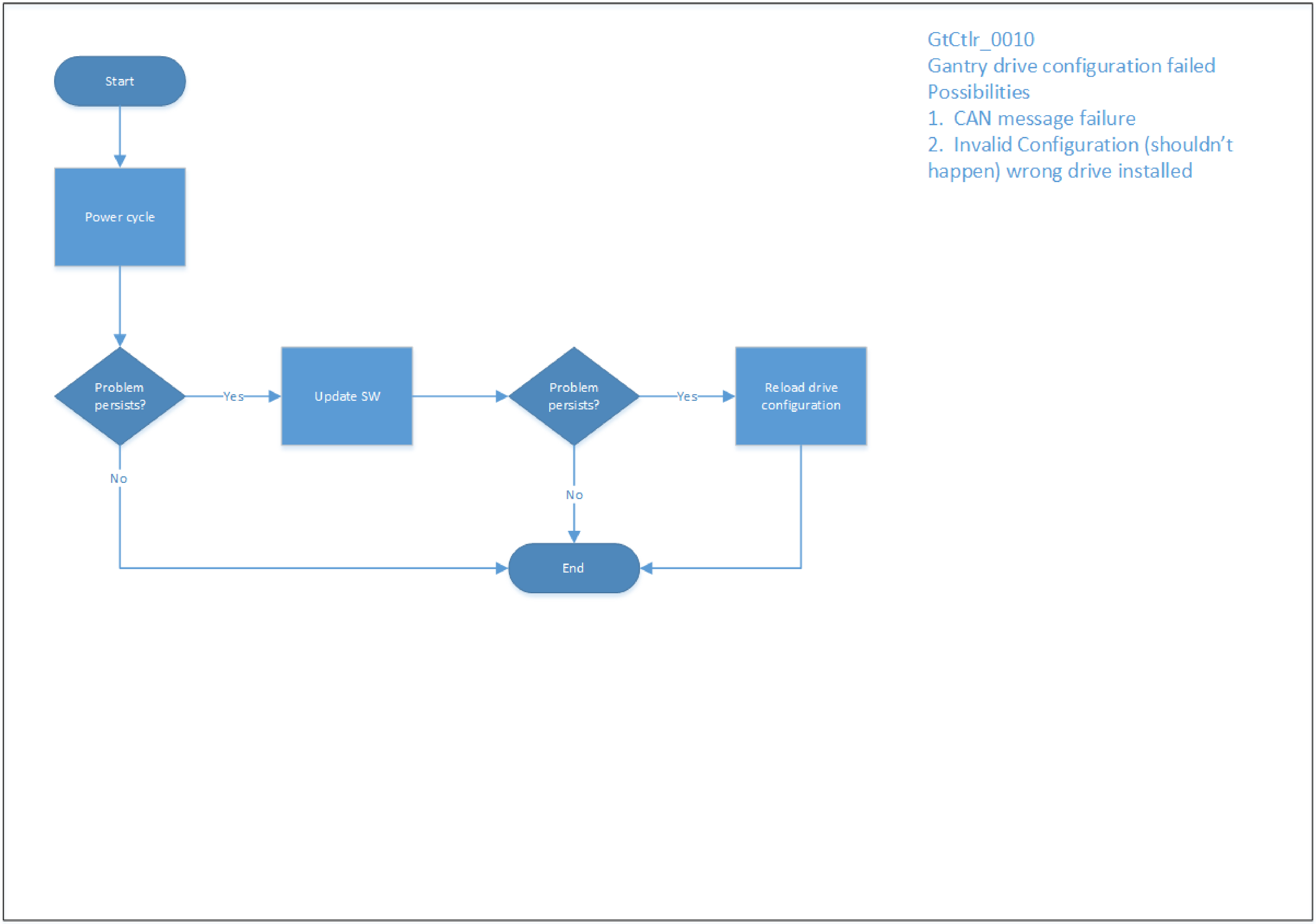



*Figure 13 – GtCtlr_0010 Gantry Drive Configuration Failed*

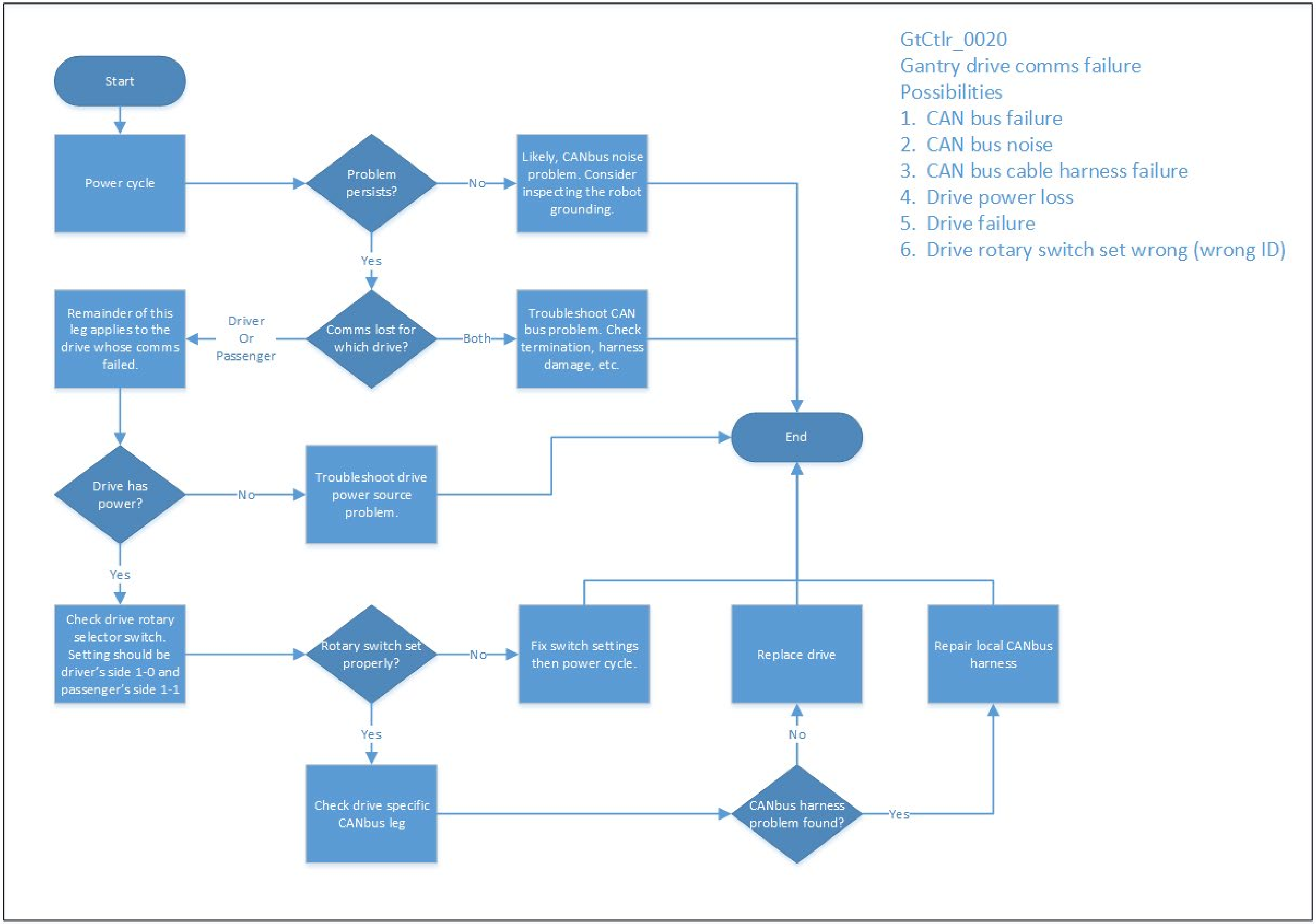



*Figure 14 – GtCtlr_0020 Gantry Drive Comms Failure*

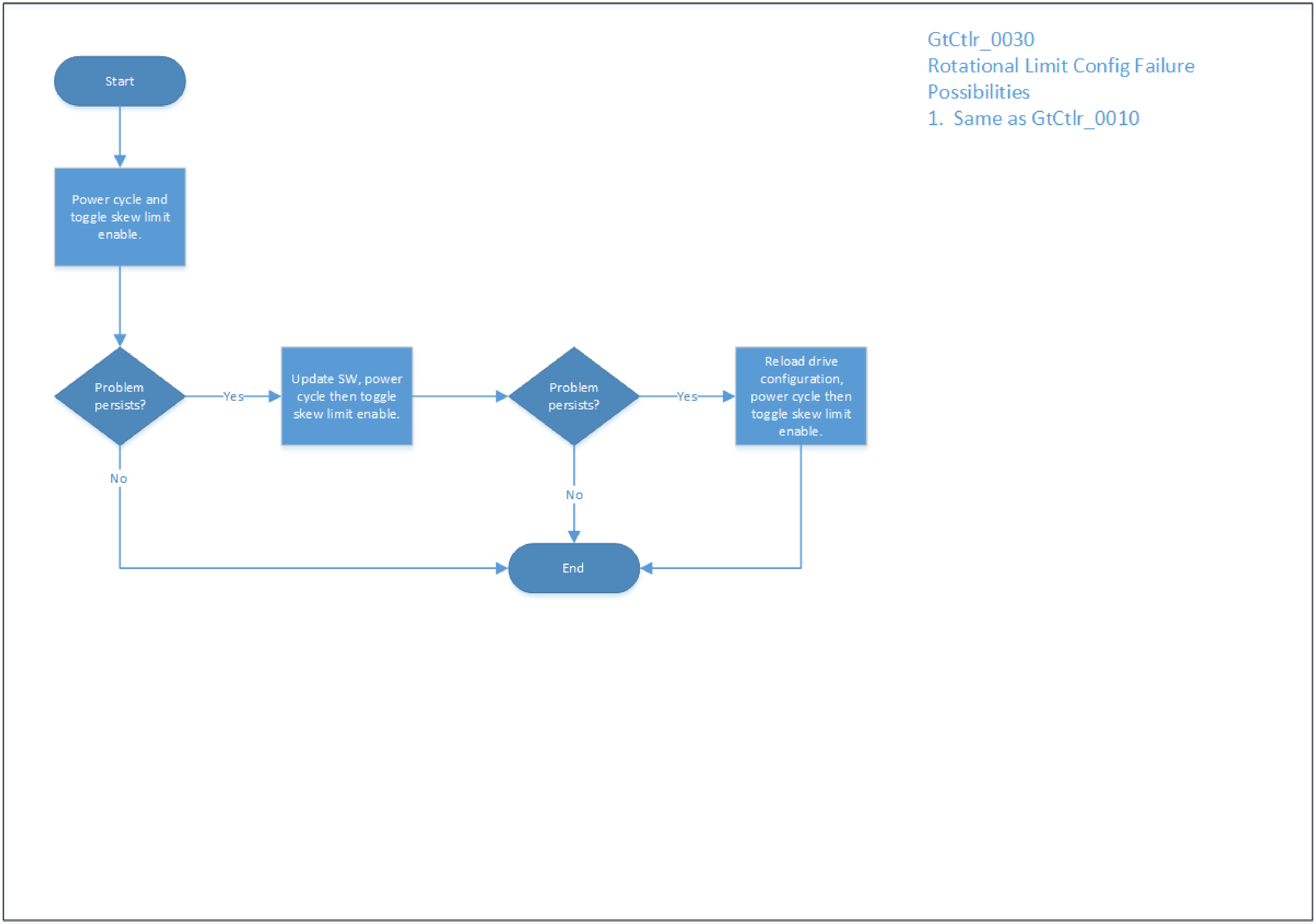



*Figure 15 – GtCtlr_0030 Rotational Limit Config Failure*

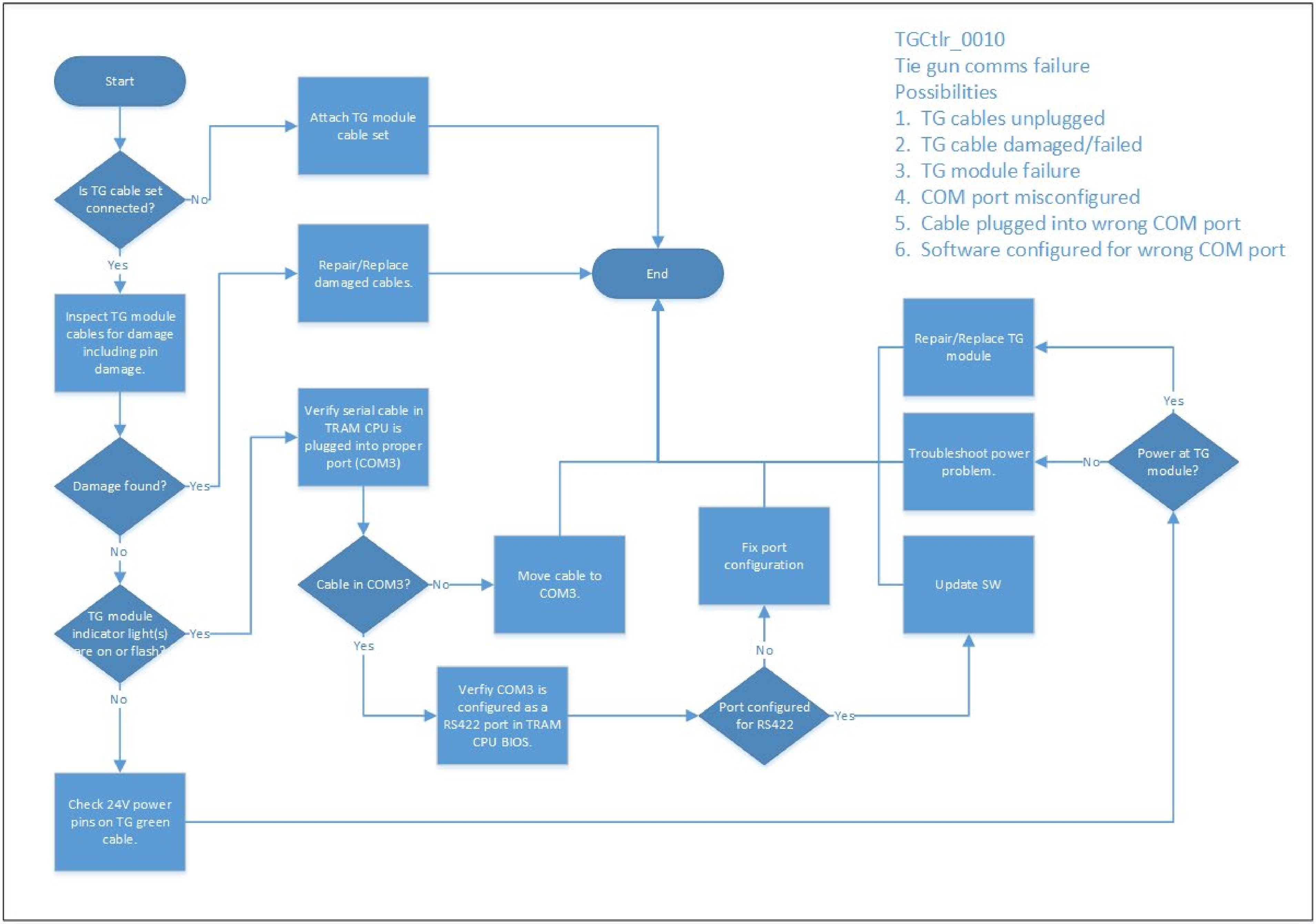



*Figure 16 – TGCtlr_0010 Tie Gun Comms Failure*