

# *WAM Wrist Cable-Maintenance Guide*



**Barrett Technology<sup>®</sup> Inc.**

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***This manual is most useful when printed in **color** or viewed on screen.***

# 1 General Wrist Cable Circuit Descriptions

The Wrist has three distinct cabling regions: (1) the motor 5 (M5) transmission, (2) the motor 6 (M6) transmission, and (3) the differential. Stages 1 through 3 of the motor transmission circuits are stages of reduction for the main motors in the base of the Wrist. The differential circuit translates the rotations of the motor circuits (M5 and M6) into the main pitch and roll motion of the Wrist. An exploded schematic of the entire Wrist, shown in Figure 1, outlines the three distinct cabling circuits.

Each stage of the cabling circuits, except the differential, is made up of one pulley and one pinion; the pinion having the smaller diameter. In the M5 and M6 input circuits, the pinion is the motor shaft in stage 1. In stages 2 and 3, the reductions are implemented with the pinion of each stage attached to the pulley on the stage beneath it. In the differential, all mating pairs of pulleys are of identical size resulting in a 1:1 ratio. In the worm gear tensioning system, the worm gear on the level with the smaller diameter creates pretension for differential levels 1 and 2, while the worm gear on the level with the larger diameter creates pretension for differential levels 3 and 4.

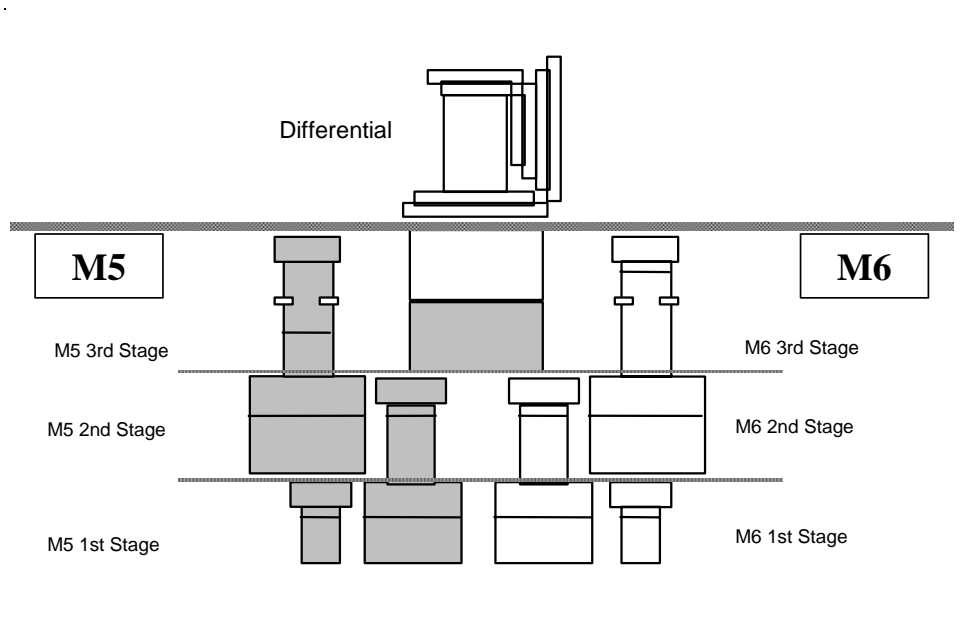


Figure 1 -- Schematic Diagram of Wrist Cable Circuits

## 2 Helpful Tools & Tips

### 2.1 For First Time Cablers

Re-cabling the Wrist is generally easier if the user is familiar with cabling other mechanisms such as the WAM Arm. If the user is cabling the Wrist for the first time, she should read this entire section on wrist cabling (especially Section 6.5 on pre-tensioning input circuits) and section 1 of the WAM Arm cabling manual before beginning to cable the Wrist. Make sure that proper tools and cable parts have been gathered prior to any cabling activities. Figure 2 shows the tools provided with the Wrist. You will also need the wider masking tape provided in the 4-DOF WAM Maintenance kit. The cabling instructions have numbered checkboxes next to each step for tracking progress. These pages may be photocopied for use as a cabling checklist.

Allow roughly 4 hours to cable one of the circuits for the first time. Subsequent cabling of the wrist after the user is familiar with the instructions can be completed in 1 hour.

One important point to keep in mind is that each cable of a given drive must be held in place at all times until the entire circuit is pre-tensioned. The wrapped cables act like light torsion springs which, when released, even momentarily, may quickly unravel your work back to your starting point. This is the most common error for the first-time cabler. Pre-tensioning, which prevents this unraveling, cannot be done until all cables in that circuit have been installed. Masking tape is a tremendous aid in temporarily preventing this unraveling. As cables are wrapped onto each pulley or pinion, hold each wrap with your fingers to keep it from unwinding. At the end of each cabling step, one or two pieces of masking tape temporarily immobilize transmission elements and keep cables in place.

Unlike the 4-DOF WAM, the Phase leads for the Wrist motors should NOT be unplugged when cabling. The Wrist should be mounted in a vertical orientation (tool end facing up). If a Barrett Hand was purchased, the Wrist can be secured in the Lexan stand. Without the Lexan stand, the Wrist should be left on the WAM Arm itself with the elbow joint propped up and taped securely to orient the Wrist vertically.

***Make sure that the Wrist is either mounted on the 4-DOF arm (with power OFF) or that the Wrist Safety Termination (Figure 2) is plugged into the bottom of the Wrist.*** This will protect the motor controllers (Pucks) from electrical damage as the motors are turned manually during the cabling process.



**Figure 2: Wrist Maintenance Kit**

## 2.2 Terminology

*Anchor* – location on the pulleys or pinions that the cable terminations are inserted into for retention and tensioning.

*Anchor-Separator* – A raised section of the pinion which creates a separate groove for the termination anchor and which only allows the cable to cross at one of two places, where it flattens out.

*Cable* – a “wire rope” typically made from very fine strands of stainless steel. The tensile strength and stiffness is very high in a stranded cable yet it maintains flexibility in bending.

*Cable circuit* – the cables and cable paths through a transmission from input (motor) to output.

*Clutch Housing* – the upper portion of the black motor shafts. It has a groove in the top of it that engages the autotensioner mechanism and can be used to push against with the push-pull hook during manual tensioning.

*Clutch Lock* – the circular aluminum piece directly above the Clutch Housing, which contains holes to place the Wrist *Cross wrap* – when spanning the distance between two parallel transmission elements (pinions or pulleys) the drive cable crosses the plane that contains the axes of both elements. This wrap results in the elements rotating in opposite directions when cabled.

*M5/M6-Side* – directions often used in this text to identify an item. The motor number indicates the motor (or side of the wrist containing the motor) the component is closest to Tension Tool in while tensioning the Wrist.

*Open wrap* – when spanning the distance between two parallel transmission elements (pinions or pulleys) the drive cable does not cross the plane that contains the axes of both elements. This wrap results in both elements rotating in the same direction.

*Pinion* – the smaller-diameter, higher-speed cylinder in a pair of cabled transmission elements.

*Pre-tension* – cable tension, internal to a cable circuit, which is present even when the drive has no external loading. Pre-tension is added to eliminate backlash (in this case, cable slack) in the transmission even with commanded torques.

*Pulley* – the larger-diameter, slower-speed cylinder in a pair of cabled transmission elements.

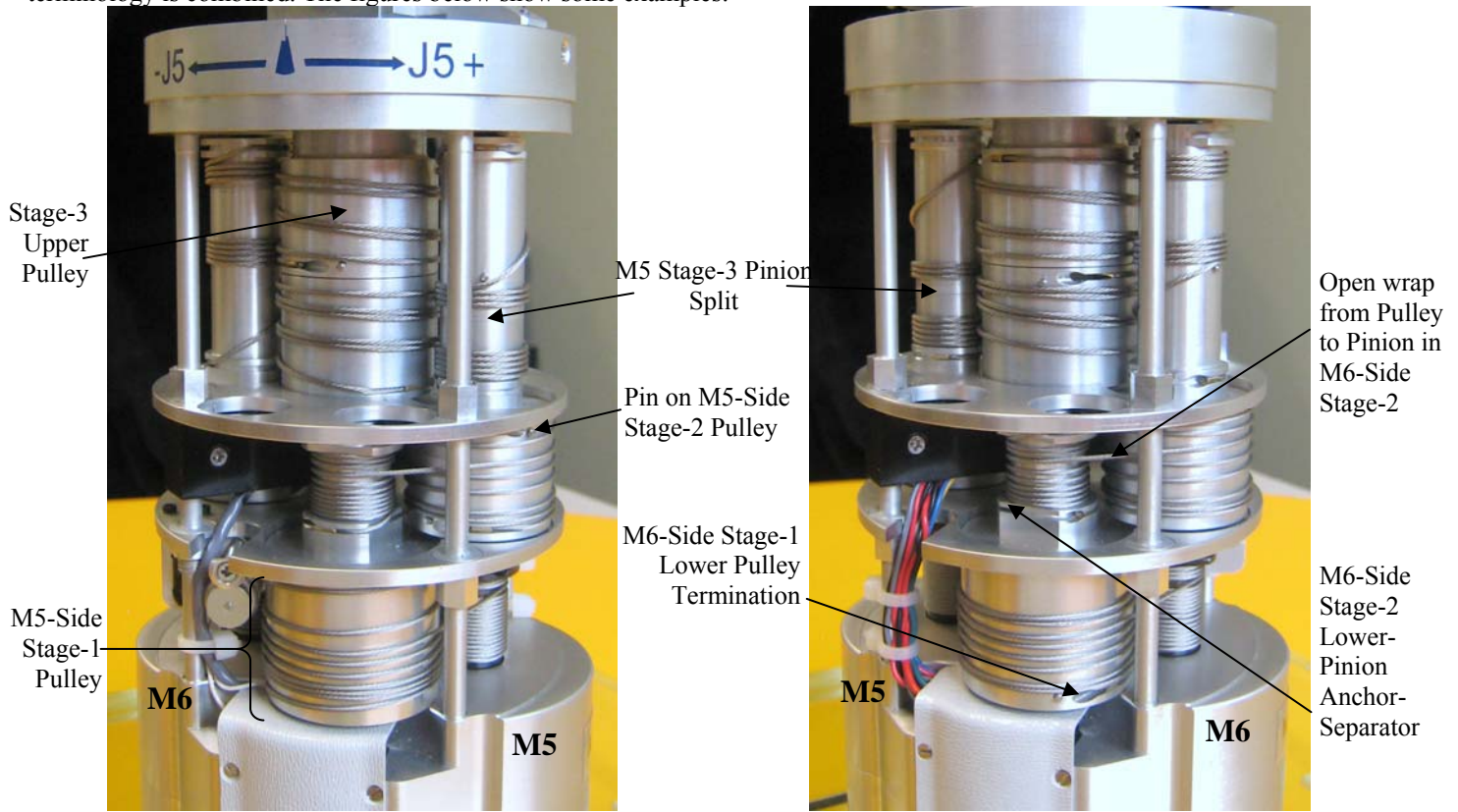
*Stages* – as with gear trains, cable circuits can be composed of several transmission stages, each contributing its part to the final transmission ratio. Stage-1 is from the motor to the first pulley, Stage-2 is from the pinion attached to the first pulley to the second pulley, and Stage-3 is from the pinion attached to the second pulley to the differential.

*Tensioner* – the mechanism in a cabled transmission, which applies and maintains pre-tension in the drive cables. Barrett’s patented single-point tensioner uses split motor pinions that counter-rotate via an integrated one-way clutch to pre-tension entire cable circuits.

*Termination* – a brass sphere swaged or crimped onto the end of a cable, which serves as a point to hold onto the cable.

*Upper & Lower* – directions used in this text to identify different sections of pinions and pulleys. Upper refers to the section of the pinion/pulley above the split (closer to the tool end of the Wrist), lower refers to the section below the split (closer to the base of the wrist).

**Combined terminology** – There are many terminations, pulleys, pinions, and stages in the Wrist. To identify a single one, the terminology is combined. The figures below show some examples:



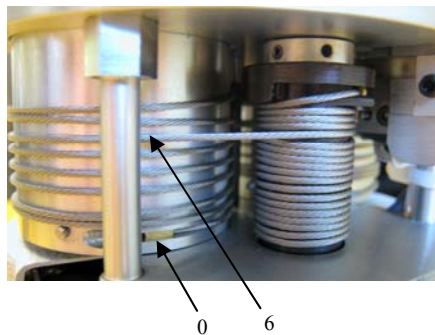
**Figure 3 – Views of the Wrist**

**Orientations**

Clockwise/Counter-clockwise: view the Wrist facing the output plate of the Wrist (base of the Wrist facing away from you).  
 M5/M6-Side: Use the labels on the side of the lower area of the wrist to determine which is the M5-Side and which is the M6-Side.

**Counting the number of turns**

Throughout this manual, there are instructions to wind a cable around a pinion or pulley a certain number of turns. It is important to understand exactly how the number-of-turns are counted. Always start at the anchor (brass termination) of the cable as the “zero” point and end where the cable comes off of the pulley. In the example picture below, the lower cable is wound around the larger pulley exactly 6 times (note the cable comes off of the pulley almost exactly above the brass termination).



**Figure 4: Example of counting the number of wraps**

### 2.3 Cables and Cabling Order

Table 1 lists the specifications of each type of cable. The Differential should be cabled first, followed by either the Motor 5 or Motor 6 circuits (all 3 stages). The motor circuits are independent and should be treated as such. Finish one side (M5 or M6) completely (all 3 stages) before working on the other motor side.

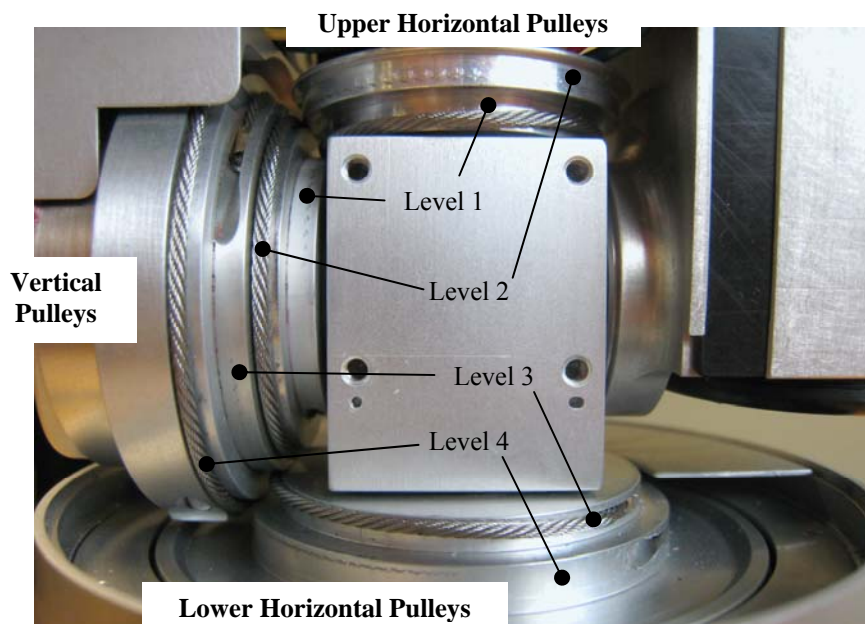
If a differential cable needs to be replaced, it is possible to replace it without having to remove all other cables. Contact Barrett for assistance. If a stage 1 cable needs to be replaced, it is generally possible to do this without removing the other cables in the transmission. If a stage 2 cable needs to be replaced, it is generally possible to do this without removing the stage 3 cables in the transmission; however, the stage 1 cables will have to be removed. If a stage 3 cable needs to be replaced, all stages on that one motor side must be removed.

**Table 1: Cable Specifications**

Barrett P/N	Barrett Description	Qty per Wrist	Qty per Maintenance Kit	Length between terminations (mm)
B1216	WristCable-Differential-Level1	1	1	97 +/- 2
B1217	WristCable-Differential-Level2	1	1	107 +/- 2
B1218	WristCable-Differential-Level3	1	1	132 +/- 2
B1219	WristCable-Differential-Level4	1	1	152 +/- 2
B3477	WristCable-Stage1	4	2	860 +/- 5
B3478	WristCable-Stage2	4	2	610 +/- 5
B3479	WristCable-Stage3	4	2	560 +/- 5

### 3 Cabling the Differential

The differential circuits are shown in Figure 5. They consist of four cables riding on four different diameter horizontal steps. The four cables make up two independent circuits. The top horizontal steps and the 2 smallest vertical steps form one circuit, and the bottom horizontal steps and the 2 larger vertical steps form the other circuit. Each circuit is tensioned with a worm gear located in the vertical steps. While cabling the differential, move J6 as necessary to have proper access to the section of the differential you are working on. Both blue RTV shrouds must be removed (2 screws each). Of the two differential wiring shield assemblies (half-moon-shaped sheet metal plus triangular machined aluminum piece), one of them must be removed – the one that does NOT include the hidden Joint 5 stop. Figure 5 shows the correct wiring shield assembly has been removed.



**Figure 5 - Differential Pulleys**

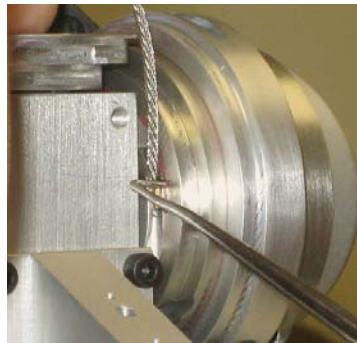


**Figure 6 -- RTV rubber shroud.**

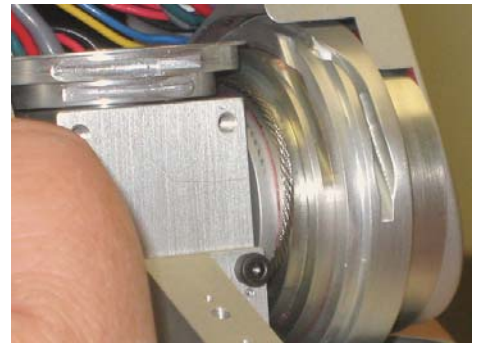
- 1. Rotate J6 to its far positive position. Using a 1/8" Hex Wrench, remove the worm on the section of the vertical steps with the smaller diameter (see Figure 7). Set it aside (keeping it in a place where it will not be lost).
- 2. Rotate J6 to its far negative position. Remove the worm on the section of the vertical steps with the larger diameter. Set it aside separately from the other worm, taking care to note which side each worm was seated, as you will need to replace it on the same side when done.
- 3. The Level 2 cable (B1217) must be pre-installed between the horizontal and vertical pulleys before any other cables are installed, because the gap between the Level 2 horizontal pulley and Level 2 vertical pulley is too small for the brass termination on the cable to fit through. The bottom 3<sup>rd</sup> stage pulley and 2 upper horizontal differential pulleys are fixed to each other. Manually turn the bottom 3<sup>rd</sup> stage pulley until the 2 upper horizontal pulleys look roughly as shown in Figure 9. Insert one end of the Level 2 cable (B1217) BACKWARDS into the Level 2 horizontal pulley anchor. Rotate the bottom 3<sup>rd</sup> stage pulley counter-clockwise approximately 1/2 turn. The cable should now be threaded through the small gap between the Level 2 horizontal and vertical pulleys. Remove the brass termination from the horizontal pulley and leave both ends of the cable unconnected.
- 4. Get a Level 1 cable (B1216) and insert one end of the cable into the vertical anchor on the level 1 wrist differential (see Figure 8) and thread the cable through the gap between the steps (see Figure 9). (All other differential cables are installed similarly, so use Figure 8 and Figure 9 as reference points for the other circuits.)
- 5. Cross the cable onto the smallest step of the upper horizontal differential level. Rotate the Level 1 horizontal pulley as required (by rotating the 3<sup>rd</sup> stage bottom pulley) and insert the termination into the anchor, then rotate the bottom 3<sup>rd</sup> stage pulley by hand to tighten the cable.



**Figure 7 – Removing the Worm**



**Figure 8 – Anchoring the Level 1 Cable**



**Figure 9 – Threading the Level 1 Cable**

- 6. Put one end of the pre-threaded Level 2 cable (B1217) in the anchor in the larger horizontal step in the differential top (Level 2)
- 7. Cross over to the Level 2 vertical step, rotate the vertical step (the tensioner worm is not yet installed) as necessary to allow the second termination to be inserted into the anchor on the second step. Then, rotate it back to tighten the cables.

- 8. Insert a tensioner worm into the worm slot in the Level 2 vertical step and tighten until the cable is taut enough not to fall off of its level (the worm can keep turning once it has reached the bottom of its slot and will continue tightening while it turns).
- 9. Move J6 slowly through its full range and allow the cables to find their preferred locations. Retighten the screw to remove any remaining slack and move J6 through its full range again to verify the cables are working properly.
- 10. Rotate J6 into roughly the zero position (pointing straight up). Insert one end of the Level 3 cable (B1218) into the anchor on the Level 3 vertical step in the differential.
- 11. Bring the Level 3 cable around roughly 3/4 turn on its vertical step and under the pulley, crossing over to the lower horizontal step (Level 3). The upper 3<sup>rd</sup> stage pulley is fixed to the 2 lower horizontal steps (Levels 3 & 4). Rotate the upper 3<sup>rd</sup> stage pulley as necessary and insert the free end of the Level 3 cable into the anchor on the horizontal pulley, and rotate back to tighten.
- 12. Rotate J6 slightly in the negative direction, while keeping tension on the Level 3 cable, so that the Level 4 horizontal termination is visible and accessible. Insert one termination of the Level 4 cable (B1219) into the anchor in the horizontal step. Wrap the cable around approximately 1/2 turn, under the differential shield, then under and around the Level 4 vertical pulley.
- 13. Rotate the Level 4 vertical step (the second tensioner worm is not yet installed) until the free termination can be put into the last anchor. Then, rotate it back to tighten the cables.
- 14. Insert the second tensioner worm into the wormhole in the Level 4 vertical step and tighten until the cable is taut enough not to fall off of its level.
- 15. Slowly move Joint 6 through its full motion ranges to confirm that the 2 new differential cables are properly installed. If new slack propagates through the cables during this step, again tighten both worms until the cable is taut enough not to fall off of its level; do not tighten it more.
- 16. Replace the missing wiring shield assembly and blue RTV shrouds. Make sure the plastic pins in the shrouds align properly with each other.



## 4 M5 Stage-3

The cabling circuit for the M5 Stage-3 is represented in Figure 10 (only the colored cables are in the M5 circuit).

- 1. Position the wrist so that you can easily access the M5-Side. Rotate joint 5 to its far positive stop (fully CCW), and flip the wrist pitch opposite to the side that you are working on. Secure J5 and J6 with tape.
- 2. Begin with a 3rd-stage cable (B3479). Attach one end to the top anchor in the lower 3rd-stage pulley. If necessary, push the termination in further and pull the cable across the surface of the pulley to force the termination into the orientation visible in Figure 10.
- 3. Wrap the cable around the pulley 2.5 times using tape to hold the wraps.
- 4. Transition over to the M5 pinion using a cross-wrap. Attach the free end of the cable to the bottom anchor of the pinion. Wind on the cable by rotating the pinion (after approximately  $\frac{1}{2}$  of a turn the cable should pass over the flat section of the anchor-separator). Rotate the pinion until the cable is tight.
- 5. Immobilize the bottom of the pinion with tape to prevent cable unwinding (see Figure 11).
- 6. Attach one end of another 3rd-stage cable (B3479) to the lower anchor in the lower 3rd-stage pulley. Wrap the cable up the pulley 3 times using tape to hold each wrap as necessary. This cable will transition above the first cable, so it must wrap between the wraps of the first (see color-enhanced Figure 10).
- 7. Cross over to the pinion using a cross-wrap. Attach the free end of the cable to the anchor in the top of the pinion and rotate the top segment of the pinion only. After approximately  $\frac{1}{2}$  of a turn the cable should pass over the flat section of the anchor-separator and the 2<sup>nd</sup>  $\frac{1}{2}$  of the first turn should track directly down below the pin on the pinion surface, and all other turns should lie on the pinion surface below the pin but above the pinion split. Guide the cable carefully to ensure that the cable winds on smoothly and evenly. Rotate the pinion until the cable is *tight*.
- 8. Immobilize the top of the pinion with tape.
- 9. Using a thin piece of tape, connect the upper and lower portions of the M5 pulley/pinion pair by laying the tape around the “pinion split” (see Figure 12).
- 10. Remove ALL other tape.
- 11. Gently move the M5 stage-3 circuit to its extremes. Ensure that the cables are not tangled or rubbing tightly. Nudge the cables into the relative positions as shown in Figure 10. If necessary, carefully remove the pinion tape, retighten the circuit, and resecure.
- 12. Continue on to Section 6 and follow the directions for the M5 circuit leaving the thin tape around the pinion split in place for now.



Figure 10 – M5 Stage-3 Cables (color-enhanced)



Figure 11 – Taping the M5 Stage-3 Lower-Pinion

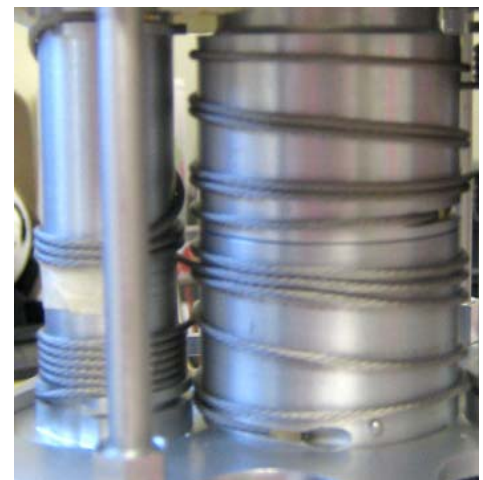


Figure 12 – Taping the M5 Stage-3 Pinion Split

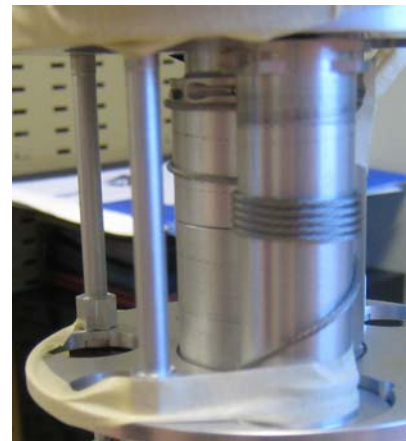
## 5 M6 Stage-3

The cabling circuit for the M6 Stage-3 is represented in Figure 13.

- 1. Position the wrist so that you can easily access the M6-Side. Rotate joint 5 to its far positive stop (fully CCW), and flip the wrist pitch opposite to the side that you are working on. Secure J5 and J6 with tape.
- 2. Begin with a 3rd-stage cable (B3479). Attach one end to the top anchor in the upper 3rd-stage pulley.
- 3. Wrap the cable around the pulley 2 times using tape to hold the wraps.
- 4. Transition over to the stage-3 pinion using a cross-wrap (the split in the surface of the M6 pinion is closer to the top of the wrist than that on M5). Attach the free end of the cable to the bottom anchor of the pinion. Wind on the cable by rotating the pinion. After approximately  $\frac{1}{2}$  of a turn the cable should pass over the flat section of the anchor-separator and the 2<sup>nd</sup>  $\frac{1}{2}$  turn should track directly above the pin in the pinion surface, and all other turns should lie on the pinion surface above the pin but below the pinion split. Rotate the pinion until the cable is tight.
- 5. Immobilize the bottom of the pinion with tape to prevent cable unwinding (see Figure 14).
- 6. Attach one end of another 3rd-stage cable (B3479) to the lower anchor in the upper 3rd-stage pulley. Wrap the cable up the pulley 3.5 times using tape to hold each wrap as necessary. This cable will transition above the first cable, so it must wrap between the wraps of the first (see color-enhanced Figure 13).
- 7. Cross over to the pinion using a cross-wrap. Attach the free end of the cable to the anchor in the top of the pinion and rotate the top segment of the pinion only (after approximately  $\frac{1}{2}$  of a turn the cable should pass over the flat section of the anchor-separator). Guide the cable carefully to ensure that the cable winds on smoothly and evenly above the pinion split. Rotate the pinion until the cable is *tight*.
- 8. Immobilize the top of the pinion with tape.
- 9. Using a thin piece of tape, connect the upper and lower portions of the M6 pulley/pinion pair by laying the tape around the “pinion split” (see Figure 12 of M5 instructions).
- 10. Remove ALL other tape.
- 11. Gently move the M6 stage-3 circuit to its extremes. Ensure that the cables are not tangled or rubbing tightly. Nudge the cables into the relative positions as shown in Figure 13. If necessary, carefully remove the pinion tape, retighten the circuit, and resecure.
- 12. Continue on to Section 6 and follow the directions for the M6 circuit leaving the thin tape around the pinion split in place for now.



**Figure 13 – M6 Stage-3 Cables (color-enhanced)**



**Figure 14 – Taping the M6 Stage-3 Lower-Pinion**

## 6 M5 and M6 Stages 1 and 2

### 6.1 Tools and Tips

- Cabling Stages 1 and 2 is a virtually identical process for both the M5 and the M6 cable circuits.
- All pictures in this section are pictures of the M6 circuit; however, they should also approximate the appearance of the M5 circuit.
- In this section, any quantities that differ between the M5 circuit and the M6 circuit will appear in the form: (<M5 quantity>/<M6 quantity>)

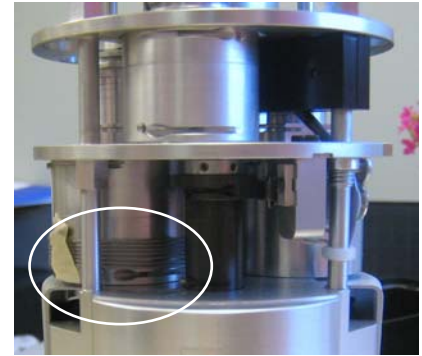
### 6.2 M5/M6 Stage-1 Preinstallation

- 1. Insert the Stage-1 Cable (B3477) into the lower anchor of the Stage-1 pulley.
- 2. Wrap all of the cable onto the section of the pulley below the split by turning the pulley clockwise, while keeping tension on the cable.
- 3. Tape the cable to the pulley to prevent the cable from unraveling (see Figure 15).

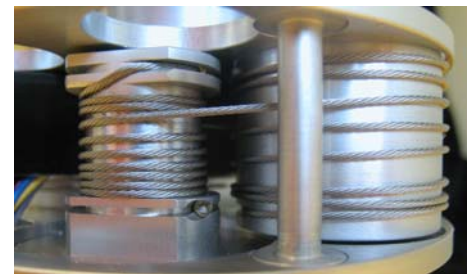
### 6.3 M5/M6 Stage-2

The cabling circuit for the second stage is represented in Figure 16.

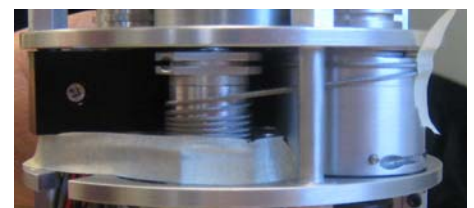
- 1. Begin with a 2nd-stage cable (B3478). Attach one end to the top anchor of the 2nd-stage pulley.
- 2. Wrap the cable around the pulley (1.75/2) times, using tape to hold the wraps.
- 3. Transition over to the 2nd-stage pinion using an open-wrap. Attach the free end of the cable to the bottom anchor of the pinion. Slowly and evenly wind on the cable by rotating the pinion until the cable is tight (after approximately  $\frac{1}{2}$  of a turn the cable should pass over the flat section of the anchor-separator).
- 4. Immobilize the bottom segment of the pinion with tape to prevent Stage-2 from unwinding (see Figure 17).
- 5. Attach one end of another 2nd-stage cable (B3478) to the bottom anchor of the 2nd-stage pulley.
- 6. Wrap the cable around the pulley (5/5.5) times using tape to hold the wraps if necessary.
- 7. Transition over to the 2nd-stage pinion using an open-wrap. Attach the remaining free end of the cable to the top anchor of the pinion and rotate the top segment of the pinion only (after approximately  $\frac{1}{2}$  of a turn the cable should pass over the flat section of the anchor-separator). Guide the cable carefully to ensure that the cable winds on smoothly and evenly. Rotate the pinion until the cable is tight.
- 8. Immobilize the top of the pinion with tape to prevent Stage-2 from unraveling. Stage-2 should now look like Figure 18.



**Figure 15 – Stage-1 Preinstallation**



**Figure 16 – Stage-2 Cabling**



**Figure 17 – Taping the Stage-2 Lower-Pinion**



**Figure 18 – Stage-2 Final Configuration**

### 6.4 M5 and M6 Stage-1

The cabling circuit for the first stage is represented in Figure 19.

- 1. Begin with a 1st-stage cable (B3477). Attach one end to the top anchor of the 1st-stage pulley.
- 2. Wrap the cable around the pulley about (1.75/1.25) times, using tape to hold the wraps. Make sure that the cable does not wrap above the pin on the upper pulley.
- 3. Transition over to the 1st-stage pinion (motor pinion) using an open-wrap. Attach the free end of the cable to the bottom anchor of the pinion. Slowly and evenly wind on the cable by rotating the pinion until the cable is tight.
- 4. Immobilize the bottom (inner) segment of the pinion with tape to prevent Stage-1 from unwinding (see Figure 20).
- 5. Unwrap approximately ½ of a turn of the cable that was pre-installed in Section 6.2 while keeping the rest of the cable taped in place on the pulley (about 7 turns).
- 6. Transition over to the M6-Side 1st-stage pinion using an open-wrap. Attach the remaining free end of the cable to the anchor on the Clutch Housing (which houses the one-way clutch) and rotate the Clutch Housing to take up the slack. Guide the cable carefully to ensure that the cable winds on smoothly and evenly. Rotate the Clutch Housing until the cable is tight. It is normal that the Clutch Housing may be a bit difficult to rotate. The stage should now look like Figure 21.
- 7. Remove all tape except for the tape across the stage 3 pinion split.



Figure 19 – Stage-1 Cabling

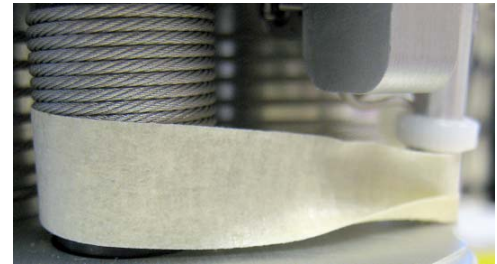


Figure 20 – Taping Stage-1 Lower-Pinion

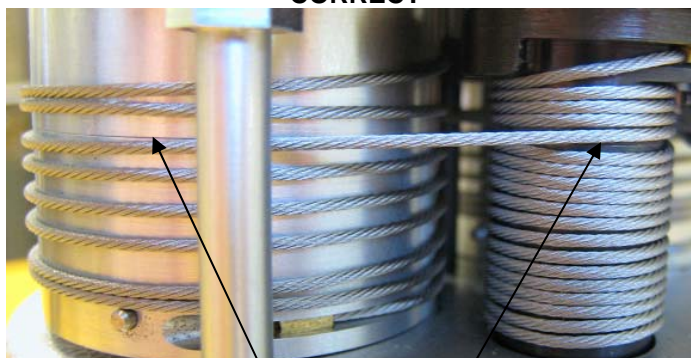


Figure 21 – Stage-1 Final Setup

### 6.5 Pre-tensioning M5/M6 Circuit

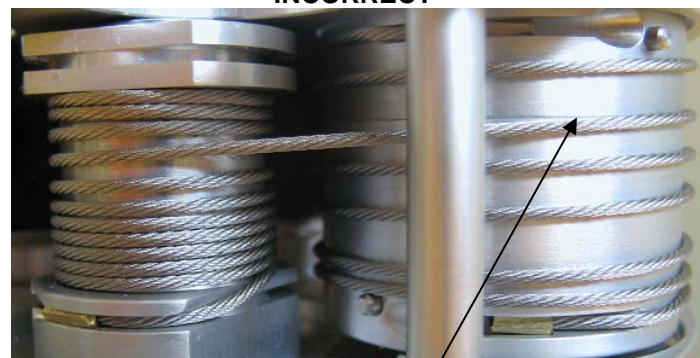
Before pre-tensioning a particular cable circuit, the cables on every stage of a transmission should be positioned on the pulley and pinion, as shown in Figure 22. All of one cable should be completely above the split in the pulley and below the split in the pinion while the other cable is completely below the split in the pulley and above the split in the pinion (make sure to check both cables that are attached between each pinion and pulley). To achieve the required cable positions, slowly back-drive the wrist until the cables properly align relative to the split lines. When the cables are located correctly, insert the Wrist Tension Tool into the clutch lock and push on the groove in the Clutch Housing with the push-pull hook to tension the entire cable circuit.

**CORRECT**



Cables do not wrap over splits

**INCORRECT**



Cables cross splits before transition

Figure 22 -- Proper Position of Wrist Cables for Pre-Tensioning

Manually run the Wrist through six cycles of J5 and J6 so that the stage 1 cables track up and down the motor shafts over their entire range. The Wrist circuits, with their three stages of reduction, require more attention than any other WAM circuits during pre-tensioning. The third stage cables must be carefully placed to prevent both scrubbing between cables placed too close together, pulling at odd angles, or falling into termination slots if cables are too far apart. Cables placed with a large angle relative to the horizontal will eventually reorient themselves, but not necessarily in the proper arrangement.

Once the cables have been repositioned as shown in Figure 22, retension again by inserting the Wrist Tension Tool into the clutch lock (to keep the motor shaft from turning) and pushing on the clutch housing with the push-pull hook. Repeat the process of running the wrist through its range of motion and re-tensioning until all the stage 1 and 2 cables are tight.

Remove the tape across the stage 3 pinions splits (M5 and M6) and repeat the tensioning procedure:

- 1) Tension.
- 2) Run J5 and J6 through full ranges of motion so both M5 and M6 cables track up and down over entire length of black motor shafts.
- 3) Repeat step 2 six times.
- 4) Repeat steps 1-3 six times minimum until cables are reasonable taught.

## 7 Autotensioning

Full instructions for using the Wrist's autotensioning mechanism are coming soon. Contact Barrett Technology for assistance.