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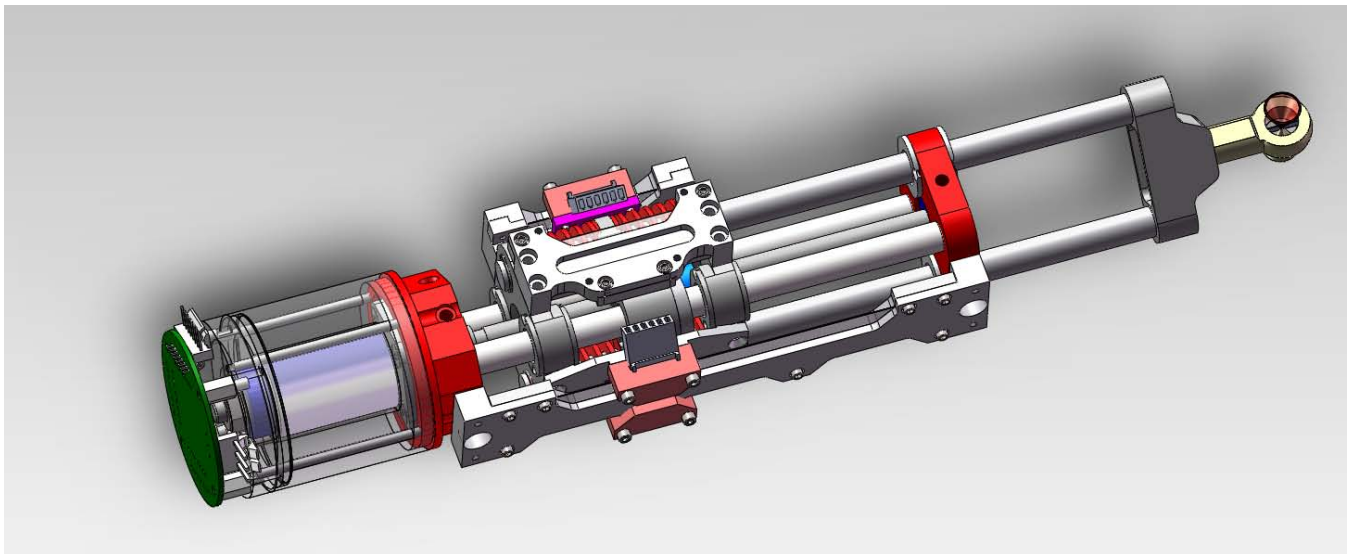
40 South Alcaniz Street  
Pensacola, FL 32502

850.202.4462

<http://www.ihmc.us/>

# **Yobotics Bipod SEA 23-23 Assembly Guide and Procedure**

Jerry PRATT and Ionut OLARU October 20, 2010



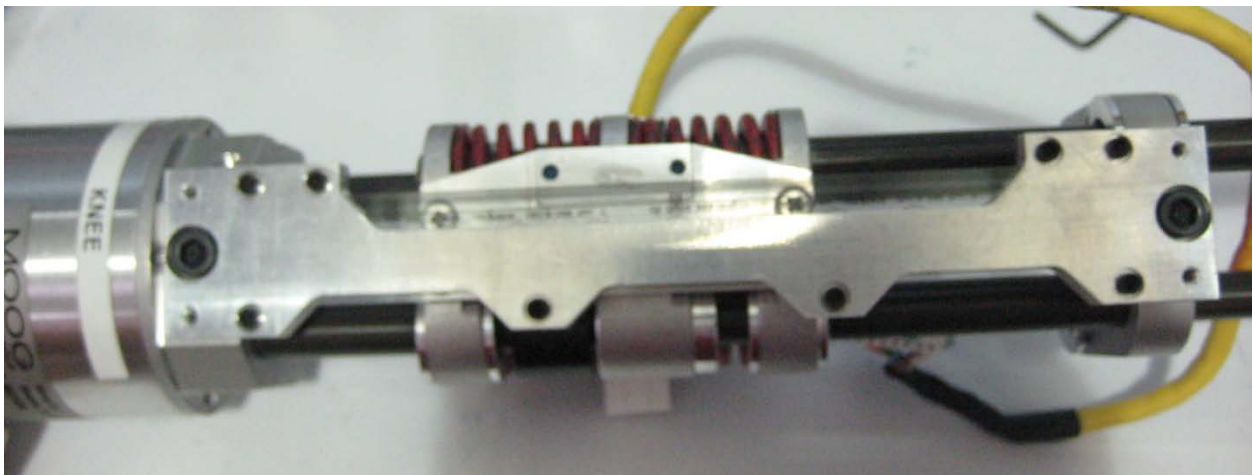
## ECO 002 M2V2 Hardware

### SEA 23-23 Assembly Procedure

#### Step by step instructions on How to rebuild a Series Elastic Actuator for the M2V2 Humanoid Robot.

##### Exemplification on a knee configured actuator.

The present Document is a step by step instruction to rebuild a Series Elastic Actuator. This procedure can be applied to rebuild any of the actuators as general instruction and guideline and should be adapted for particular cases depending on the actuator configuration.



In general same part number is used for all the actuators except the plunger shafts specific for each actuator individual. Also the final configuration of the Force Sensor, Position Sensor and the encoder board should be accordingly with the chosen configuration of the actuator for the designated location on the M2V2 Humanoid Robot.

The procedure is using pictures taken during the rebuild of the knee actuator.

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## **1. GUIDE LINES ON REBUILDING AN ACTUATOR USING REUSABLE COMPONENTS FROM AN OLD ONE.**

2. Check the parts if they are in a perfect condition and still can be reusable
3. Clean the old glue and decontaminate the assembly surfaces from any remaining traces of old glue oil and foreign elements.
4. DO NOT reuse damaged components. Once glued some of the components become non reusable.
5. Replace the springs in the carriage if spares are available.

## 1. PREPARE YOUR WORKING SPACE

Choose a clean area free of dust and any other tools or components that may interfere with your assembly space. Create a space that will allow you to have sufficient freedom to move and perform the whole assembly process.

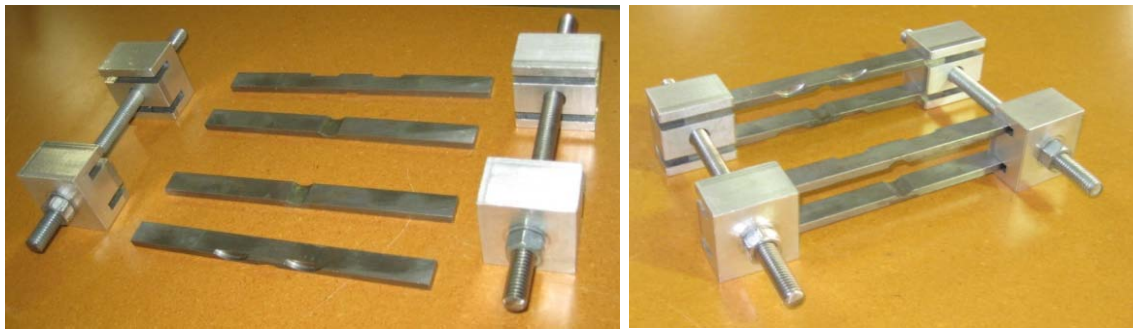
At one moment the assembly process will require two people. This requirement may occur when the shafts is glued to the carriage, due to the short time of inserting the components in the necessary order to be glued.

- a. Get the orange **Toolbox** marked “ACTUATOR ASSEMBLY” from the M2V2 Shelve



- b. **Understand the tools** you will use during the assembly process. The most important and confusing tool is the **Carriage Press (fixture press)** used to compress the springs in order to assemble the carriage. Notice the Round Extruded cut on one side of the each **jaws**. This should be aligned later with the groove spacing retaining caps on the carriage assembly. The middle extruded cut will give clearance and avoid interference with the other pair of aluminum ceramic coated shafts. This will prevent damaging the shafts.

**WARNIG! CAREFULLY ALIGN THE JAWS AND INSERT THEM BETWEEN THE SHAFTS TO AVOID SCRATCHING THE ALUMINUM CERAMIC COATED SHAFTS AND TO CONTACT WITH THE HELICAL SURFACE OF THE BALL SCREW!**



c. **Get the consumable materials and substances you will need in the assembly process**


- ACETONE
- ALCOHOL cleaning Swabs




- **Permanent Glue HAYSOLL 9433**




- **LOCTITE 242 THREAD LOCKER MEDIUM STRENGHT**

	<b>LOCTITE 242</b> Thread Locker	<b>MEDIUM</b> STRENGHT	<b>BLUE</b>	<b>Removable with hand tools.</b> 1/4" to 3/4" diameter fasteners. NSF/ANSI-61 certified. Seals metal threads.
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- LOCTITE 262 THREAD LOCKER HIGH STRENGHT

	LOCTITE 262 Thread Locker	HIGH STRENGHT	RED	<b>Permanent adhesive.</b> High strength. 3/4" diameter and smaller fasteners. NSF- P1 registered. One little drop prevents leakage. Seals metal threads
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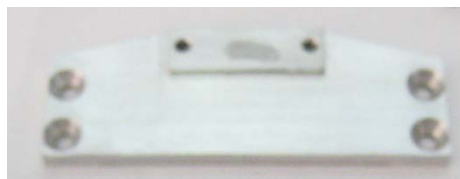
- LOCTITE 680 Slip Fit HIGH STRENGHT

	LOCTITE 680 Retaining Compound	Slip fit HIGH STRENGHT	GREEN	<b>Retaining Compound</b> Applications: Joins Fitted Cylindrical Parts With Gaps Up To 0.015
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d. You will need the **following parts** to **use them as tools** in the assembly process:

- **Force sensor mounting plate**

This part it will be use in order to adjust the height of the whole carriage when the aluminum shafts is glued to the machined end caps of the carriage.



- **Position sensor (encoder) mounting plate**

This part will be use in order to adjust the length of the plunger and defining the active stroke of the actuator.





- **Flange P/N: 002-400-P-1026 carriage machined part**



This part will be used in order to maintain the alignment when the shafts will be glued on the **Motor Cap P/N: 002-400-P-1022**

e. **Prepare a list of the P/N to rebuild the actuator.**

You can find the spare parts in the following places:

- **Carriage spare parts** of the actuator: bearings, spacers, machined parts, springs, plastic spacers, square nut kit's can be found **in the plastic shelf drawers marked ACTUATOR PARTS.**



- **Actuator shafts** can be found in the plastic drawer marked: ACTUATOR SHAFTS, GROOVE SPRINGS and “O” rings as well as in the auxiliary plastic BOX marked ACTUATOR PARTS.



- The **actuator shafts** are stand alone P/N from MISUMI or custom machined parts for KNEE ANKLE and HIP. The MISUMI P/N: is **U-PBF0.38-L8.5-** Father Shaft. 3/8 Aluminum 6061-T6. Ceramic Coating. The number after “L” represents the length of the shaft which can be ordered directly from MISUMI.
- Available lengths are:
  - 7” HIP YAW and general use for carriage
  - 7.38”
  - 8.00” ANKLE configuration
  - 8.50” KNEE internal P/N after machining 002-400-P-1031
  - 9.50”
- **Motor electrical parts, stators, magnets, machined caps** parts look in the **main M2V2 metallic Shelf** in the boxes marked BIPED MOTORS.
- **Ball Screws** (NEW and used) look **under the M2V2 Desk** in the cardboard boxes marked **NSK BALL SCREWS**.

**WARNING! HANDLE WITH CARE IT CAN BE EASILY DAMAGED!**

- **Screws** metric and imperial size **and retaining rings** can be found in the **general plastic drawer with screws**.

## 2. CHOOSE THE SPECIFIC COMPONENTS (SHAFTS) for the desired configuration of the actuator



- **Choose the plunger for the desired configuration**
- **P/N: 002-400-P-1031 YOBOTICS internal P/N**
- Description: SEA 23 PLUNGER ROD for M2V2 **Actuator KNEE.**
- Machined from MISUMI P/N: U-PBF0.38-L8.5- Father Shaft. 3/8 Aluminum 6061-T6. Ceramic Coating



### 3. LAY DOWN THE WHOLE P/N YOU WILL USE TO REBUILD THE ACTUATOR.

Start putting in order all the parts needed to build the actuator. Be careful in manipulating sensitive components such as:

- **Ball Screw**
- **Thrust bearings**
- **Aluminum Ceramic Coating shafts**
- **Groove spacing.**

**WARNING! HANDLE WITH CARE IT CAN BE EASILY DAMAGED!**



#### 4. CHECK IF ALL NECESSARY PARTS ARE AVAILABLE.

#### 5. START BUILDING THE ACTUATOR

- Assembling the ball screw into the middle carriage flange.
- Clean the aligning holes where the shafts will be glued.
- Clean the aligning holes where the grove spacing bushings will be seated.
- Clean the area where the Ball Screw Nut will be inserted.
- Clean the threaded holes for Ball Screw Nut Assembly



- Let the cleaned surfaces to dry. Do not touch any more the cleaned surfaces.
- Apply a small quantity of **LOCTITE 262 – RED HIGH STRENGHT** directly in the threaded holes and clean the excess.



- Assemble the Ball Screw and the nut on to the middle Carriage flange in the designated machined slot.
- Use the **M3 X 8 SHCS metric Screw the Blue Screws** to secure the Ball Screw Nut assembly.



**WARNING! TIGHT SCREWS PROPERLY YOU WILL NOT HAVE ACCESS TO THEM ONCE THE CARRIAGE ASSEMBLY IS COMPLETE!**



## **6. PREPARE TO GLUE THE MOTOR CAP P/N: 002-400-P-1022 TO THE SHAFTS.**

- Clean with alcohol / acetone the ends of the ceramic coated aluminum shafts.
- Clean with alcohol / acetone the holes where the shaft will be glued.



- Use a small bag and assemble the square flange in the position. To avoid to glue the square flange to the motor cap with the excess glue pushed away from the hole when inserting the shafts.



- Apply a small quantity of **Permanent Glue HAYSOLL 9433** directly into the holes and spread around the inside surface. Use the special gun and the mixing tube.



- Insert the corresponding stroke length Shafts into the holes and clean the excess glue.

**WARNING! IF THE EXCESS GLUE IS NOT CLEANED IT WILL BE HARD TO REMOVE WHEN IS DRY!**

- Use the Flange **P/N: 002-400-P-1026** carriage machined part as a tool to maintain the alignment of the shafts, set up the assembly vertical.



- Let the assembly to dry for **12 HOURS MINIMUM**.

## 7. PREPARING THE CARRIAGE FOR ASSEMBLY

- Assemble the “O” rings on the Groove Spacing



- Be sure that the “O” ring is the right size and is not damaged.
- Insert the “O” ring assembly into the corresponding holes on the carriage machined parts.



- Check to see if the “O” ring assembly is fitting easily into the each hole of the carriage machined parts. The result assembly should be not too tight and too loose.
- Insert the **NMB Bearing P/N: DDR-1960ZZ** in the end Carriage Machined part **P/N: 002-400-P-1026** before assemble the Groove retaining rings.

**WARNING! THE GROOVE RETAINING RINGS OVERLAP THE OUTSIDE DIAMETER OF THE BEARING PREVENTING THE AXIAL DISPLACEMENT OF THE BEARING!**



- Use small amount of LOCTITE 242 THREAD LOCKER MEDIUM STRENGTH – BLUE on each threaded hole.





- Clean the excess if any.
- Apply a small amount of LOCTITE 242 THREAD LOCKER MEDIUM STRENGTH – BLUE on the end of each screw DO NOT use too much.



- Assemble the Groove retaining flange  
**P/N: 002-400-P-1076** and **P/N: 002-400-P-1076 E** on each side and on each carriage machined part.

**WARNING! THE THICK GROOVE RETAINING FLANGE WILL BE ASSEMBLED ON THE MIDDLE CARRIAGE MACHINED PART SAME WITH THE BALL SCREW ASSEMBLY!**



- Use **Screws 2-56X5/16** for the thick Groove Retaining Flange  
**P/N: 002-400-P-1076 E**



- Use **Screws 2-56X3/16** for the thin Groove Retaining Flange  
**P/N: 002-400-P-1076**



## 8. CARRIAGE ASSEMBLY

- Take the aluminum Shafts Ceramic Coated specific for the actuator you are building Locate the machined Grooves.
- Get the retaining rings for **3/8 SHAFTS MC#91590A117** from WHASHER & NUTS plastic drawer.



- Use the Grabber for the retaining ring and place the retaining rings on the end of each shaft.



- Insert the shafts into the corresponding holes on **P/N: 002-400-P-P-1023**



- Choose a set of 4 springs.

**WARNING! MATCH THE SET OF 4 PCS. SPRINGS. WHEN CHOOSING THE 4 SPRINGS BE SURE THAT ALL OF THEM HAVE THE SAME LENGTH AND ALMOST THE SAME COMPRESSION CONSTANT!**

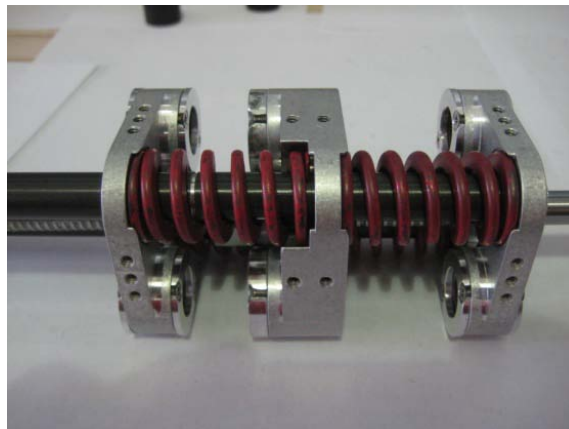
- Assemble the 1<sup>st</sup> set of springs one on each shaft as follow



- Assemble the middle carrier machined part preassembled with the ball screw.



- Assemble the 2<sup>nd</sup> set of springs on each shaft



- Assemble the **P/N: 002-400-P-P-1023** to complete the carriage. Using the grabber for retaining ring and place retaining rings on the shaft as close as possible to the carriage.

**WARNING! SUFFICIENT ENLARGE THE RETAINING RINGS USING THE RETAINING RING GRABBER TO AVOID SCRATCHING THE CERAMIC COATED SURFACE ON THE ALUMINUM SHAFTS!**

- Take the preassembled motor cap and shafts



- Position the preassembled motor cap in order to easily slide into the carriage.

**WARNING! DO NOT FORGET TO ASSEMBLE THE RUBBER BUSSING STOPS. THERE WILL BE NO WAY TO ASSEMBLE THEM LATER WITHOUT TAKING APART THE WHOLE ASSEMBLY!**

- Place the two rubber bussing stops on the shafts between the carriage elements and continue with the assembly



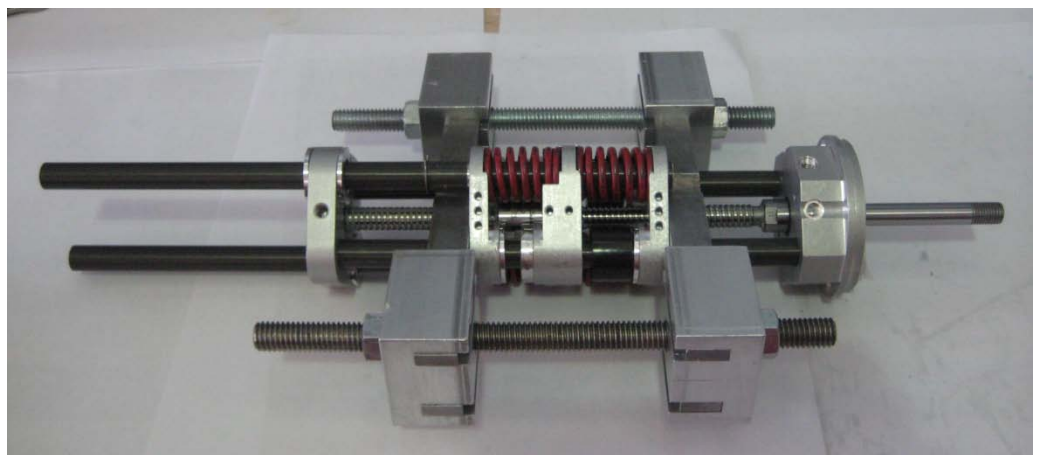
- Verify if the shafts are easily sliding into the assembly.

- Assemble the **P/N: 002-400-P-P-1023** preassembled with the bearing and secure it with **bearing retaining ring for 6mm shaft MC P/N: 90967A110**.



- The carriage should be centered and allow a translations when the ball screw is rotated.
- Position the carriage at the middle of the stroke.
- Assemble the fixture press in the carriage assembly.

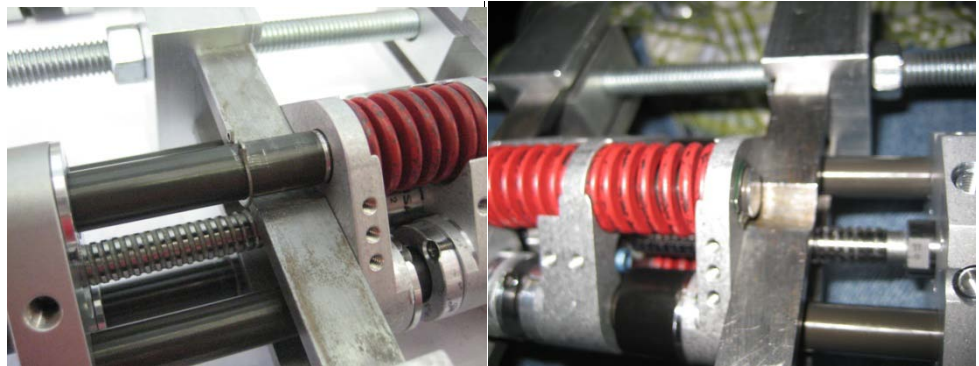
**WARNIG! CAREFULLY ALIGN THE JAWS AND INSERT THEM BETWEEN THE SHAFTS TO AVOID SCRATCHING THE ALUMINUM CERAMIC COATED SHAFTS AND THE CONTACT WITH THE HELICAL SURFACE OF THE BALL SCREW!**



- Close the jaws of the fixture press by manually screwing the nuts on the screws.



- Verify to equally close the jaws on each side and the jaws remain parallel.
- Adjust the position of the jaws in order to clear any interference may occur with the rest of the parts when the press fixture will compress the whole carriage.
- Assure a proper seating on the carriage and the clearance with all groove retaining flanges.
- Assure that once compressed, the jaws will have clearance to easily slide the retaining rings into the shaft groove and to allow the shafts to easily rotate.



- Compress the assembly up to the point that the Second groove in the shaft is cleared and allow insertion of the 3/8 Retaining Ring into the Groove slot. The carriage should be compressed 5 mm more in order to give to the shaft an translation play when applying the glue on the retaining rings.

**WARNING! TIGHT EACH SCREW OF THE FIXTURE PRESS EQUALLY. TIGHT ONE TURN ON EACH SIDE AND ALTERNATE THE SIDE. DO NOT TIGHT TOO MUCH ONE SIDE. MAINTAIN PARALLEL JAWS .THE BALL SCREW AND THE SHAFTS CAN BE EASILY BENDED!**

- Check if the shafts can be rotated and that the retaining ring can be easily moved into position in the Shaft Groove.
- Clean the area to be glued on the shafts with alcohol or acetone and let it dry.

**WARNING! LOCTITE 680 RETAINING COMPOUND IS DRYING VERY FAST. THE PROCESS TO GLUE THE ENDS OF THE SHAFTS, PARTIAL RELEASING THE FIXTURE PRESS TO THE PROPER POSITION, INSTALLING THE FORCE SENSOR MOUNT IN ORDER**

**TO TUNE THE EXACT DISTANCE BETWEEN THE MOUNTING SCREWS SHOULD BE DONE IN A QUICK SUCCESSION!**

- Apply a small quantity of **LOCTITE 680** Retaining Compound Slip fit **HIGH STRENGHT GREEN** on each ends of the grooved shafts and spread equally the glue. Translate and rotate the shafts so the glue can enter and fill in between the shafts and the hole.
- Release the fixture press until the carriage is partial decompressed and the carriage ends are touching the retaining rings.
- Check if the screw holes from the force mounting plate can be aligned with the threaded holes in the carriage ends. Adjust the press fixture in order to facilitate the alignment.

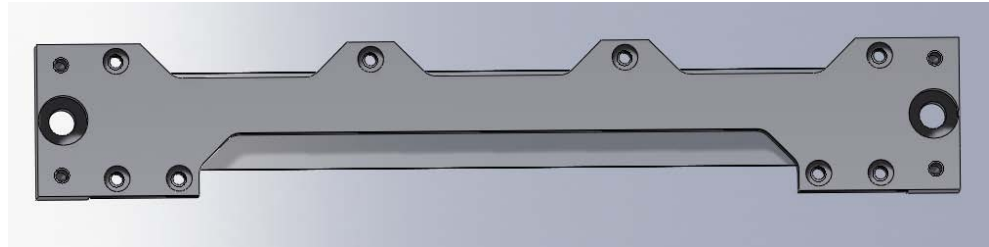
**NOTE:** the following picture was taken after removing the fixture press at this moment the press is still assembled on the carriage.



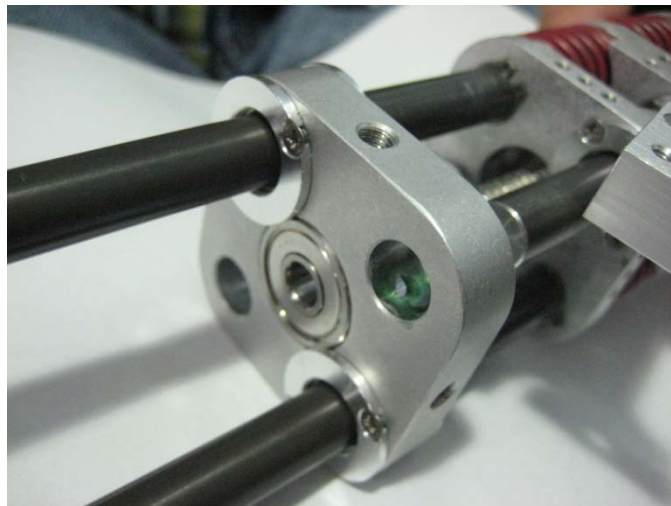
- Clean the excess of the LOCTITE 680 glue.
- Once in place let the assembly drying for 15 minutes.
- Carefully release the fixture press and remove it from the assembly. Following the reverse assembly procedure.
- Temporary remove the Bearing retaining ring and the preassembled part **P/N: 002-400-P-P-1023**.
- Clean the area to be glued on the shafts with alcohol or acetone and let it dry.

**WARNING! LOCTITE 680 RETAINING COMPOUND IS DRYING VERY FAST. THE PROCESS TO GLUE THE ENDS OF THE SHAFTS, POSITION THE PART AND TUNE THE EXACT DISTANCE BETWEEN THE MOTOR BLOCK AND THE CARRIAGE END SHOULD BE DONE IN A QUICK SUCCESSION!**

- Prepare the position sensor plate and use it as a tool later to tune the exact distance between the motor block and the carriage end.

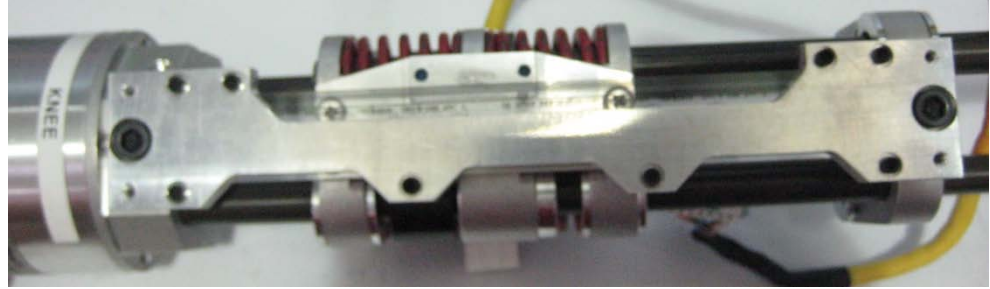


- Apply a small quantity of **LOCTITE 680 Retaining Compound Slip fit HIGH STRENGHT - GREEN** and equally distribute it in the hole.



- Slide the parts in position and tune the distance between the motor block and the carriage end using a spare position ribbon mount as a tool.

NOTE: The shown picture includes the position ribbon assembly. Use a spare position ribbon mount as a tool.



- Use the screws to align the holes and tight them.
- Clean the excess of LOCTITE glue on both sides and on the both shafts
- Press the bearing into position.
- Reattach the Bearing Retaining Ring using the special grabber.



- Once in place let the assembly drying for 15 minutes.

## 9. ASSEMBLY THE MAGNET AND THE MOTOR.

- Remove the square flange from the motor cap and remove the plastic bag.
- Clean the exes dried HYSLOLL 9433 glue using a cutter or DREMEL.
- Clean the resulting contamination.
- Get the THRUST BEARINGS kit.**P/N: NHBB SSMER-2280SD502**



**WARNING! CAREFULLY MANIPULATE THE BEARINGS DO NOT APPLY ANY AXIAL LOAD SINCE THE BEARING ASSEMBLY EASILY CAME OFF!**

- Verify if the one of the thrust Bearing is sliding easily on the ball screw end. If not then carefully sand the end of the ball screw where the thread is ending or the entire ball screw end with **SAND PAPER Granulation P600**.
- Remove any resulting contamination clean with Alcohol or Acetone and be careful not to contaminate the ball screw helical surface.
- Match the thrust bearing in order to form a DIMOND shape with the marks printed on the outer ring of the Thrust Bearings.



- Insert both bearings in this configuration all the way on the ball screw shaft and fit them in the motor cap in the designated place.

- Apply LOCTITE 242 THREAD LOCKER MEDIUM STRENGTH – BLUE in the threaded holes.
- Clean the excess of LOCTITE if any.
- Attach the square flange and secure it with 4 screws. Tighten all 4 screws close to the flange and tighten them in a diagonal sequence. The corners of the flange should bend a little when complete since the flange will not be flat on the motor cap.



- Insert the Spacer between the thrust bearing and the magnet **P/N WBK08K** on the shaft ball screw shaft.
- Prepare Rotor Magnet
- Prepare Axial Bearing **P/N: NMB 608MNSS**
- Prepare the square nut. At this moment is not necessary to install the brass cap and the set screw.
- Clean again the shaft using Alcohol or Acetone for any traces of hand grease and dust and let it dry.

**WARNING! LOCTITE 680 RETAINING COMPOUND IS DRYING VERY FAST. THE PROCESS TO GLUE THE ROTOR MAGNET TO THE BALL SCREW SHAFT SHOULD BE DONE IN A QUICK SUCCESSION!**



- Apply **LOCTITE 680 Retaining Compound Slip fit HIGH STRENGHT - GREEN** on the shaft and inside the magnet and spread evenly.
- Insert the magnet on the shaft having the radial ring close to the thrust bearings



- **Insert the Axial Bearing P/N: NMB 608MNSS**

**WARNING! DO NOT USE FORCE TO TIGHT THE SQUARE NUT! BENDING THE BALL SCREW IS THE MAIN DANGER AT THIS POINT.**

- Approach the nut and **TIGHTEN IT BY HAND.**
- Clean the excess of LOCTITE between the magnet and the thrust bearing using an alcohol swab.
- Remove the nut and the bearing and clean the excess of the glue between the bearing and the magnet also clean the end of the shaft and the threaded area.
- Reinsert the bearing on the shaft.

**WARNING! DO NOT APPLY FORCE! YOU CAN EASILY BEND THE BALL SCREW!**

- Tighten the square nut by hand and use the wrench just for a little to secure the magnet.
- Secure the Square Nut: **P/N: WBK08L-01**



- The Square nut kit contains the NUT, the Brass cap and a small set screw.
- Position the brass cap with the convex side pointing to the thread on the ball screw and insert it in the threaded hole in the square nut.
- Screw down the set screw with the corresponding Allen key and tighten properly.
- Attach the stator of the motor with the electronics and with the coil and position in such way that the stator will allow the 4 long screws to pass through.



- Apply LOCTITE 242 THREAD LOCKER MEDIUM STRENGTH – BLUE in the threaded holes.
- Tighten all screws properly in a diagonal sequence.

## 10. GLUE THE PLUNGER END ON THE SHAFTS.

- Select the designated plunger for the actuator.

- Clean the end of the shaft and the corresponding mounting holes using alcohol or acetone.

**WARNING! LOCTITE 680 RETAINING COMPOUND IS DRYING VERY FAST. THE PROCESS TO GLUE THE PLUNGER END TO THE END OF THE SHAFTS SHOULD BE DONE IN A QUICK SUCCESSION!**

- Apply **LOCTITE 680 Retaining Compound Slip fit HIGH STRENGHT - GREEN** on the shaft and inside the mounting holes on the plunger end.
- Insert the plunger and align flat the surface on the plunger with the end surface of the shafts.



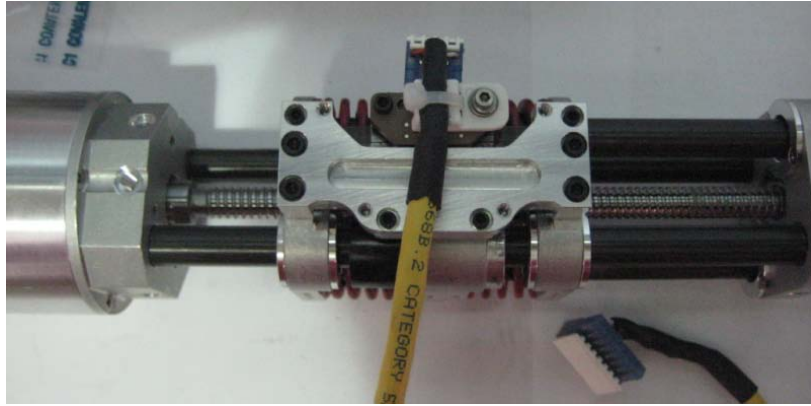
- Let it dry for 15 min.

## **11. CONFIGURE THE ACTUATOR.**

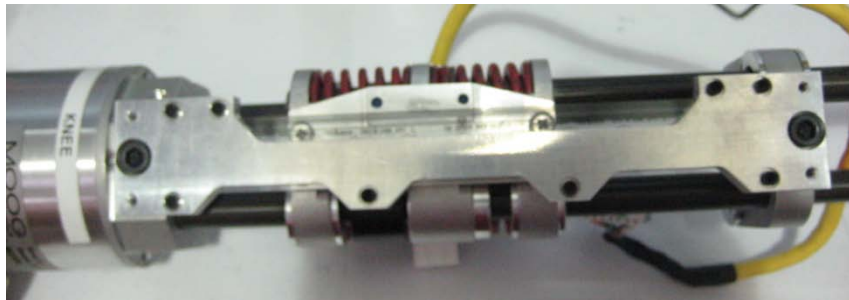
- Based on the plunger position the actuator will require to be configured properly for the designated place on the robot. The components have been preassembled and tuned properly following the original YOBOTICS procedure for tuning the sensors.

The following components must be properly placed on the actuator to achieve the final configuration.

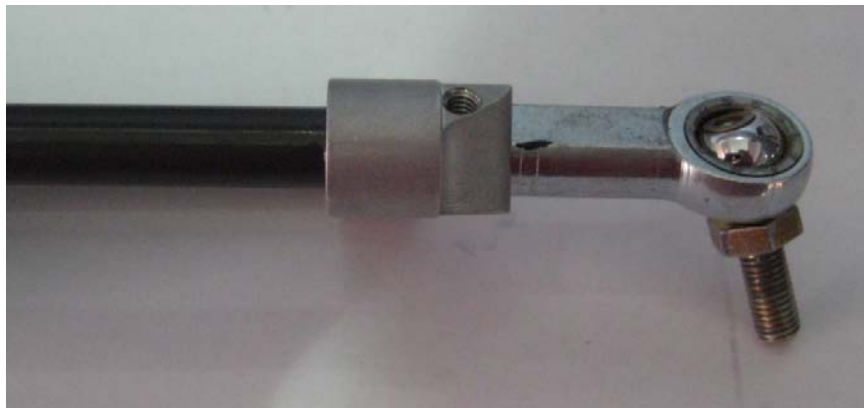
- The Force sensor assembly.



- The position sensor Assembly.



- Spherical Joint must be configured for the desired position.



- Apply LOCTITE 242 THREAD LOCKER MEDIUM STRENGTH – BLUE in the threaded holes.
- Tighten all screws properly.
- Attach the Encoder Board on the back on the motor using 4 screws.

- Connect the wires into the connectors as follow:
- **YELLOW** (sometimes **WHITE**) – **FORCE SENSOR** to the force connector on the Encoder Board.
- **GREEN** – **POSITION SENSOR** to the position connector on the Encoder Board.
- Motor connectors are different sizes. Match the corresponding size on the corresponding connector on the Encoder Board.

## 12. MOVIES AND OTHER INSTRUCTIONS FOR ASSEMBLY SEA.

For more instructions see also the following documents:

- Documents:  
071031\_Biped\_SEA\_23\_AssemblyGuide.doc by Jerry Pratt and Ben Krupp
- Movies:
  1. Ball Screw With Carriage
  2. Ballscrew Front Asm
  3. CarriageNutAsm
  4. CarriageOutsideAsm
  5. encoder force encoder assembly
  6. encoder position encoder assembly
  7. Encoder2inAsm
  8. Encoder5.75inAsm
  9. MotorBlockAsm
  10. MotorBlockWithMotorAsm
  11. SEA 23-23 x 3.3 Asm
  12. SEA no motor
  13. SEA with motor

END OF PROCEDURE