White Paper

The Compact FlowBot - A Robotic Pick and Place Motion System

Pack Flow Concepts LLC

Dr. Stephen Derby
172 Lockrow Rd
Troy, NY 12180
518-279-3419 (office)
518-441-6101 (cell)
sderby1@gmail.com

Gene Eckert
23 Briar Ct.
Hamburg, NJ 07419
201 317 5777
eck327@aol.com

David Brown
9 Surrey Lane
Pittsford, NY 14534
585-267-7829

Dr. John McFadden
35 Creek Rd
Wynantskill, NY 12198
518-429-5746

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Executive Summary

An innovative robotic pick and place motion design (the FlowBot) was previously created by Pack Flow Concepts LLC (PFC) to address the changing needs of the packaging and automation industry. A full patent has been filed covering this technology. This paper documents a refinement to the FlowBot concept that produces a more compact implementation, the Compact FlowBot.

Current single head pick and place robots have reached their practical limit for throughput rates due to impractical speeds and acceleration which often damage or lose the product being transferred. The new system uses 2 XY motion slides and an indexing flexible conveyor to achieve a more desired motion while achieving a high throughput rate.

1.0 Original FlowBot Concept

If one learns from Pack Flow Concept's previously designed chip bag case loader and the robotic streaming pouch case loader, and if one watches a colony of ants transfer food back to the nest, one can evolve to the FlowBot concept.

Figure 1a shows 2 standard SCARA robots linked by a flexible conveyor with a series of suction cups, grippers or scoopers. The item to be picked (Figure 1b pink block) is targeted by the left robot. The flex conveyor then moves the picked item to the right robot (Figure 2) where the right robot targets the placing location. (Note: initial figures here do not show the 2 robots moving or the flexible conveyor support adapting to the motion)

So the key is to have one robot target only the pick locations and the second robot target the place locations. Since the pick locations are usually grouped together, and likewise the place locations grouped together, this should reduce robot motions to a minimum. Both robots' motion may look similar to that of a chicken pecking for corn seed rather than the standard larger back and forth transfer motion. The flexible conveyor indexes quickly but not by a large displacement. The flexible conveyor support system (not shown) needs to accommodate different positions and orientations of the 2 robots. Pick rates of 120 to 180 per minute are the target.

Figure 1 a) FlowBot System **b) Picking First Product**

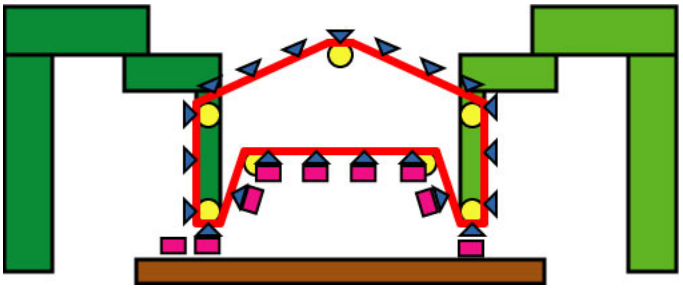


Figure 2 Flow of Products to Placing Locations

Not shown in Figures 1-2 are the relative motion of each SCARA robot or the changing of the flexible conveyor length between the picking robot location and the placing robot location. Figures 3a and 3b show how the conveyor length can change and thus create an adjustable buffer between picking and placing. The yellow rollers support the flexible conveyor and thus move to adjust the conveyor length (buffer size). The support system for these yellow rollers is not shown. The support system can be a combination of motor driven adjustable levers and drives, plus a system of springs and air cylinders.

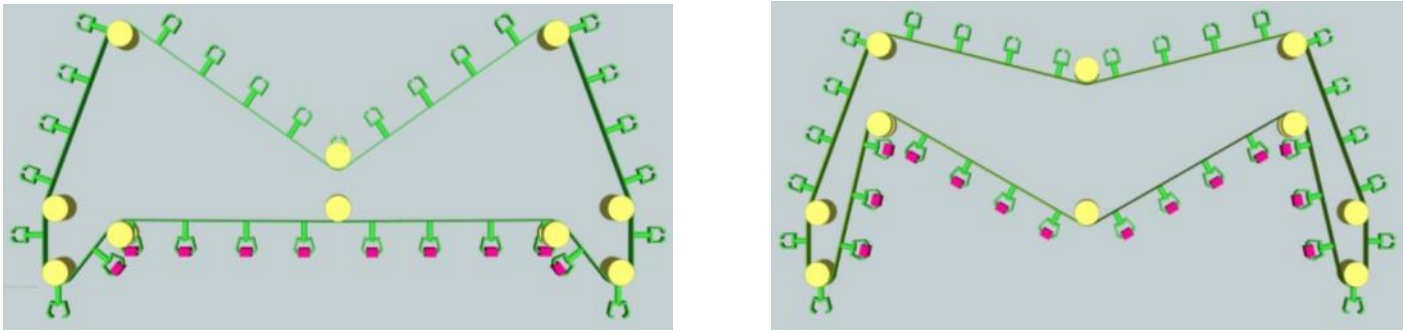


Figure 3 a)Nominal Buffer Size (Conveyor Length) b) Increased Buffer Size (Conveyor Length)

A typical implementation can be seen in Figures 4 where the robots are shown picking and placing at different locations at their respective conveyors.

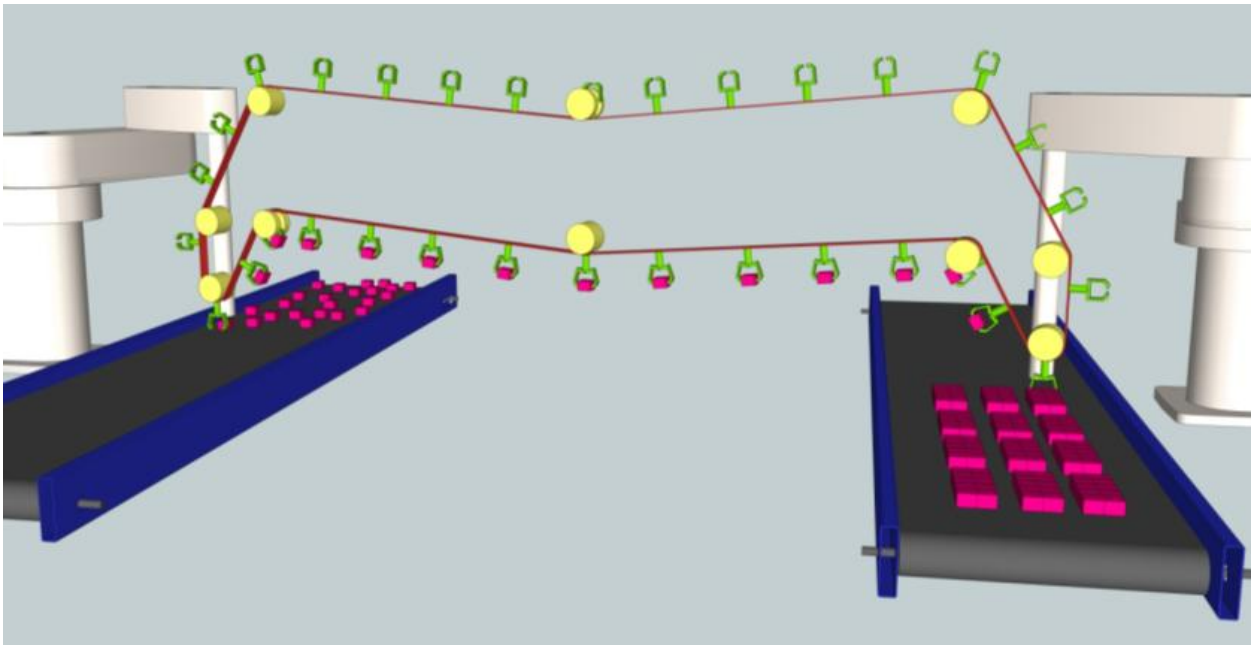


Figure 4 FlowBot Robotic System at Full Extension

2.0 Compact FlowBot

The original FlowBot concept has a great range of pick and place motion but safety guarding for the entire system of 2 SCARA robots and the flexible conveyor does encompass significant volume and floor space. For many packaging projects the range of motion of the SCARA robots will never be utilized.

So a second, more compact system has been designed. The Compact FlowBot is shown in Figure 5. Here a flexible conveyor chain is moved by the pick and place heads (the blue pulleys in Figure 5) and the excess of conveyor chain is accommodated by the take-up pulleys (the green pulleys in Figure 5). The grippers (orange) are carried by the conveyor, circulating from the infeed conveyor (yellow) to the packaging trays (purple) on the outfeed conveyor (blue) and back again. The picking and placing heads' Z axis motion is performed by the up and down linear slide (pink).

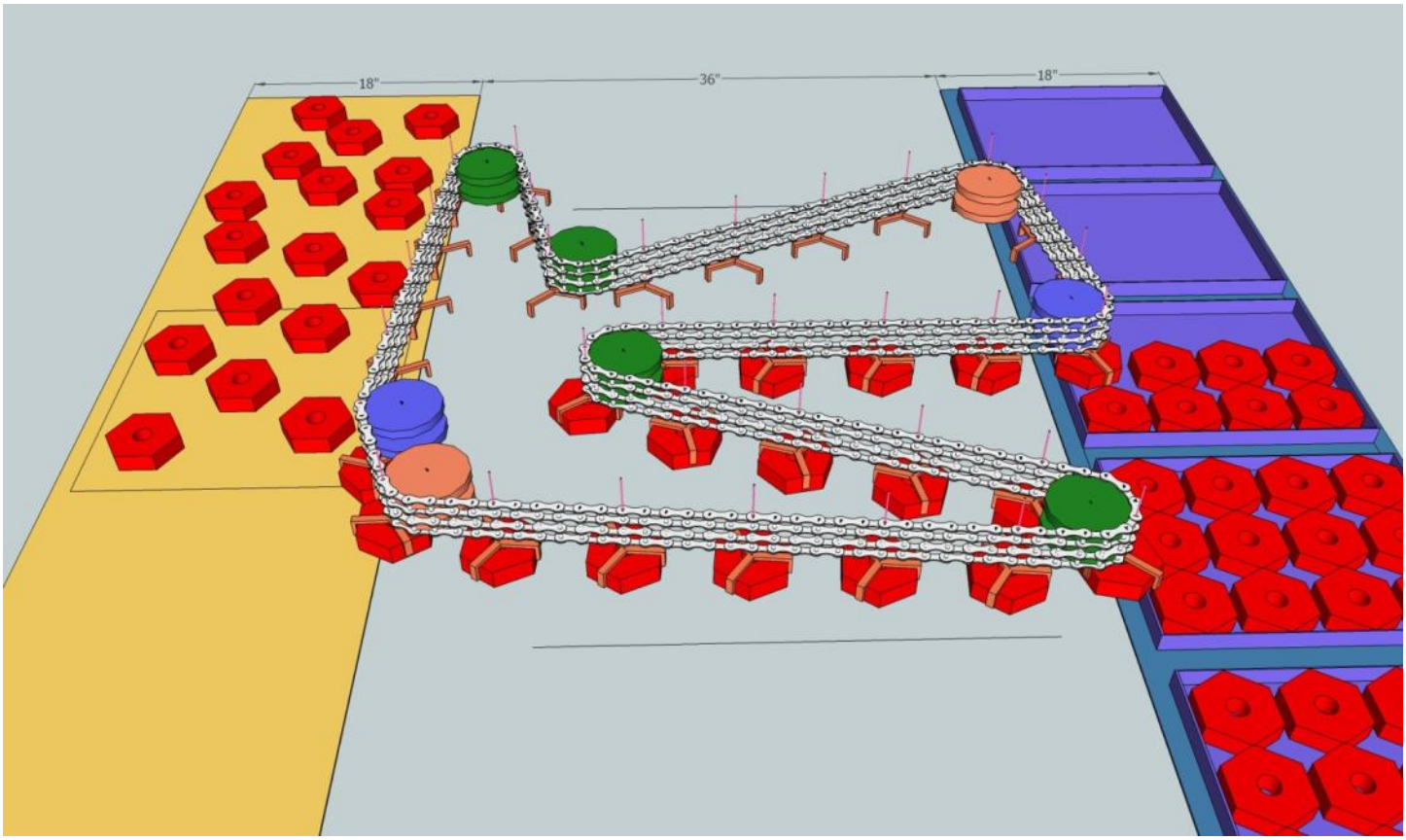


Figure 5 Compact FlowBot – Pick from Left Conveyor and Place into Tray on Right

One of the key features of this implementation is the ability to accommodate moderate delays (1 to 1.5 seconds depending on pick rate) of the packaging trays, similar to the 2 SCARA robots original FlowBot design. Figures 5 and 6 are showing the compact FlowBot's grippers holding a full complement of products (the buffer is full). This extra length of conveyor and grippers is a buffer. Similar to the original FlowBot, it is assumed that placing into the trays is quicker than the picking process, so the extra items in the buffer will eventually be emptied. If a larger buffer capacity is desired, additional conveyor lengths can be added to the system.

The overall support structure for the Compact FlowBot is not shown in these figures for clarity purposes. There is an overall support frame and set of guides for the pulleys to travel. The pick and place heads can move along the direction of their conveyors as well as perpendicular to their conveyors. The limiting motion of the 2 linear axes makes the safety guarding requirements significantly smaller than the 2 SCARA robots and flexible conveyor of the original FlowBot (also smaller floor space and head room of a Delta style robot).

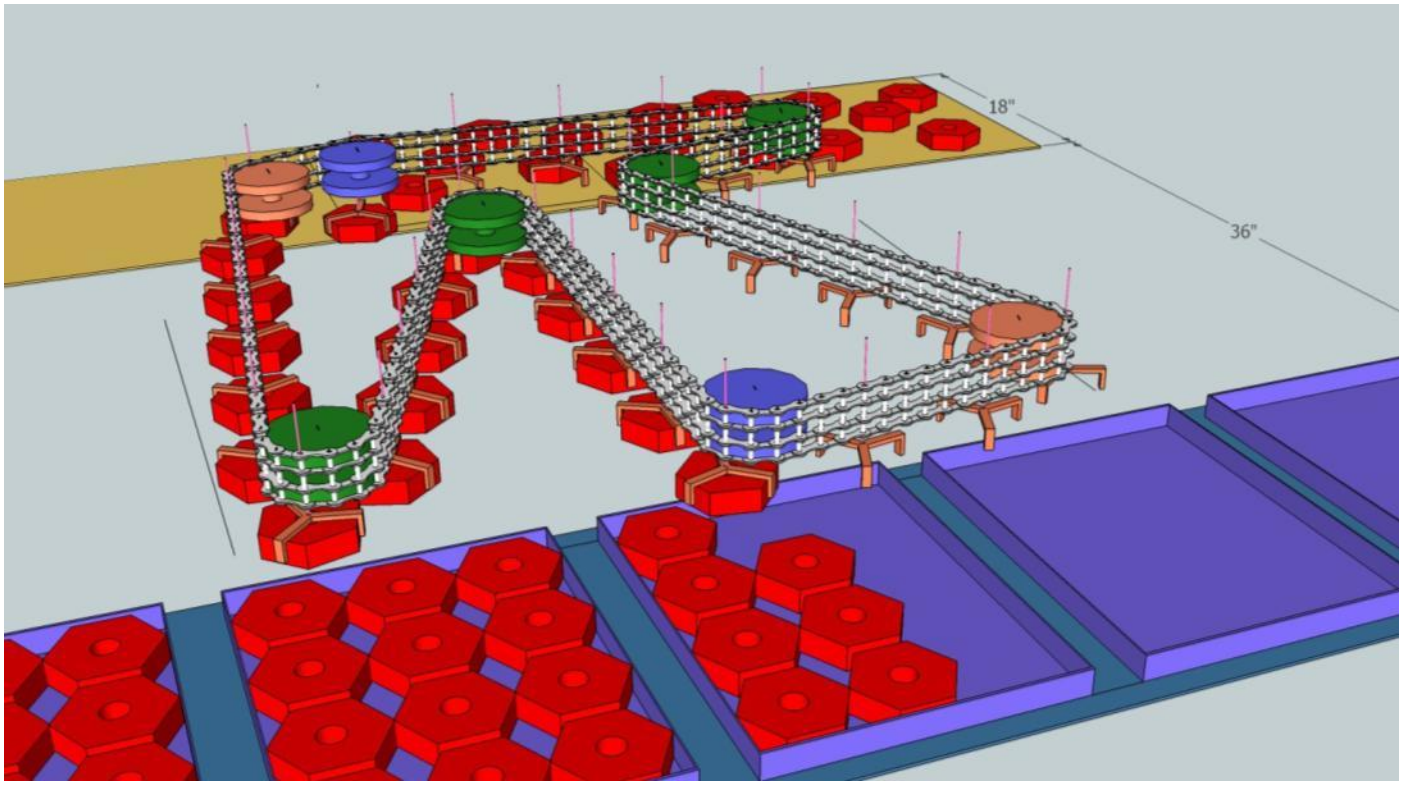


Figure 6 Compact FlowBot – Ready to Place Product

Figure 7 shows the conveyor and pulley system at a different Pick and Place Head location.

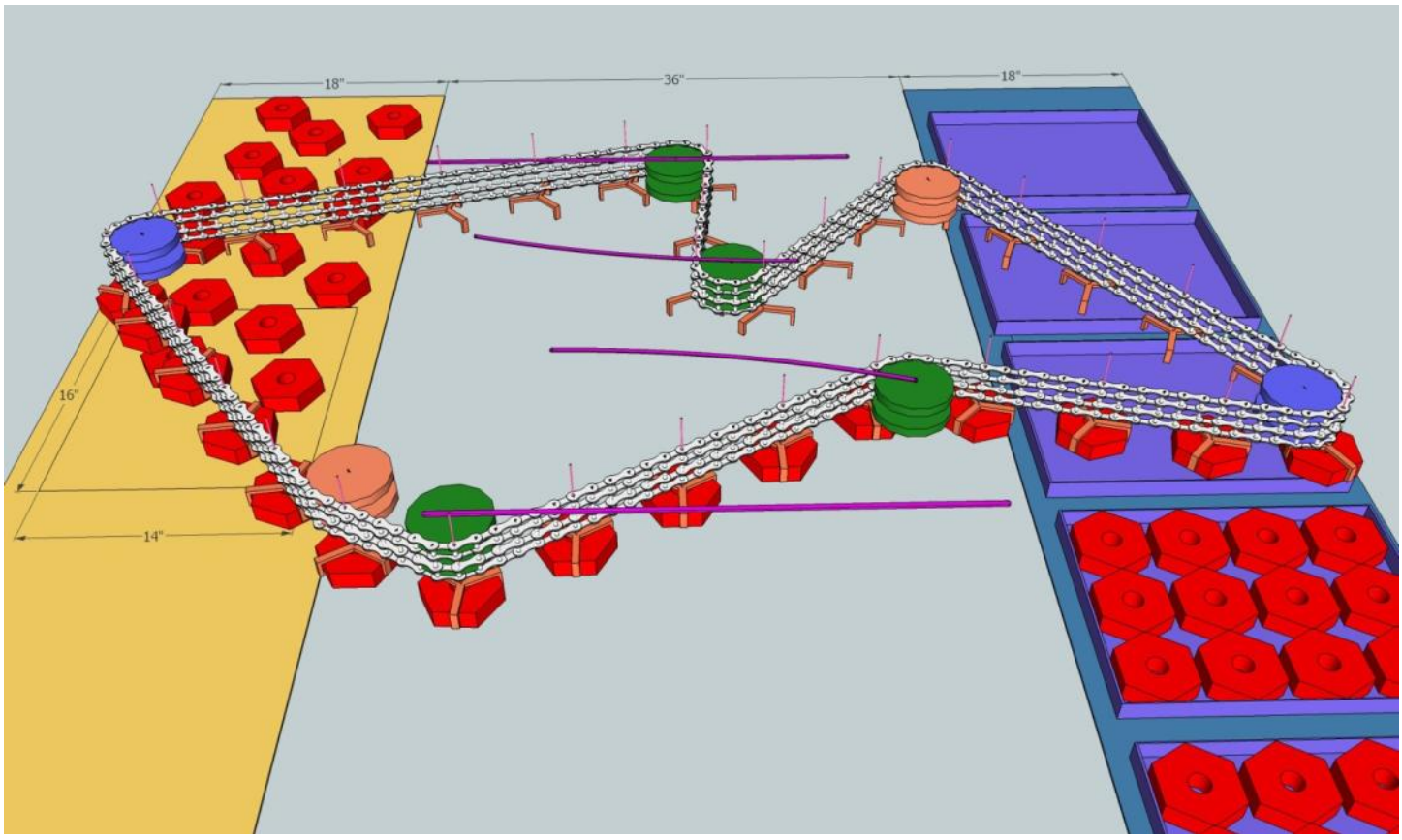


Figure 7 Compact FlowBot – Conveyor and Pulley System at Different Pick and Place Head Locations

Figure 8 shows the Compact FlowBot with many of the key elements labeled

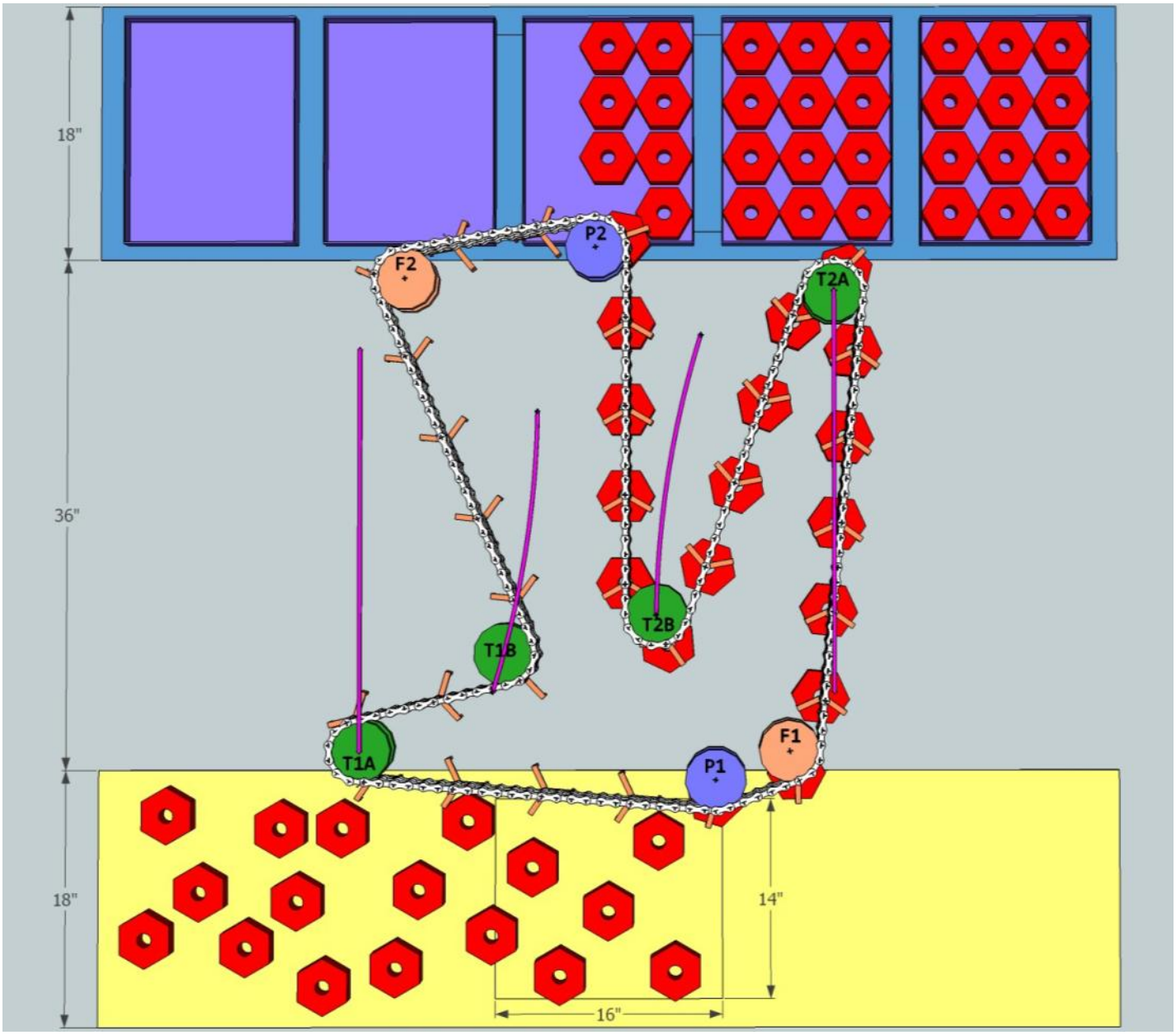


Figure 8 Compact FlowBot Major Components Labeled – Closest Reach Position

The major components are:

P1	Pick Head
P2	Place Head
F1	Fixed Pulley 1
F2	Fixed Pulley 2
T1A	Take-up Pulley 1A
T1B	Take-up Pulley 1B
T2A	Take-up Pulley 2A
T2B	Take-up Pulley 2B

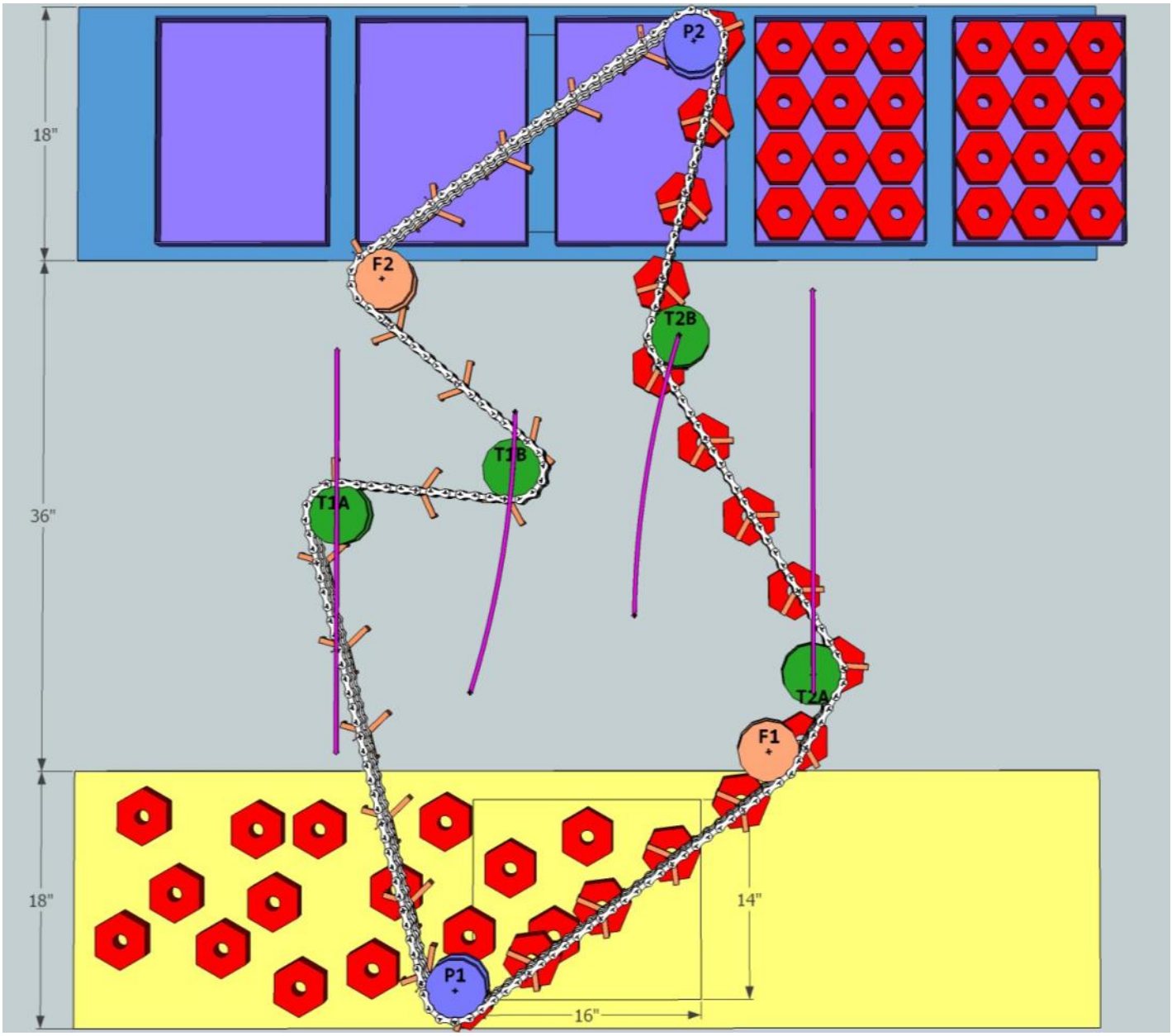


Figure 9 Compact FlowBot Major Components Labeled – Farthest Reach Position

The Pick and Place Heads can move in a 16 inch by 14 inch zone. The Fixed Pulleys guide the conveyor to eliminate interference. The 4 Take-up Pulleys move along their individual paths (shown in purple) to both

- increase or reduce the buffer size
- allow the Pick and Place Heads to traverse their zones

The position of the Take-up Pulleys is determined by the position of the Pick and Place Heads and the indexing of the conveyor and grippers at these heads. The tension in the conveyor on either side of the pick head can be balanced by essentially spring loading the Take-up Pulleys to allow for minimal conveyor slack.

The grippers are held in place by their unpowered Z axis (pink shaft in Figure 10). The Z motion of the grippers is achieved by engaging the actuator located at the Pick and Place heads (Not shown in Figure 10). Here the process is:

- gripper and Z axis engages Z motion actuator
- gripper is lowered (and opened if required)
- product is gripped
- gripper is raised
- gripper is locked (if required) and Z axis disengaged
- conveyor is indexed

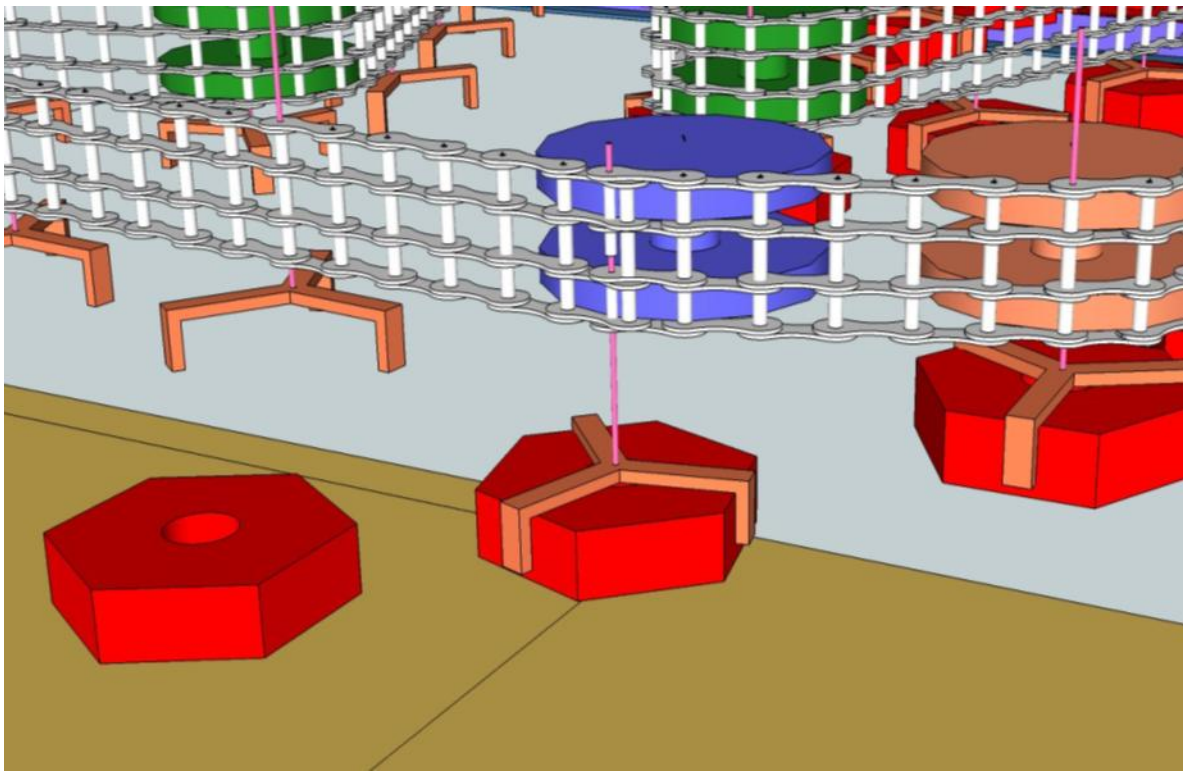


Figure 10 Pick Head Close-up – Product is at Closest Possible Pick Location

Compact FlowBot Options

There are several options to the Compact FlowBot. One option is to increase the buffer size. The dimensions of the figures shown are for grippers and/or product being 6 inches in diameter at a pick rate of 120 to 180 per minute will produce a buffer of 1 to 1.5 seconds. Grippers can be placed closer on the conveyor if the product is smaller. Additional loops of conveyors and grippers can be added to each side of the system to increase the buffer size.

Another option is to actuate the grippers with a supply of compressed air plumbed to the grippers for actuation and/or vacuum generation. The tubing can be supplied to the grippers as a whole, and the mechanism at the Pick or Place Head can locally turn off or modify the air supply as needed. The air supply to the entire Compact FlowBot can used a single rotary union with a few flexible air hoses connected to manifolds on the top of the conveyor. A similar strategy can be used for electrical power. Communication to and from each gripper can also be linked by a rotary union or more likely a wireless remote system.

Perhaps the wildest option is to take advantage of the compact layout and stack one system over a second system (Figure 11). This is an option rarely tried before with traditional robots!

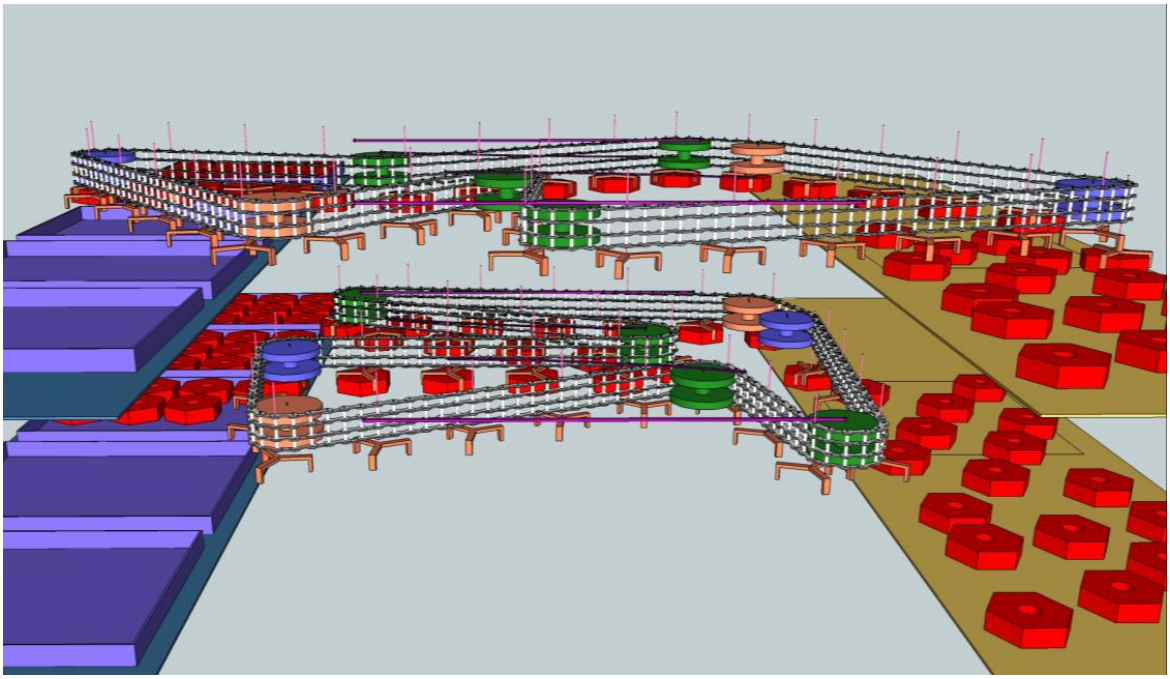
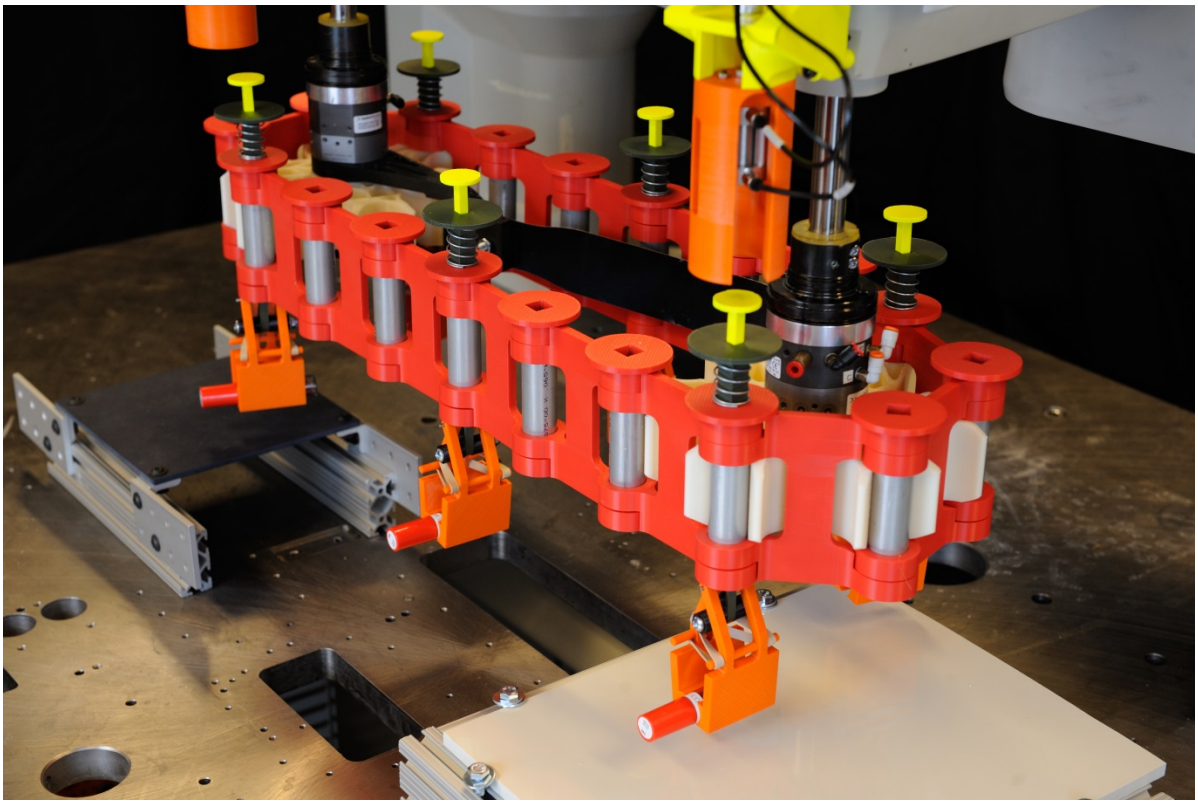


Figure 11 Dual Level Compact FlowBot Implementation

Two Arm Mockup

In early 2014 a mockup version was created with the assistance of the RPI CATS Center, shown in Figure 12



Mockup 2.0 Compact FlowBot