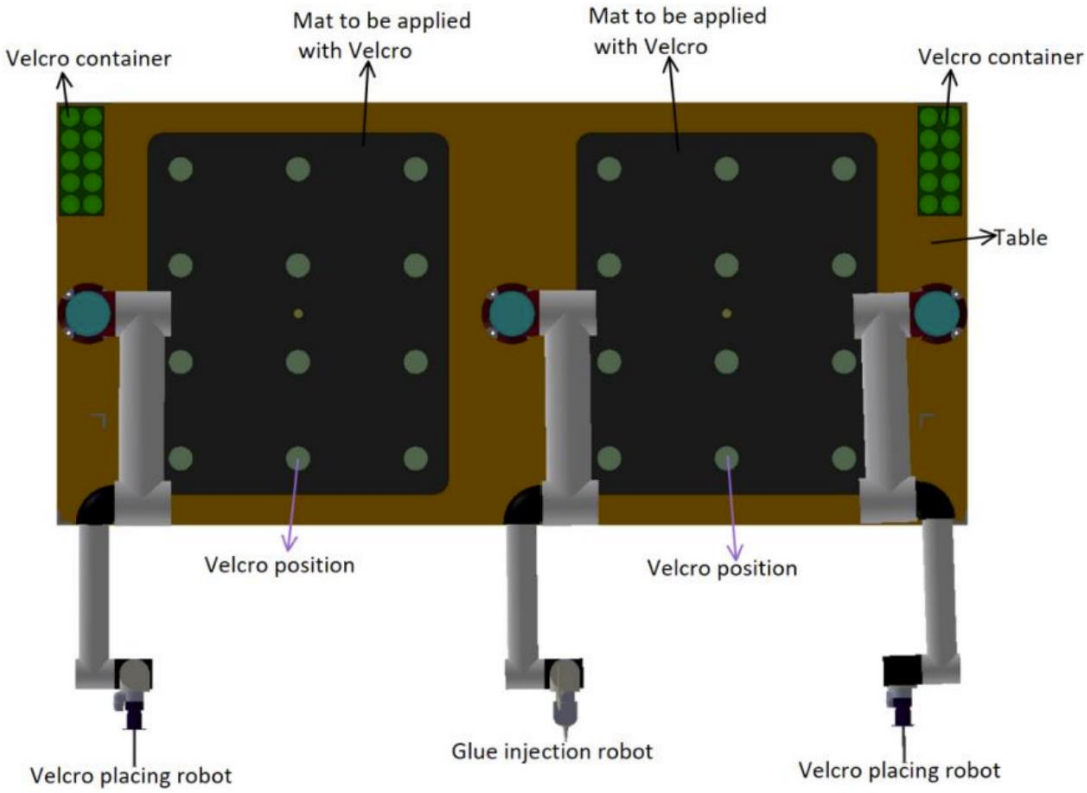
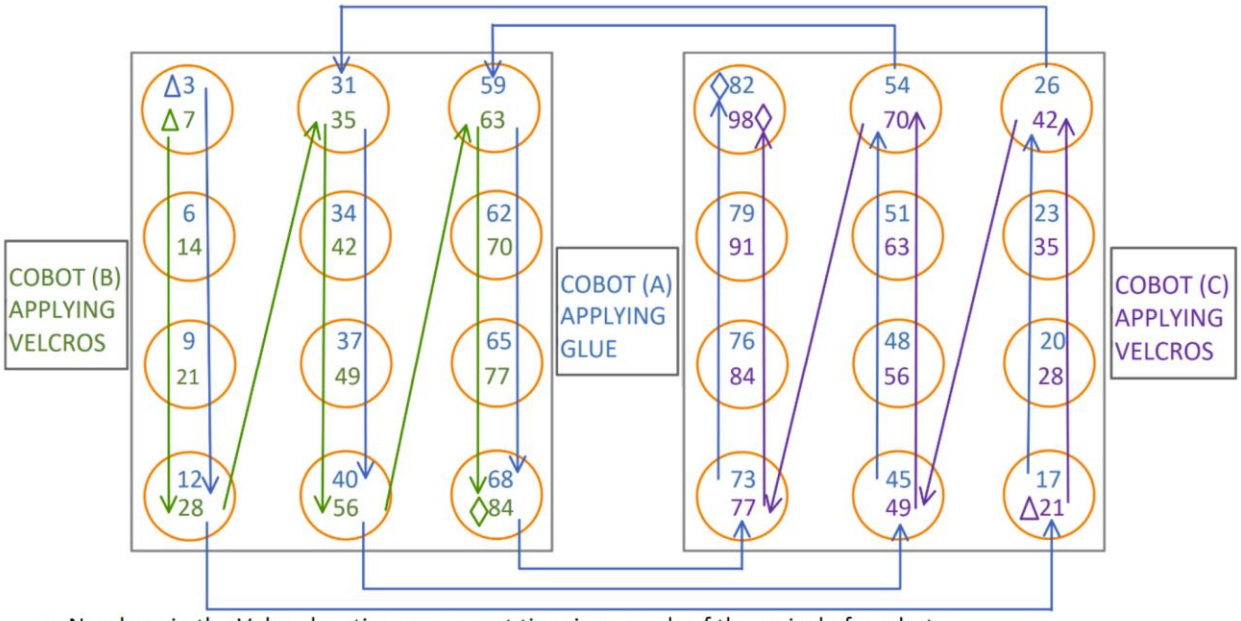
Due to confidential reasons (photos and some data cannot be shown) and ease of reading, the final design of my 4th year Capstone design project for Neocon International is summarized here. The concerned production lines produced mats to be used in car floors and trunks with dimensions from approximately 0.5m*0.5m to 1.2m*1.2m weighing within 3kg. The raw mats were loaded into a thermoforming machine, two at a time, in which they were formed into the desired shapes with desired patterns, in 118 seconds. Then, distributed to two parallel production lines, they go through trimming (97±23s), Velcro promotion with glue (107±13s), Velcro pressing (43±7s), and packaging (81±6s). To explain, trimming was to trim out the leftover materials of the thermoformed mats, Velcro promotion was to stick 4 to 12 Velcro pieces onto the desired locations with glue, Velcro pressing was using a table with a heavy cap to press the glued Velcro to let them bond, and packaging was to pack the mat into a plastic bag and seal it. The takt time between the completion of each mat for one production line was 145s±16s. One of this production line needed one worker for trimming, one worker for Velcro promotion and pressing, and one worker for packaging, being 3 workers per production line. Also, all the transferring works were covered by the corresponding worker.

Our task was to automate any of the production steps to cut labor, and to automate the transferring to cut takt time. Our solution was to automate the Velcro promotion step with three OMRON TM12 robotic arms for two parallel production lines, and to automate all the transferring jobs before the Velcro promotion step with two mobile robots made of OMRON LD250 AGVs each carrying one OMRON TM12 robotic arm.

The automated Velcro promotion workstation, drawn in Solidworks, is shown below, with the largest mats and the highest number of Velcro positions:

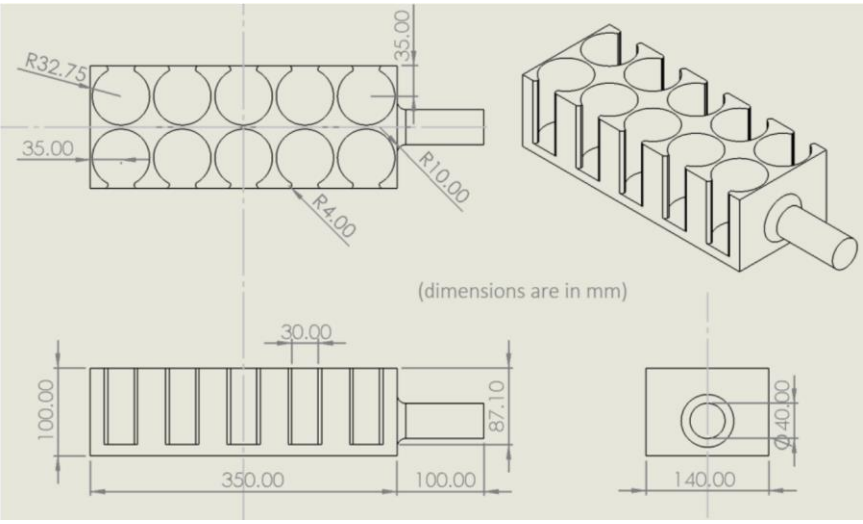


The automated Velcro promotion only took within 100 seconds in the worst case. As an example, the figure below shows how they cooperated without interfering in the above case.



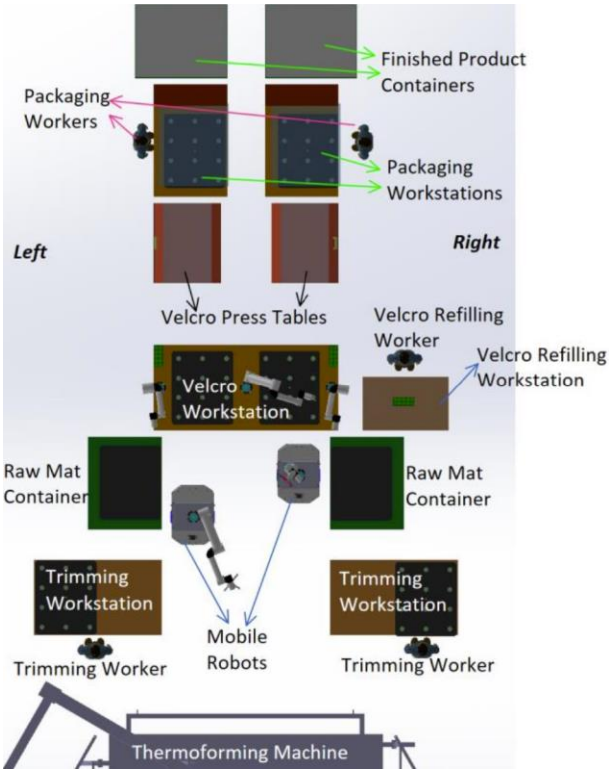
- Numbers in the Velcro locations represent time in seconds of the arrival of a robot.
- Δ represents the start point, and ◊represents the end point of a route.
- Arrowed lines represent the order of Velcro locations that the robots arrive. The actual trajectories of movement may differ.

As noticed, there were specially made Velcro containers for the robotic arms to work with, as shown below.

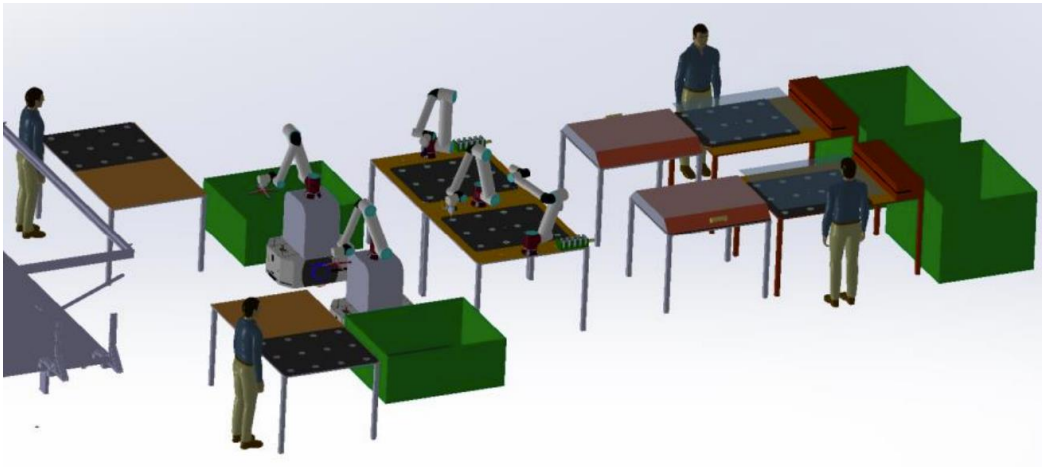


One container contained 120 Velcro pairs, which needed to be manually loaded by an additional worker. But during our tests, one person was able to refill and deliver 3 Velcro containers in a cyclic manner that matched up the consumption rate of 3 production lines. Thus, when there were 3 parallel production lines, 3 Velcro promotion workers were cut with the addition of 1 Velcro refilling worker, being 0.67 worker cut per production line.

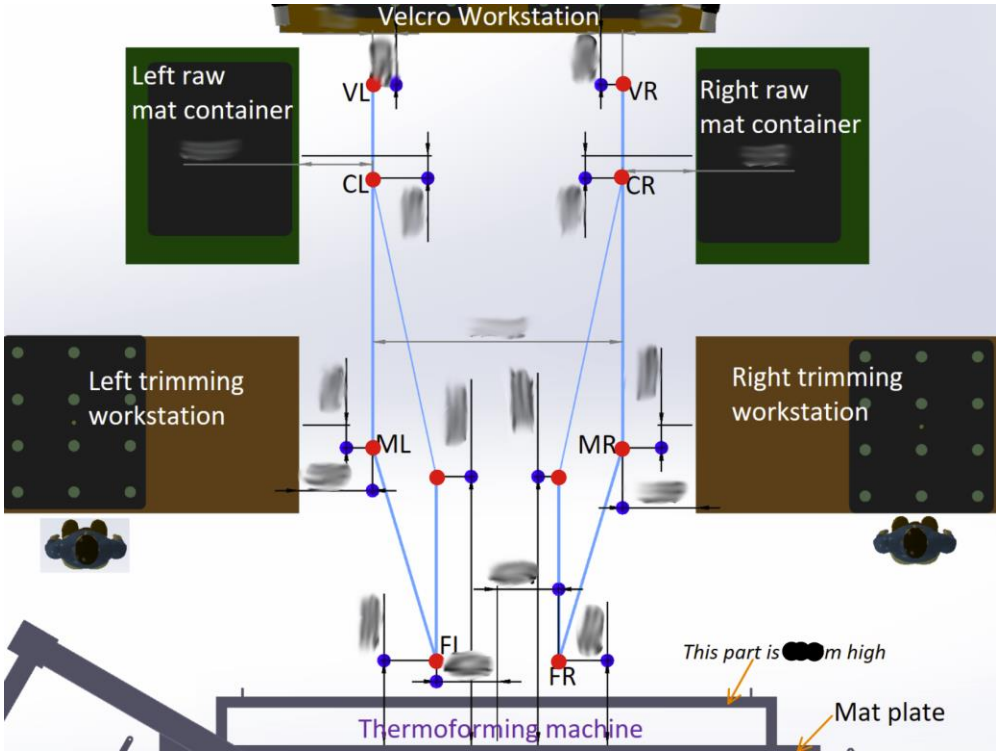
With added mobile robots to transfer mats between the thermoforming machine, the trimming table and the Velcro promotion table, the redesigned configuration of 2 parallel production lines drawn in Solidworks is shown below:



And a view from another angle:



Below are the scheduled routes of the mobile robots. Each mobile robot unloaded a thermoformed mat, put it onto the trimming table, moved a trimmed mat to the Velcro workstation, picked up a raw mat, and loaded it into the thermoforming machine, then waited for the next cycle. Since the trimming worker no longer needed to move the mats, they had more time redundance for their trimming works.



Overall, the semi-automated production lines could complete 79 mats per each 3-hour session comparing to the original 71, with 0.67 worker cut per production line.