Conveyance Route Design
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Production Systems Management

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Seeing the Value Stream:

The first step in designing the conveyance routing for this pull system, was to first understand the value stream. This was important because it allowed the team to see the entire process of material and information flow despite the sheer amount of information to consider. After seeing the value stream it became clear as to what data was missing, the transportation times for every piece of material and information flow.

Data Collection:

The times were collected by walking the flow at least twice from one location to the other. In the situation where a cart or a pallet was being transported we walked at a slower pace while timing to simulate moving the material. Also, during material transportation we made sure to use ramps instead of stairs. On trips without any carts or pallets we used the most direct route which involved taking the stairs.

Analysis:

The transportation activities that we collected data on, are the tasks shown below in Table 1. These tasks are described by the object being transported, and the locations they are moved from and to. The frequency for each task, if not already given, was dependent on three factors: transportation batch size, 15 - 30 minutes of WIP between the four assembly line stations, and the 30 second cycle time of each station. The duration for each task was the total time spent handling an object at the two locations (ie. loading and unloading an object) and transporting the object.

The workload for each task was determined by scaling the frequency to a 15 minute work cycle, and then taking the duration divided by the scaled frequency. Frequencies were scaled to a 15 minute work cycle by simply dividing the frequency by 15. The work cycle of 15 minutes was chosen so that way each assembly line station would be supplied with 15 minutes of material, when there is expected to be 15 minutes of material left at each station. This work cycle would ensure the required 15 - 30 minutes of WIP between assembly line stations at any given time.

Finally, the workload analysis in Table 1 concludes with the total amount of work to do every 15 minutes. The value of 28.6 minutes indicates that two water spiders would be sufficient, assuming that nothing goes wrong. The team decided to choose 3 water spiders instead, to allow for more buffer time in our conveyance routing design, making it more stable against natural system variability.

Table 1: Workload Analysis

Workload Analysis							
ID	**Task**	**Frequency**		**Duration**		**Workload**	
1	motors - BR to FR	16.0	min	3.7	min	3.4	min/cycle
2	shrouds - BR to FR	80.0	min	13.9	min	2.6	min/cycle
3	fans - BR to FR	80.0	min	13.9	min	2.6	min/cycle
4	hardware - BR to FR	480.0	min	4.6	min	0.1	min/cycle
5	cart - FR to AL	15.0	min	4.0	min	4.0	min/cycle
6	FG's - AL to SB	12.0	min	1.5	min	1.9	min/cycle
7	FG's - SB to SH	12.8	min	3.3	min	3.9	min/cycle
8	trays - FR to BR	16.0	min	3.4	min	3.2	min/cycle
9	p kanbans - FR to BR	120.0	min	3.4	min	0.4	min/cycle
10	containers - AL to FR	15.0	min	0.2	min	0.2	min/cycle
11	cart & p kanbans - SB to AL	12.0	min	1.5	min	2.3	min/cycle
12	pallet & w kanbans - SH to SB	12.0	min	3.3	min	3.9	min/cycle
Total Work Required Every 15 Minutes:						28.6	min/cycle

The water spider task assignment was accomplished by organizing all of the tasks into three distinct frequency groups that appeared in our workload table. The groups were a 12 minute frequency, a 15 minute frequency and an 80 minute frequency. From there we looked to see if each of the tasks in that frequency group could be completed in the given time period. We found that for each of the frequencies groups you could complete all of the task required in the given frequency with extra time to spare. For water spider 1 and water spider 2 the sequence that they went through didn't require any extra moves. The end of the cycle brought the water spider back to the front of the sequence for that water spider. Water spider 3 was not able to do all of the tasks within its sequence period without doing extra moves, so the moves were added to complete all of the tasks. This still allowed the water spider to complete all of its tasks in the time required.

Results:

The results include three tables, shown below, one for each of the water spiders, and a process flow diagram, attached, showing the information and material flow by water spider.

Water Spiders:

The tables indicate the sequence in which each water spider is to perform their tasks from the beginning to the end of their frequency time. Any extra time that the water spiders may have is spent doing 5S. 5S was chosen as the value added-activity to fill in the buffer times, because it allows for smoother flow for the upcoming work cycles.

The task sequence table for Spider 1 shows the 5 steps the spider follows in a 12 minute cycle. Spider 1 starts with task 7, which takes 3.3 minutes to complete. Then they perform task 12 which takes 3.3 seconds as well. The time elapsed shows the time the spider should be at in completing the tasks in the order shown. The total cycle time for Spider 1 is 12 minutes. After the first four tasks are complete the spider completes 5S activities until the 12 minute point is reached, at this point he or she begins again with task 7 to repeat the cycle.

Table 2: Water Spider 1 Tasks

Water Spider 1 Task Sequence		
Task	**Time Elapsed**	**Due By**
7	3.3	12.8
12	6.6	12.0
11	8.1	12.0
6	9.6	12.0
5S	12	-

The task sequence for Spider 2 follows similar logic to the process for Spider 1. Spider 2 begins with task 1, which takes about 3.7 minutes. The spider then performs task 5, which takes about 4 minutes. Again, the time elapsed is shown for each of the steps and the total cycle for Spider 2 is 15 minutes. The last step for the spider is to complete 5S activities until the start of the next 15 minute cycle.

Table 3: Water Spider 2 Tasks

Water Spider 2 Task Sequence		
Task	**Time Elapsed**	**Due By**
1	3.7	16.0
5	7.7	15.0
10	7.8	15.0
8	11.3	16.0
5S	15	-

Each of the tasks identified for Spider 3 have been identified following similar logic as spider 1 and spider 2. In this case, Spider 3 starts with task 2 which takes about 13.9 minutes. The elapsed time of 17.3 minutes shows that task 9 takes 3.4 minutes to complete. Spider 3 completes his or her set of tasks on an 80 minute cycle. Similarly to Spider 1 and Spider 2, Spider 3 completes 5S activities until his or her 80 minute cycle is complete. Each spider is allotted time to perform 5S activities, this recurring habit sustains a clean and orderly system.

Table 4: Water Spider 3 Tasks

Water Spider 3 Task Sequence		
Task	**Time Elapsed**	**Due By**
2	13.9	80.0
9	17.3	120.0
3	31.3	80.0
FR to BR	33.5	-
4	38.1	480.0
FR to BR	40.3	-
5S	80	-

Process Flow Diagram:

The process flow diagram illustrates the tasks the water spiders perform during their cycles. The tasks for each water spider are shown in a different color.

Starting from the customer end, when sending finished goods from the supply buffer to the marshalling area at shipping, both the withdrawal kanban card and the product is being shipped. In this case, each pallet of 24 parts has four kanban cards since product moving from assembly to the supply buffer travels in batches of 8 finished goods. As shown on the process flow chart, the time for these tasks combined is 3.3 minutes. Similarly, from assembly to the supply buffer the finished goods being shipped in batches of 8 are traveling with a production kanban card. As shown by the process flow chart, the total time for these tasks is 1.5 minutes.

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Concerns & Limitations:

The first concern with our system is that water spider 3 is doing 40.3 minutes of work every 80 minutes. This leaves half of this employee's workload being dedicated to the lean activity of 5S to ensure smooth flow, after completing the required tasks to maintain the flow. Another concern with water spider 3 is that he or she will have to make two moves without any material or information every 80 minutes. Another concern is that the water spider 2 and 3 routings overlap at the elevator and lift. In an occurrence when both spiders are trying to use a resource at the same time, will incur a 1- 2 minute expected delay to their work cycle. This will impact the amount of 5S activity that can happen at the end of each of their work cycles.