

# Evaluation and Comparison of a Car-Based vs. a CFT Material Handling System for a 300mm Fab

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## *Abstract*

*The industry shift to 300mm will have a tremendous impact on fab automation requirements. The size of wafers, their value, the increased number and complexity of process steps, the increased cost of the facility and equipment itself, and chipmakers' competitive pressures to improve their own manufacturing economics will place demands on a fab's automated material handling system (AMHS) requirements that even today's most advanced 200mm fabs will be unable to fulfill. The fact that fabs will have "pervasive automation" is not disputed; what form that automation will take remains to be seen. This paper compares the performance of two types of automation systems: a conveyor-based Continuous Flow Transport Technology (CFT) system and a Car-Based system using simulation.*

## Introduction

The layout options studied in this paper correspond to a "farm" style layout for a 300mm wafer fab and were sized using SEMATECH information. This study uses simulation to compare the performance of this standard fab using both a CFT AMHS and a Car-Based AMHS. All the simulation runs for both systems were executed using AutoMod 10.0 simulation software.

The Car-Based AMHS includes car/track systems for interbay automation and overhead hoists for intrabay automation. Stockers are located at the head of each bay serving as the interface between the two systems. The CFT AMHS consists of asynchronous conveyors that move lots independently on the conveyor. The lot stops movement when it gets within close proximity of another lot that has stopped on the conveyor for loading or redirection. In the CFT system, lots use the conveyor as a means of delivery directly to a tool-loading module. The tool-loading module combines storage capability with intrabay automation to provide buffer storage for tools and direct tool loading.\*

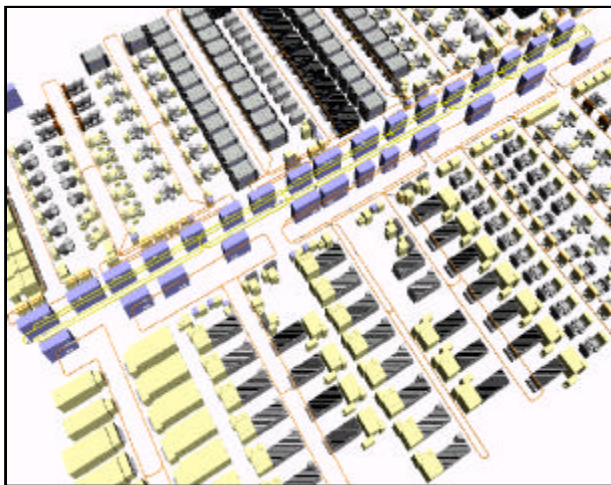
\* For future reference, any mention of the stocker for the CFT system refers to this distributed bay storage.

## Problem Statement

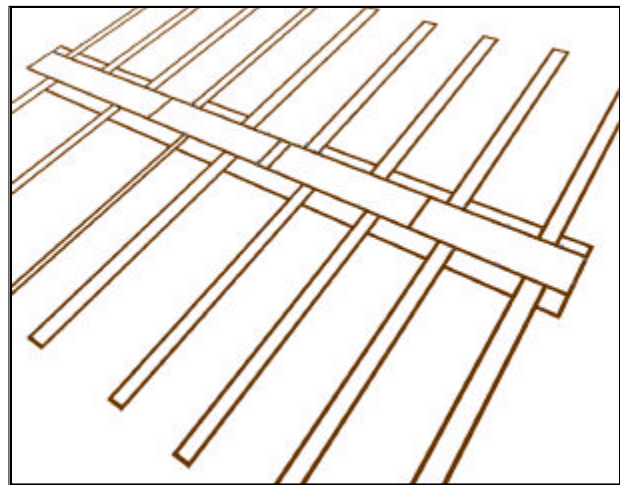
The goal of this study was to measure the impact each one of these two automation systems have in four performance parameters. The performance parameters measured were: delivery time, transport time, throughput, throughput variability and maximum throughput (up to 1028 Moves/Hr for the interbay systems and 382 Moves/Hr for the intrabay systems). In order to measure throughput variability a coefficient of variability (CV) was determined. A CV is defined as the standard deviation of the values observed divided by the average of those same values ( $CV = \sigma/\mu$ ) and is a metric commonly used to measure variability in a system.

## Interbay Analysis

The analysis was conducted in two sections. The first section compares the performance of the interbay AMHS. The second section compares the performance of the intrabay AMHS. **Figure 1** corresponds to the layout of the interbay and intrabay AMHS for each system.



**Car-Based**



**CFT**

**Figure 1. Interbay and Intrabay AMHS.**

The following definitions for delivery and transport time were used for both interbay systems:

Interbay Delivery time: time measured from when a lot was ready to be moved out of the source stocker to when the lot was placed on a shelf at the destination stocker.

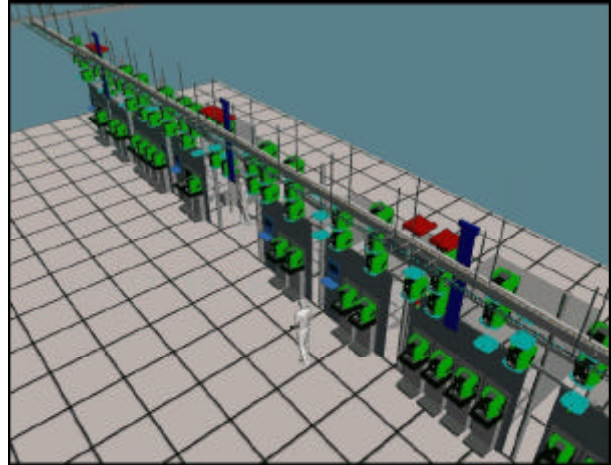
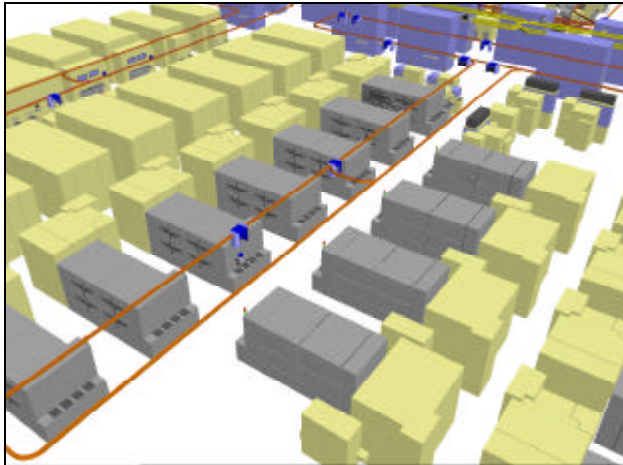
Interbay Transport time: time measured from when a lot was removed from a shelf in the source stocker to when the lot was placed on the shelf at the destination stocker.

Thus, transport time included two stocker robot cycles and the travel time on the rail or conveyor system.

## Intrabay Analysis

For the intrabay analysis, four high-volume bays were simulated in order to perform the study. The bays chosen correspond to the diffusion (1 bay) and photo areas (3 bays). The bay in the diffusion area was simulated considering batching requirements for that area. In the photo area, the car-based AMHS layout for bays Photo2 and Photo3 was interconnected to improve performance of the system and reduce car count.

The following figures represent an example of the intrabay layouts.



**Intrabay Car-Based AMHS**

**Intrabay CFT AMHS**

**Figure 2. Intrabay Transport Layout**

The following definitions for delivery and transport time were used for both types of intrabay systems:

Intrabay Delivery Time: time measured from when a lot was ready to be moved out of the source stocker/tool to when the lot was placed on the port/shelf of the destination tool/stocker.

Intrabay Transport Time: time measured from when a lot was removed from a shelf/port in the source stocker/tool to when the lot was placed on the shelf/port at the destination stocker/tool.

## Interbay Results

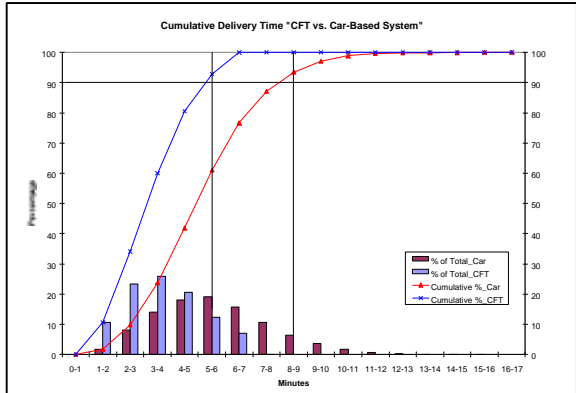
The interbay models for both systems were built and run for a period of 11 days with statistics for the first day discarded in order to account for the warm-up period. **Table 1** summarizes the output results for the Car-Based and CFT interbay models.

The total number of moves per hour for the CFT system was 862. This number includes all moves that required time spent on the conveyor, whether it is an intrabay move or interbay move. For the moves between different bays, the CFT had a 107 seconds advantage in the Average Delivery Time, while the Car-Based system was 56 seconds faster in the Average Transport Time.

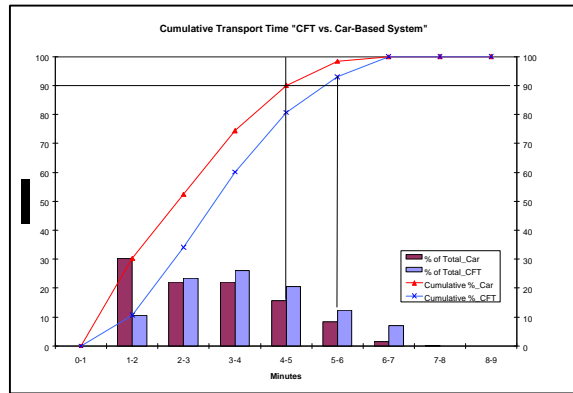
	CFT Solution	Car-Based Solution
Average Moves/Hr Required Total	862	-
Average Moves/Hr Completed Total	862	-
Average Moves/Hr Required Bay to Bay	411	420
Average Moves/Hr Completed Bay to Bay	411	427
Average Moves/Hr Required Within Bays	451	-
Average Moves/Hr Completed Within Bays	458	-
Number of Vehicles Required	-	25
Average Delivery Time Total	3 min, 32 sec	-
Average Transport Time Total	3 min, 31 sec	-
Average Delivery Time Bay to Bay	3 min, 44 sec	5 min, 31 sec
Average Transport Time Bay to Bay	3 min, 44 sec	2 min, 48 sec
Average Delivery Time Within Bays	3 min, 14 sec	-
Average Transport Time Within Bays	3 min, 14 sec	-
Delivery Time for 90% of the Moves Bay to Bay	< 6 min	< 9 min
Transport Time for 90% of the Moves Bay to Bay	< 6 min	< 5 min

**Table 1. Interbay Summary Table**

**Graphs 1 and 2** show a comparison of the Cumulative Delivery Time and the Cumulative Transport Time between the CFT and the Car-Based interbay systems. For 90% of the moves we can see a reduction of 3 minutes in delivery time and an increase of 1 minute in transport time when we use the CFT solution versus the Car-Based solution.

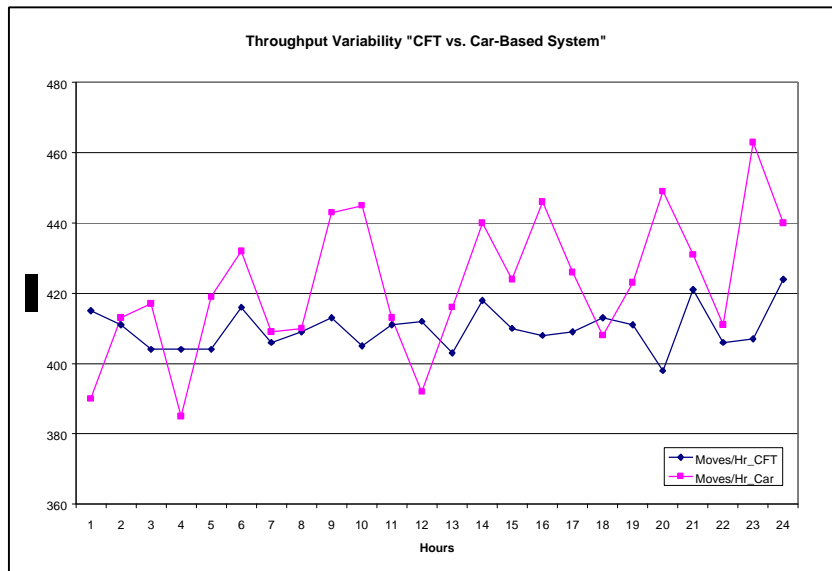


**Graph 1. Cumulative Delivery Time**



**Graph 2. Cumulative Transport Time**

In addition to the delivery time and travel time analysis, the throughput variability was also used as a measure of performance. This study was completed over a 24-hour period, and from these results a CV was determined. **Graph 3** demonstrates a lower variability in the number of moves/hour with the CFT system over the Car-Based system. The smaller CV for the CFT system (0.015) versus the CV for the Car-Based system (0.047) also indicates a lower variability using the CFT system.



**Graph 3. Throughput Variability Results for Interbay Systems.**

When the Maximum Interbay Throughput was tested on the individual transport systems, the results showed that the CFT was more robust in its delivery capacity. The results demonstrated that the CFT system was able to meet 2.5 times the original throughput requirements with an average delivery time of 3 minutes and 50 seconds, while the Car-Based system was only able to meet 1.5 times the original throughput requirements with an average delivery time of 5 minutes and 52 seconds.

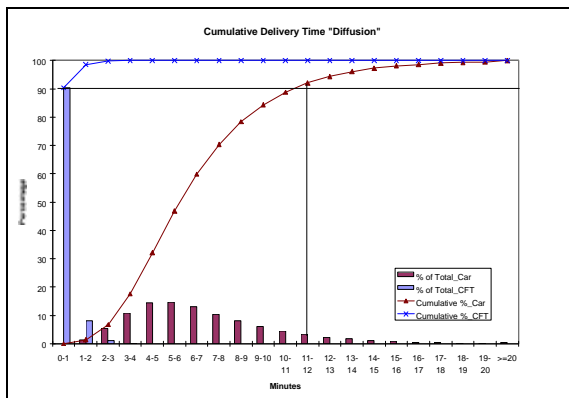
## Intrabay Results

The intrabay models for both systems were built and run for a period of 11 days, with statistics for the first day discarded in order to account for the warm-up period. **Table 3** summarizes the output results for the Car-Based and CFT intrabay models. On average, the CFT delivers the lots 271 seconds faster than the Car-Based system within a bay. In addition to an average faster delivery time, the average travel time is 156 seconds faster for the CFT. The large delta in times can be attributed to the advantage the CFT system has of utilizing a distributed stocker down the bay, rather than the traditional stocker location at the top of the bay.

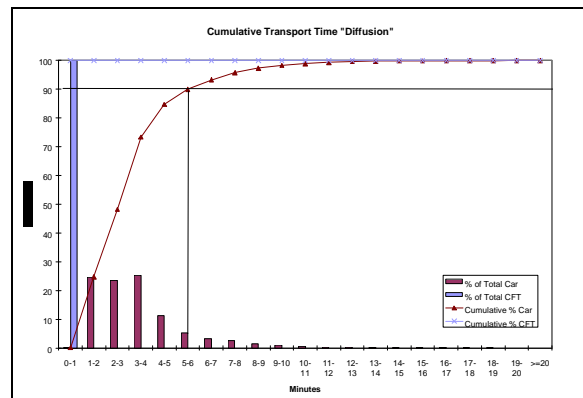
	Diffusion		Photo 1		Photo 2		Photo 3	
	CFT Solution	Car-Based Solution	CFT Solution	Car-Based Solution	CFT Solution	Car-Based Solution	CFT Solution	Car-Based Solution
Average Moves/Hr Required	135	135	155	155	85	85	210	210
Average Moves/Hr Completed	135.2	135.92	155	155.3	85.4	85.4	206	211.74
Number of Vehicles Required	-	12	-	8	-	10	-	10
Average Delivery Time	47 sec	6 min. 53 sec	49 sec	4 min. 34 sec	50 sec	4 min. 52 sec	50 sec	5 min. 2 sec
Average Transport Time	14 sec	3 min. 27 sec	14 sec	2 min. 20 sec	16 sec	2 min. 40 sec	16 sec	2 min. 59 sec
Delivery Time for 90% of the Moves	< 1 min	< 12 min	< 1 min	< 7 min	< 1 min	< 8 min	< 1 min	< 8 min
Transport Time for 90% of the Moves	< 1 min	< 6 min	< 1 min	< 4 min	< 1 min	< 4 min	< 1 min	< 5 min

**Table 3. Intrabay Summary Table**

Further analysis of the delivery and travel times is shown below for the diffusion bay with **Graphs 4 and 5**. Cumulatively, 90% of the CFT's travel time and delivery times were less than 2 minutes, versus 90% of the Car-Based delivery times being under 12 minutes and travel times being under 6 minutes. By having such a small range of delivery and travel times, this lends further evidence to the advantages of the CFT system by demonstrating the predictable nature of this type of delivery system over the Car-Based.



**Graph 4. Cumulative Delivery Time**



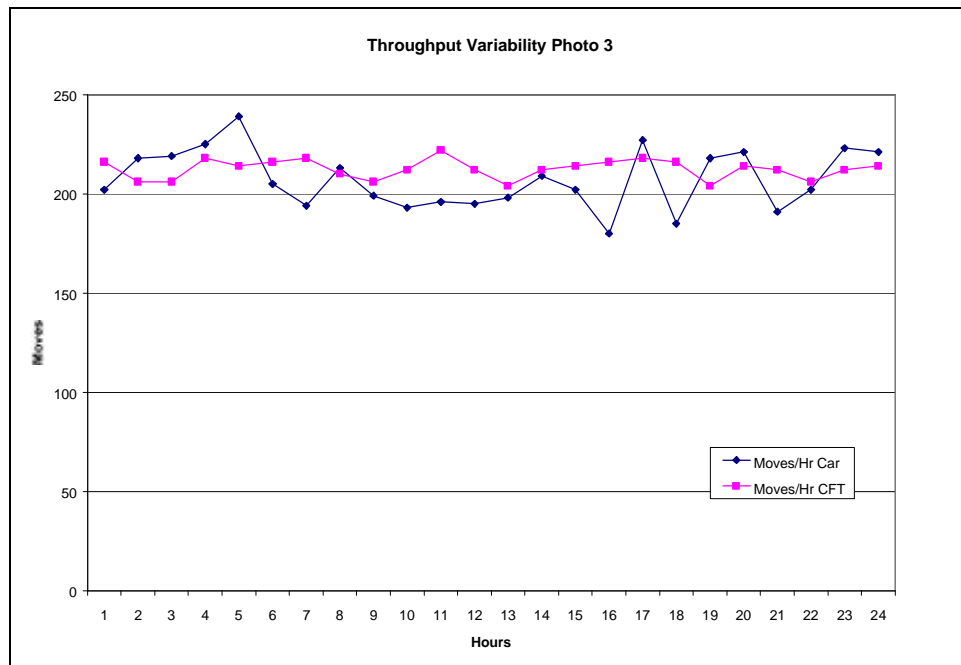
**Graph 5. Cumulative Transport Time**

Just as it did with the interbay results, the Throughput Variability and CV results for the intrabay study demonstrated lower variability with the CFT over the Car-Based system. An example of a Throughput Variability graph is provided in **Graph 6** for bay Photo3. The CV

results for each bay are listed below:

	Diff.	Photo1	Photo2	Photo3
CFT	.06	.03	.08	.02
Car-Based	.14	.08	.08	.07

From both the graphic results and the CV it can be seen that the variability with the CFT system is lower than the variability with the Car-Based system.



**Graph 6. Throughput Variability Results for Bay Photo3 Intrabay System.**

Along with the Throughput Variability, the Maximum Throughput was also tested on both systems. The factors by which the throughput was increased were 1.5, 2.0, and 2.5. The purpose of doing this was to test the robustness of each system. In 3 out of the 4 bays, the CFT was able to meet up to 2.5X the throughput requirement, while keeping the delivery time at less than 1 minute. In contrast, the Car-Based system was able to achieve 2.5X the throughput for only 2 bays while managing an average delivery time between 6 and 8 minutes.

## Conclusions

The CFT solution with a track resource always available for lot movement provides a more robust throughput potential compared with the shared vehicles capability provided by the Car-Based solution. The CFT solution was able to meet 61% more Moves/Hr than the Car-Based solution for the interbay system and 27% more Moves/Hr than the Car-Based solution for the Photo2 intrabay system. In the Car-Based system adding cars over a certain number

didn't increase the throughput due the limited capacity of the turntables to handle the additional cars. In the CFT intrabay system the limiting factor observed to meet additional throughput in one of the bays was the capacity of the stockers to deliver lots into the tool ports.

Lower delivery times and transport times were observed with the CFT solution in average and for 90% of the moves. Intrabay results showed how the capability of the CFT system to deliver lots directly from and to its storage locations to and from the tool ports is reflected in considerable reductions to the intrabay delivery and transport times. These results imply a more robust delivery capability for hot lot transportation since the lots in the CFT system will be able to get to their destinations quicker.

The lower CV with the CFT solution implies more consistent arrivals to the tools that will reflect in less variability imparted onto the manufacturing system.

## References

- [1] Campbell, Elizabeth and Ammenheuser, Jim. "300 mm Factory Layout and Material Handling Modeling: Phase 2 Report" *International SEMATECH*, June 30, 2000.
- [2] Pillai, Devadas et. al., "Integration of 300 mm Fab layouts and Material Handling Automation", *ISSM Paper*, San Jose, CA. 1999.
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- [4] Gaxiola, Gabriel and Hennessy, Larry. "Evaluation of Advantages of Integrating 300mm AMHS Fab Layouts in the Photo Area", *ISSM Paper*, San Jose, CA. 2001.

## Authors Biography

**Frederika Tausch.** Ms. Tausch is a Senior Simulation Engineer for Asyst Technologies in their Automated Material Handling Systems department, where she is primarily responsible for developing simulation studies for the FasTrack product. Before joining Asyst, she served for 4 years as a simulation engineer and technical sales engineer with Jenoptik Infab (now Brooks Automation) focusing on Front-End Automation products. She has 7 years of semiconductor automation experience and holds a Bachelor of Science from Southwest Texas State University.