**AN EVALUATION OF THE IMPACT OF THE MOBILE SHOP SYSTEM ON THE PERFORMANCE OF RESIDENCE HALL MAINTENANCE FOR THE OFFICE OF STUDENT LIFE AT THE OHIO STATE UNIVERSITY:  EXECUTIVE SUMMARY**

**1 OCTOBER 2019**

From February to July 2019, a team from the Department of Integrated Systems Engineering conducted a study involving a representative sample of the 19 maintenance workers who perform residence hall maintenance at The Ohio State University. The workers were observed performing their duties on a daily basis with the goal being to evaluate what impact, if any, the Mobile-Shop System would have on the productivity potential of the group.

MSS positively impacted the following Key Performance Indicators:

- Continuity of work effort (the amount of time required to leave a job to get a tool or part was reduced);
- Quality of work effort (the frequency that the correct tool was used in a specific task increased);
-  Employee satisfaction (technician adoption, implementation and expressed satisfaction with the MSS greatly exceeded expectations)

More Specifically, the insert below highlights some of the more significant and tangible improvements:

1. **On average, use of the Mobile-Shop System across Turnover and Regular Maintenance duties freed up 2.85 hours per week per employee which could be used to accomplish additional maintenance tasks;**

2. **Turnover Maintenance engineers actually increased productivity (jobs per day) by an average of 36%.**

3. **For Regular Maintenance, the % of jobs left for a tool, part or ladder decreased from 62 to 32 (0% for tool).**

We also concluded that the design of the Mobile-Shop System conforms to sound lean design principles (5S and LeanSigma). It has a positive impact on the quality of work effort, inventory control, and employee satisfaction. In short we found the Mobile-Shop System to be highly effective because it has been designed based on well grounded and tested principles of efficiency and productivity.

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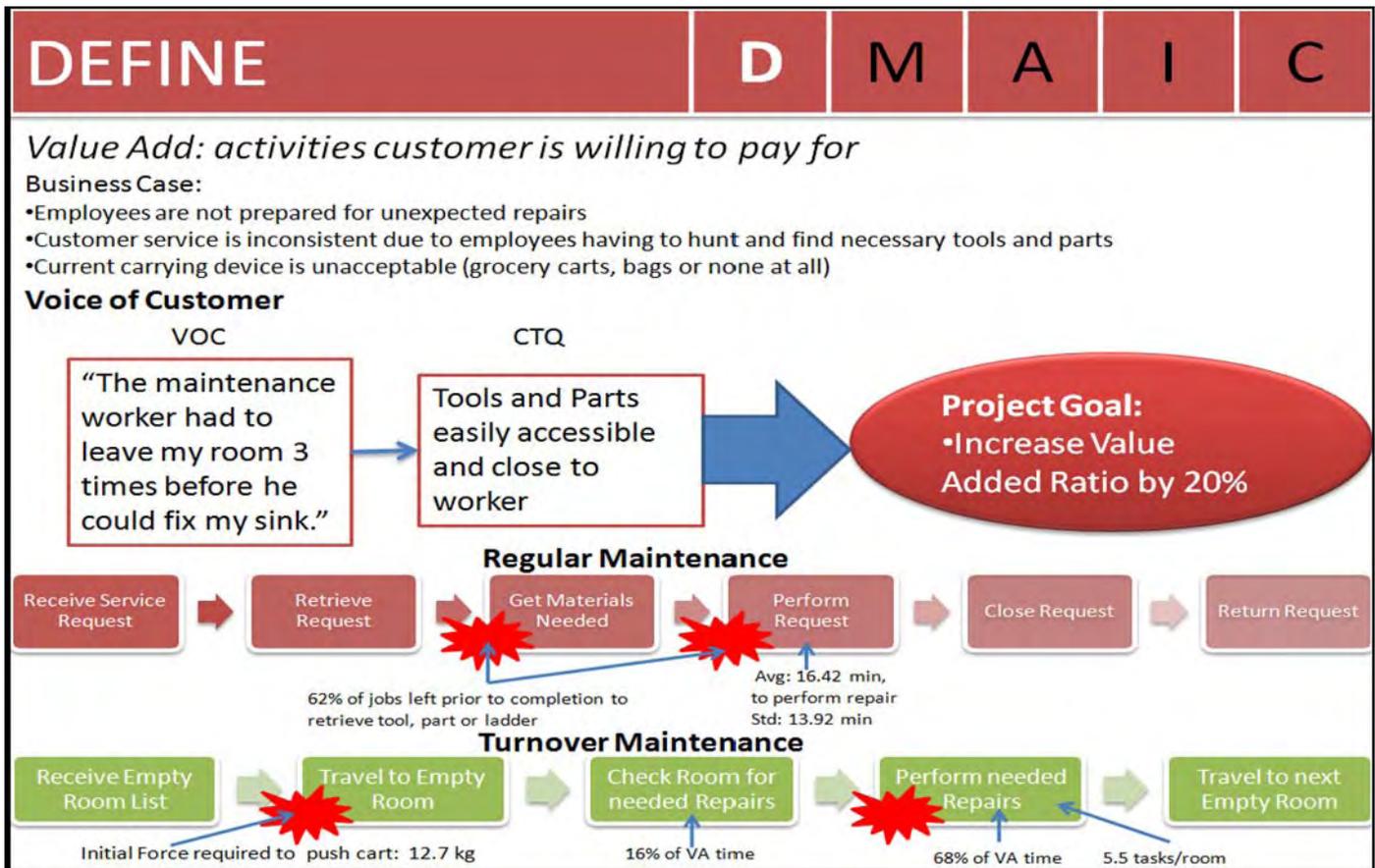**Laura Czuba, MS and LS Belt Candidate**

Figure 1

## Define

The purpose of this Lean Sigma project was to evaluate the impact the Mobile Shop System has on select key performance indicators within a maintenance process. Two types of maintenance work were evaluated with the use of mobile shop, regular maintenance (service requests while rooms are occupied and classes are in session), and turnover maintenance (unoccupied resident hall room turnover during the summer). A process map was created for both processes to help understand the "waste" within these processes as shown in figure 1. Time was also spent understanding the Mobile Shop System in order to identify potential impact the system would have on the identified waste within the maintenance process. The value added ratio was determined to be the appropriate primary y or goal of this evaluation project for two reasons.

The Mobile Shop System was designed with lean principals - such as 5S - in mind to ensure the worker has the right tool at the right time for every job. The waste within the process would be evident with quantification of the value added ratio, thus seeing the full potential of the Mobile Shop System.

A cross-functional team was then assembled consisting of volunteers from the Student Life Maintenance Department of Ohio State University. The team included four maintenance employees for the regular maintenance pilot and three maintenance employees for the summer turnover pilot whom would be testing the Mobile Shop System.

Based on the initial process maps and identified types of waste (e.g. transportation, motion) within the maintenance process, a goal of increasing the value added ratio by 20% was established. Figure 1 showing the voice of the customer translated into critical to quality characteristics leading to the project goal. The benefits to Student Life Maintenance would include improved customer service (employees not leaving a job to retrieve necessary material), staff utilization (less running around in search of materials) and consistency in quality of repairs (using the right tool for the job) and employee satisfaction (giving employees ability to perform well with ownership of their job and cart).

## Measure (Without Mobile Shop)

The measurement plan required extensive work sampling to quantify the value added ratio and other metrics with and without the Mobile Shop System. The total maintenance employee population consisted of 19 employees working a typical 40 hour week.

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Figure 2

For regular maintenance, work sampling was accomplished through the use of phone calls to the participants randomly throughout the day with a resulting 90% contact ratio, a total of 8 calls per day as shown in figure 2. A few other metrics (e.g. reasons for leaving a job prior to completion- transportation and processing waste) were self-reported on daily logs. There were two participants as the control group and two as a treatment group; control never received a Mobile Shop but continued to be measured while treatment used the Mobile Shop. The data collection without the Mobile Shop continued for four weeks. This was followed by four weeks with the Mobile Shop. By the time the treatment group received the Mobile Shop (Analyze phase), the control group seemed to give up with collecting data for the study therefore this data is suspect.

The current state of the regular maintenance customer value added ratio was 41%, business value added ratio 35% with a potential total value added percent of 87% due to the redeployable time of 44% as shown in figure 2. The redeployable time is defined as excess break or recovered time that could be allocated to value added activities per a management decision.

For the summer turnover maintenance, the work sampling was accomplished through direct observation of the participants, including three employees. Each employee was their own control, with an average of 60% of the potential observation time (including overtime) was observed. The observations lasted 20 days in total but varied per employee pending on the time restriction of room turnover due to demand of the building use during summer. Direct observation removed any concerns regarding bias due to self-reporting during the regular maintenance pilot.

The current state of the summer turnover maintenance customer and business value added ratio was 66% with a potential total value added ratio of 70% due to the redeployable time (11%) as shown in figure 2. These ratios include only one subject, (P1).

The three participants' data for summer turnover were kept at an individual level due the varying behavioral characteristics which impacted the data. All produced a different, however all positive,

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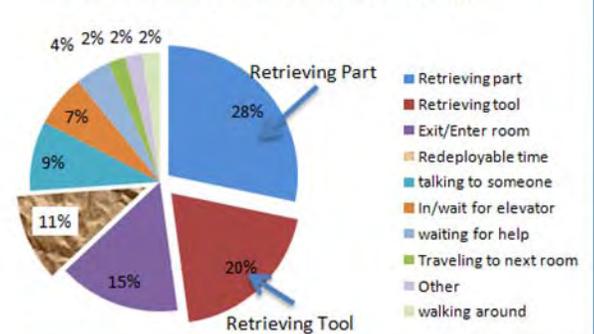
## ANALYZE — D M A I C

### Value Added Ratio: **With** Mobile Shop

**Redeployable Percent:** Recovered Time to do other Value added activities; excess break

#### Regular Maintenance
2 treatment and 2 control participants
Work Sampling via phone calls
- 90% Contact ratio
- 8 calls per day
- 18 days of calls (4/22-5/19)
Self Reporting of key secondary metrics

> Significant improvements in VAR will only occur if "freed up" time (redeployable time) is allocated to do other value added activities

#### Turnover Maintenance
3 participants
Work Sampling via direct observation
- 66% of potential observation time was observed
- 20 days of observations (7/6-7/17)

| Treatment Group (Participant 1 & 3) | | Without | With |
|---|---|---|---|
| | Customer Value Added Percent (CVA) | 41% | 51% |
| | Business Value Added Percent (BVA) | 35% | 25% |
| | Non-Value Added Percent | 25% | 25% |
| | •Redeployable Percent | 44% | 61% |
| | Potential Total VA Percent | 87% | 91% |

| Participant 1- (P1) (Old building) | | Without | With |
|---|---|---|---|
| | CVA & BVA Percent | 66% | 62% |
| | •VA time spent on repairs | 68% | 80% |
| | Non-Value Added Percent | 34% | 38% |
| | •Redeployable Percent | 11% | 58% |
| | Potential VA percent | 70% | 84% |

**Conclusion:** Implementing Mobile Shop, over all 19 employees the weighted average potential productivity gain is **2.9 hrs/week/employee ~2,600 hours or 1.5 fte**
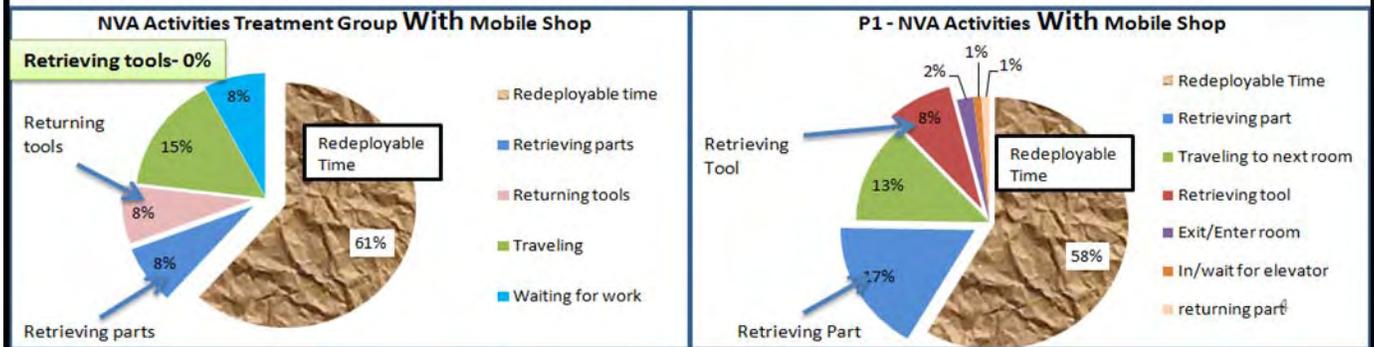
**NVA Activities Treatment Group With Mobile Shop**
- Retrieving tools- 0%
- Returning tools 15%
- Retrieving parts 8%
- 8%
- Waiting for work 8%
- Redeployable Time 61%

Legend: Redeployable time, Retrieving parts, Returning tools, Traveling, Waiting for work

**P1 - NVA Activities With Mobile Shop**
- Retrieving Tool 8%
- Traveling 13%
- Retrieving Part 17%
- Redeployable Time 58%
- 2%, 1%, 1%

Legend: Redeployable Time, Retrieving part, Traveling to next room, Retrieving tool, Exit/Enter room, In/wait for elevator, returning part

**Figure 4**

potential improvement from the use of Mobile Shop System.

The other two participants' (P2 and P3) VAR was 76% and 53%, respectively. P3 had a potential total VAR of 72% due to 40% of NVA being redeployable while P2 had zero redeployable time.

Prior to the Analyze phase, all participants received a training/customization of the Mobile Shop System in order to fairly evaluate the system. This training consisted of not how to use the tools within the Mobile Shop but to know where they are located on the Mobile Shop for quick retrieval (eliminating waste of excess motion and/or transportation). The customization was to ensure the appropriate tools and parts were assembled on the Mobile Shop that each participant uses on a daily basis. This customization was critical to our test.

## Analyze (With Mobile Shop)

Moving into the analyze phase, regular maintenance treatment group received the Mobile Shop System to use for four weeks while the same data collection methods (work sampling via phones and self reporting) continued. The contact ratio for this time period stayed consistent with the measure phase (without the Mobile Shop) at 90% as shown in figure 3.

The turnover maintenance analyze phase continued with starting the use of the Mobile Shop System for the three participants involved using direct observation as the work sampling method, with a 66% of the potential observation time (including overtime) was observed.

Significant improvements resulted from the use of the Mobile Shop System in both regular and turnover maintenance. For regular maintenance, the redeployable time (recovered time, excess break) went from 44% to 61% of the non-value added percent. Meaning, 61% of 25% NVA could be allocated to value added activities as shown in figure 2 (without Mobile Shop) and 3 (with Mobile Shop). The resulting total potential percent value value added could be as high as 91%. The customer value added percent increased from 41% to 51% while the business value added percent decreased from 35% to 25% as shown in figure 2 and 3. A critical factor to realizing the full potential of these results is in the hands of management to introduce procedures and rewards motivating employees to redirect the redeployable time to value add activities.
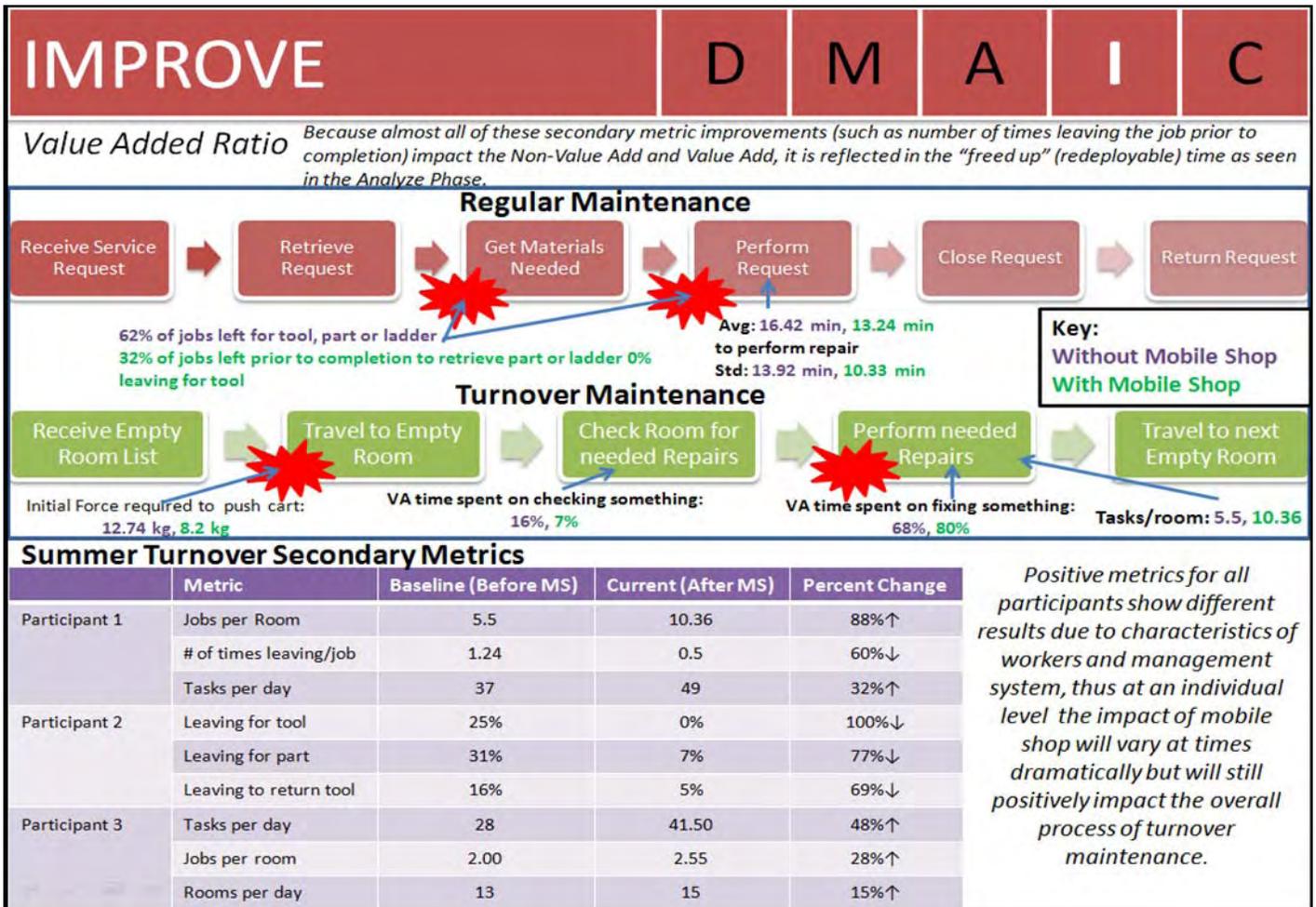
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## IMPROVE — D M A I C

### Value Added Ratio

Because almost all of these secondary metric improvements (such as number of times leaving the job prior to completion) impact the Non-Value Add and Value Add, it is reflected in the "freed up" (redeployable) time as seen in the Analyze Phase.

**Regular Maintenance**

Receive Service Request → Retrieve Request → Get Materials Needed → Perform Request → Close Request → Return Request

62% of jobs left for tool, part or ladder
32% of jobs left prior to completion to retrieve part or ladder 0% leaving for tool

Avg: 16.42 min, 13.24 min to perform repair
Std: 13.92 min, 10.33 min

**Key:**
Without Mobile Shop
With Mobile Shop

**Turnover Maintenance**

Receive Empty Room List → Travel to Empty Room → Check Room for needed Repairs → Perform needed Repairs → Travel to next Empty Room

Initial Force required to push cart: 12.74 kg, 8.2 kg

VA time spent on checking something: 16%, 7%

VA time spent on fixing something: 68%, 80%

Tasks/room: 5.5, 10.36

### Summer Turnover Secondary Metrics

| | Metric | Baseline (Before MS) | Current (After MS) | Percent Change |
|---|---|---|---|---|
| Participant 1 | Jobs per Room | 5.5 | 10.36 | 88%↑ |
| | # of times leaving/job | 1.24 | 0.5 | 60%↓ |
| | Tasks per day | 37 | 49 | 32%↑ |
| Participant 2 | Leaving for tool | 25% | 0% | 100%↓ |
| | Leaving for part | 31% | 7% | 77%↓ |
| | Leaving to return tool | 16% | 5% | 69%↓ |
| Participant 3 | Tasks per day | 28 | 41.50 | 48%↑ |
| | Jobs per room | 2.00 | 2.55 | 28%↑ |
| | Rooms per day | 13 | 15 | 15%↑ |

*Positive metrics for all participants show different results due to characteristics of workers and management system, thus at an individual level the impact of mobile shop will vary at times dramatically but will still positively impact the overall process of turnover maintenance.*

Figure 6

Essentially, employees' time has been "freed up" due to working smarter (more efficiently) because of the use of Mobile Shop. Waste of transportation, excess motion, processing (over handling due lack of necessary tools were all eliminated).

Turnover maintenance produced a similar result with redeployable time. For P1, the redeployable time went from 11% to 58% of the non-value added percent. Thus, 58% of 38% of the non-value added percent has the potential to be value added, giving a result of 84% VAR as shown in figure 2 and 3. As for the other participants, P3 has the potential to go from 72% to 78% VAR and P2 went from 76% to 67%.

Recall that nothing else was changed within the maintenance system expect for the introduction and use of the Mobile Shop System. In fact, some participants actually took the Mobile Shop System into each room they were working on while others left it in the hall way which would further reduce excess transportation and motion waste. This difference shows up in the data. For example, P1 left the cart outside the room during room turnover therefore, his activity element "leaving for a tool" reduced from 20% to 8% (as shown in figure 3) while P2 took the cart

inside the room, resulting in a 100% elimination of "leaving for a tool," as shown in figure 4.

Extrapolating the results to all 19 employees requires a modest estimate. If the Mobile Shop System pilot testing results for regular maintenance and turnover maintenance are combined as a weighted average over all employees, the estimate of improvement would be a 17% increase in VAR. Assuming approximately 70% of yearly demand is spent in regular maintenance and 40% is summer turnover, with 35% of 50% (NVA) is redeployable for regular maintenance and 40% of 50% (NVA) is redeployable for turnover maintenance. The result would be a productivity gain of 2.6 hr for 70% of the year and a 3.5 hr for 40% of the year with a weighted average of 2.83 hr/wk/employee or 2,580 hrs or 1.4 fte.

### Improve

Moving into the improve phase, other metrics were identified to help build a business case for Student Life Maintenance for their use in deciding whether the Mobile Shop System adds value to the business. For regular maintenance, leaving the job prior to its completion to obtain tool, part or ladder went from

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**Figure 8**

62% to 32% with leaving for a tool never occurring as shown in figure 4. This would totally eliminate leaving to retrieve a tool to complete a job. For turnover maintenance, the metrics were kept on an individual subject level because behavioral characteristics of participants and the management system under which they were operating varied dramatically impacting the results. In figure 4, data illustrates the differences in the secondary metrics for each participant for whom there was a significant improvement. Despite these individual differences, key performance indicators combined with the characteristics of each participant which allows Student Life to judge the full potential impact of the deploying the Mobile Shop System.

Participant 1 (P1) achieved an 88% increase in the number of tasks per room completed during summer turnover as shown in figure 4. This metric is critical to Student Life or any maintenance company/department because the assumption is the more jobs/repairs or preventative maintenance completed during turnover, the fewer service requests will be generated during the school year (regular maintenance). In all likelihood, this should result in higher customer satisfaction. For this same subject, the

number of times leaving per job decreased by 60%, explaining the time "freed up" time with the use of the Mobile Shop System.

## Control

The control plan which would permit Student Life to sustain the results from the use of the Mobile Shop System include refining the management system in order to ensure the "freed up" time is allocated to value added time. One possibility would be for employees to spend their time fixing broken down equipment that is occupying floor space in all of the maintenance shops.

Other critical changes will include inventory checks of the Mobile Shop by the employees and management and periodic data collection for some of the key metrics. Lastly, to further create ownership of each Mobile Shop, the employees will need to engrave each tool with their cart number.

The Mobile Shop System has the potential to increase the value add ratio by 17% even with the different behavioral characteristics of employees and a structured control plan will ensure this improvement is sustained in the building maintenance sector.

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