Improving Throughput of Taxi Maintenance & Repair Operations (MRO)

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1. DEFINE

Singapore Technologies Kinetics (ST Kinetics) is the land systems and vehicle arm of Singapore Technologies Engineering Ltd, a public listed company in Singapore. In anticipation of an increase in taxi MRO services. This project aims to provide a quantitative tool to measure the current throughput as well as to make possible recommendations to increase the throughput with the help of Process Flow Mapping, Discrete-Event Simulation Model, and Time Series Analysis.

2. MEASURE

Operational details of current business model
- The workshop provides two kind of services, namely Preventive Maintenance (PM) and Corrective Maintenance (CM).
- PM services are divided into PM A, PM B and PM C, each consists of different scope of maintenance.
- Arrival of taxis for PM services are scheduled in advance, though taxi driver tardiness is often observed; Arrival of taxis for CM services are random as and when taxis breakdowns occur.
- Tire and air-conditioner services are also provided.
- There are 15 general repair bays, 1 dedicated air-conditioner repair bay, and 2 dedicated tire bays in operation.

Process Flow Mapping of Current Process
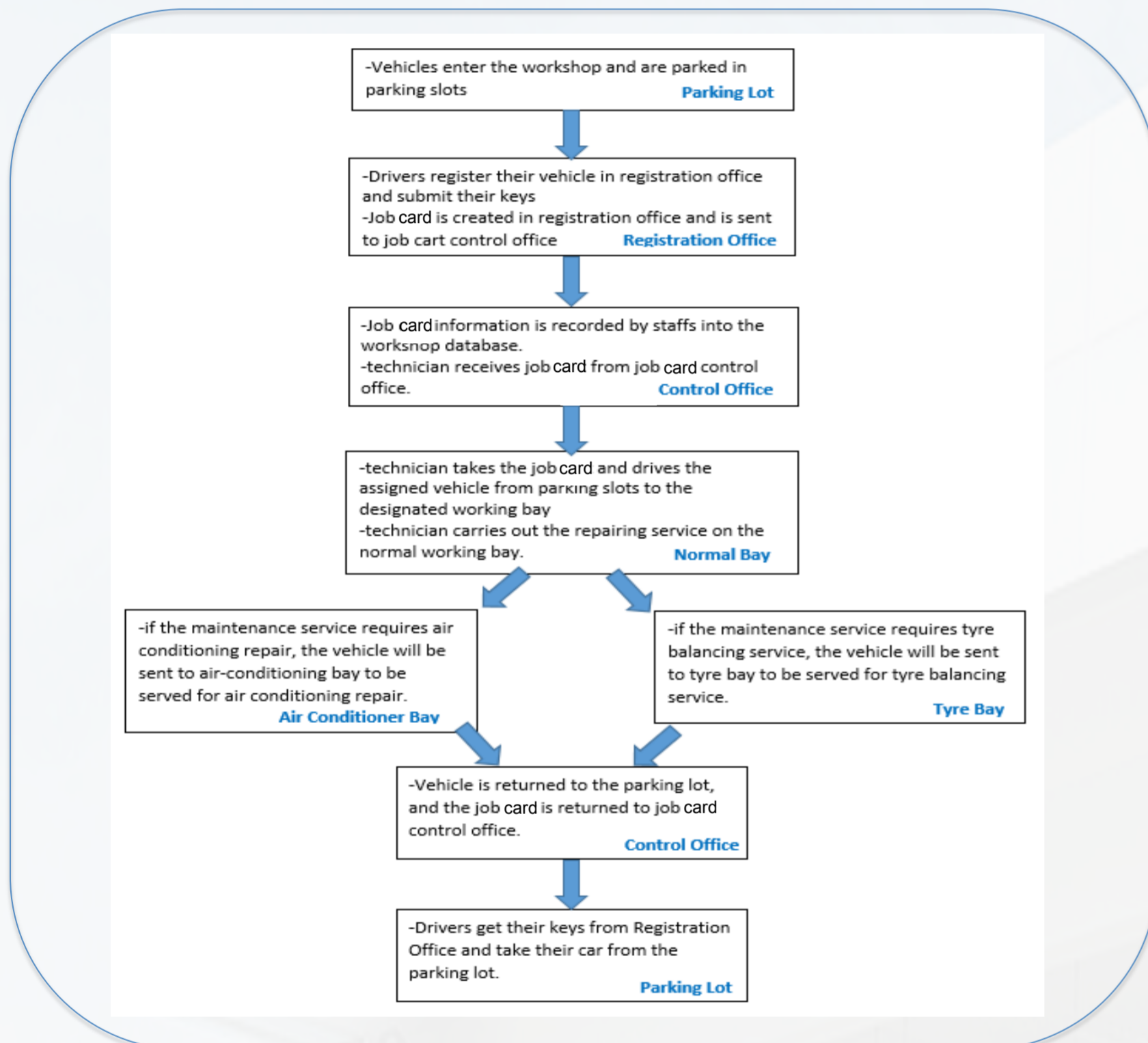
Data Collection
- Data collection are derived from company's database as well as on-ground time study

Database	On-ground time study
Arrival time of PM (A,B,C) and CM repairs	Service time of air-conditioner repairs and tire repairs
Service time of PM (A,B,C) and CM repairs	Frequency of air-conditioner and tire repairs
Collection time of PM (A,B,C) and CM repairs	

5. CONTROL

On maintaining the feasibility of proposed scheduling
- Incentives to encourage taxi drivers to come at their scheduled time slot
- Demand pattern especially for CM services does not change from the basis of the proposed model as the proposed PM scheduling is based on the CM arrival patterns
- No bottleneck on the air-conditioner, tire, and administrative service counters. Repair services are the most important factor in measuring the throughput

On Cost-Benefit of Possible Scenarios
- The study shows that an increase of 30% in throughput can only be achieved when proposed scheduling is implemented together with manpower and one more loading bay. This solution may come with high cost
- Proposed scheduling is estimated to incur the least incremental cost, followed by manpower allocation, and finally one more loading bay
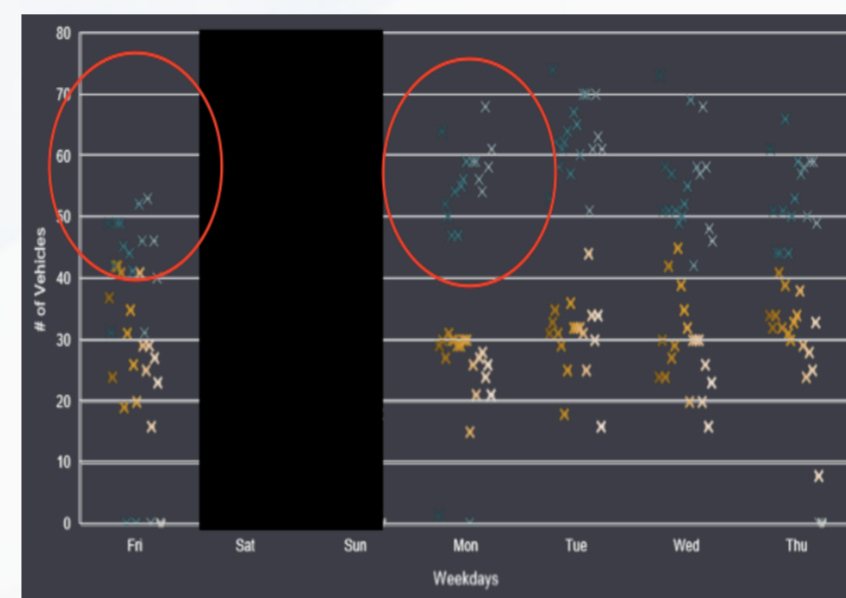
3. ANALYSE

Definitions
- Throughput: average no. of taxi processed per day
  - Min (#taxis repaired, #taxis collected)
- Total Processing Time
  - Repair Time + Collection Time + Waiting Time
- No. of Taxis Repaired = C * U / T
  - C: Total working hours per week
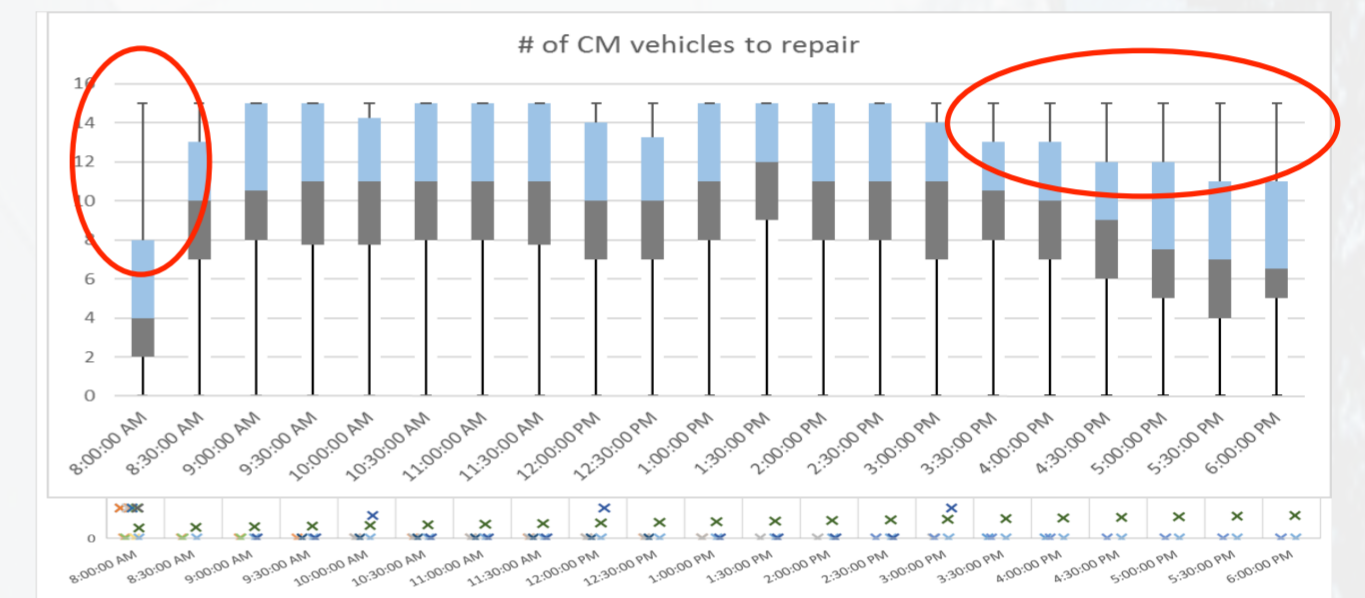 - U: Utilization of the working bays
  - T: Average repair time per taxi

Capacity Analysis of Current Process
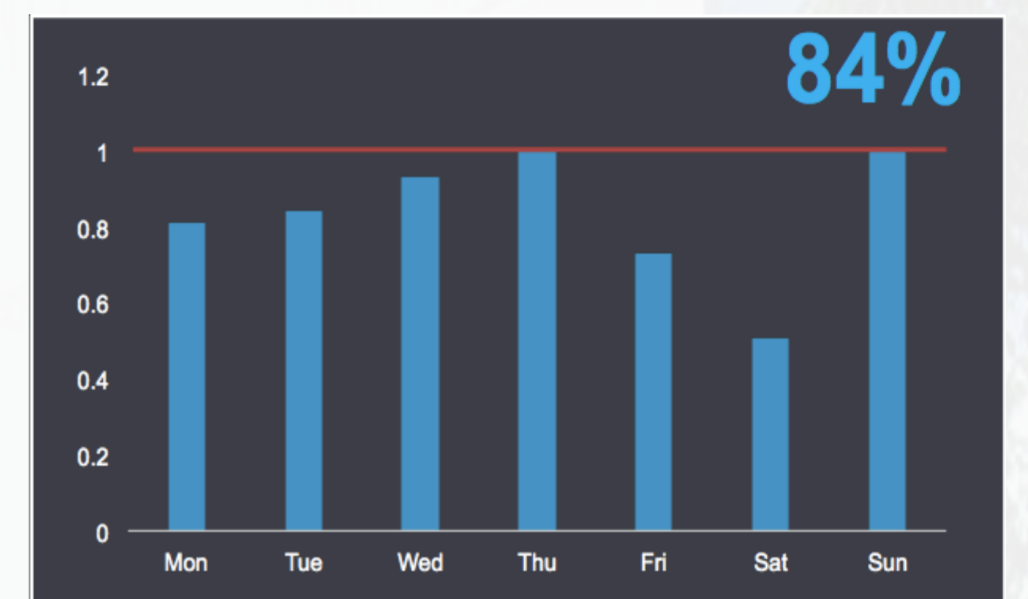
Time Study of Current Process

Time Study of Current Process

Key observations:
1. CM arrival rates is relatively lower on Monday while they are similar for other days
2. PM arrival rates is relatively lower on Friday while they are similar for other days
3. A lower demand is observed from 8-9am and from 4pm-6pm for CM

Simulation Results

Service Type	Baseline	Raw Data	Baseline (w/o tardiness)
PM A	34.55	36.75	35.79
PM B	3.24	3.89	4.88
PM C	11.82	11.97	11.97
CM	23.52	22.92	21.82
Total	73.12	75.53	74.45

Key observations:
1) Validation against raw data shows that the simulation model gives similar number of repairs done per type
2) If all taxi drivers follow the scheduled PM timeslot (no tardiness), the number of taxis done generally increase but the increase is only at 1 taxis done per day as when more PM services are scheduled, number of CM done decreases as they are competing for the same resources

Key insights to increase throughput
- A more balanced scheduling where PM services are spread across timeslot when CM services are lower
- Incentives to get taxi drivers to come on-time based on their scheduled PM slots
- Reduction in time needed to service a taxi

4. IMPROVE

Proposed Scheduling

Service Type	Scheduling (w/o tardiness)
PM A	36.15
PM B	5.00
PM C	11.58
CM	24.33
Total	77.06

Key ideas: to spread PM loads across timeslot with lower CM arrivals
- Schedule more PM between 8am – 9am and 4pm – 6pm
- Schedule more PM on Monday and Friday
- Real time forecasting methods: Boxes Jenkins, Holt Winters methods
- Compared to the current business model, the number of taxis done increases by 4 taxis per day. Compared to current scheduling w/o tardiness, the number of taxis done increases by 3 taxis per day

Additions of Resources (in conjunction with the proposed scheduling)

Scenario 1: Maintain full capacity at night shift (15 mechanics)

Service Type	Scheduling + Manpower
PM A	45.39
PM B	6.33
PM C	14.21
CM	23.70
Total	89.64

Scenario 2: Maintain full capacity at night shift (15 mechanics) + one more loading bay

Service Type	Proposed + Manpower + 1 more loading bay
PM A	50.67
PM B	6.33
PM C	15.97
CM	24.03
Total	97.00

Improvement in total throughput relative to Baseline

Baseline	Baseline with no tardiness	Proposed scheduling with no tardiness	Proposed scheduling + manpower	Proposed scheduling + manpower + one more loading bay
0%	+1.82%	+5.39%	+22.59%	+32.66%

Reducing Repair Time
- Create a few tire supply points in the workshop, which is replenished regularly instead of using a centralized tire inventory place
- Create a tooling kit to keep the workspace tidy to increase workers' productivity

Reducing Collection Time
- Implement an automated messaging system which reminds taxi drivers to collect their vehicles 10-15 minutes before the estimated finish time