

Final Examination Component 2

Akanksha Singh(200070) | Priya Gole(200727)

Problem Statement

Estimate the berth and loader utilization of Port Shippo. The port consists of an offshore anchorage, a tugboat, a loader and functions 4 out of every 12 hours. The tugboat is needed to move ships from the anchorage to the loader, taking an hour each time, and the loader loads coal into ships in 14 to 18 hours.

We also aim to analyze the impact of increased number of tug boats on the service time for the ships. The aim is to calculate the optimal number of ship boats that lead to significantly improved service times.

Further, we also want to analyze the impact of increasing operation times from 4 to 6 per 12 hours of tidal waves. This can be achieved by dredging if it is an appropriate solution to optimize service times.

Berth and Ship Loader Utilization

We simulated the arrival of one ship every 28 hours with a possible day of a maximum of five days. Further, we assumed 4 out of every 12 hours as operational time and a uniform distribution of loading time between 14 and 18 hours. In the initial simulation we used just one tugboat. The simulation was run for 720 hours or 30 days.

With these simulation conditions, we calculated the following estimated berth and loader utilization:

Berth Utilization: 80.63%

Ship Loader Utilization: 56.24%

This significant disparity between berth and loader utilization arises from the fact that berths are acquired while waiting for tugboats while loaders are only used during the actual coal loading operation.

Analysis on Number of Tugboats

We ran different simulations with varying numbers of tugboats and other conditions remaining the same. We ran the simulations for different numbers of tugboats for 30, 45 and 60 days and compared results.

In the simulation with just 1 tugboat, the average service time for ships were as follows:

Average Service Time for 30 day Simulation: 23 hours 02 minutes

Average Service Time for 45 day Simulation: 23 hours 40 minutes

Average Service Time for 60 day Simulation: 23 hours 20 minutes

With the introduction of one additional tugboat, the service times change to the following:

Average Service Time for 30 day Simulation: 23 hours 10 minutes

Average Service Time for 45 day Simulation: 23 hours 20 minutes

Average Service Time for 60 day Simulation: 23 hours 05 minutes

As we can see, there is a very small, insignificant change in the average service time with the addition of one more tugboat. The extra tugboat does not improve service times by much as the bottleneck on service times is the loader and its availability. Thus, as long as there is only one loader, extra tugboats will not lead to very significant improvement in service times, as is seen in our simulation.

When we add another tugboat, increasing the total number of tugboats to three, we observe the following:

Average Service Time for 30 day Simulation: 23 hours 05 minutes

Average Service Time for 45 day Simulation: 23 hours 30 minutes

Average Service Time for 60 day Simulation: 23 hours 20 minutes

We see that there is an even smaller change in service times by the addition of the third tugboat. This is a reflection of the fact that since the bottleneck is the availability of a berth, the maximum number of tugboats that can create an improvement is two, one for onboarding and one for offboarding. Any additional tugboat would be idle anyway, since there is no berth for ships to occupy or vacate.

Conclusion: The addition of one tugboat leads to an insignificant improvement, while the third tugboat would be practically useless in improving the average service time for ships. This is because the availability of only one loader is the bottleneck.

Analyzing the impacts of dredging

We simulated the port with 4, 5 and 6 hours of operational time every 12 hours. The results of the simulation repeated for 30, 45 and 60 days were as follows:

Operational time (out of 12 hours)	Service Time 30 day simulation	Service Time 45 day simulation	Service Time 60 day simulation
4	23 hours 02 minutes	23 hours 40 minutes	23 hours 20 minutes
5	22 hours 55 minutes	23 hours 20 minutes	23 hours 10 minutes
6	22 hours 50 minutes	23 hours 05 minutes	23 hours 10 minutes

As we can see, the dredging usually does not lead to significant decrease in time in the system for ships. This is because the increase in the time window does not lead to much increased coincidence with ship availability, as ships come only once every 28 hours.

Conclusion: The optimal service time is achieved with one tugboat and no dredging.