Ground Traffic Control

Team Flow
Members: Drew, Daniel, Sean, Russ
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Program Description

The program was intended to model the ground traffic at SEA-TAC. The model would require a distribution of Landings over the course of a day as input. The distribution would be generated on each sim run, and as a result brings variety and an interest in analysis. The model would take the input, spawn the jets based on the time of their landing, and then guide them through the airport process. Each jet has its own time and consumption tracking, and will store the results as output of the model once the Jet successfully takes off, and leaves the airspace. The analysis would be conducted on the average time and consumption a jet goes through at the airport. From there, the model would be modified to see if there are potential improvements to the average stay-time and consumption, or if there are big pitfalls to avoid.

User Manual

There is no need for external libraries. The program is standard plug and play, the sim_driver has all the imports needed to run the file. We have several python files for the supporting classes but everything is in the same directory.

Basic Rules about the model:

- The distance between each grid point is 1 unit, which is equivalent to 141.7 ft in the real world. We know this because the left-most runway is covered by 84 units, and the length of the runway in the real world is 11,901 ft.
- Each jet moves on a unit based speed meaning 1 block per minute.
- The model step time is by minute, but we equivalate the 1 minute to 1 second.
- The total number of tics is 1440 a full 24 hour day but played at 1min=1sec.

Variables the model leaves out:

- Cars, buses, and other ground crew operations are not simulated. Only the jet traffic is simulated.
- Wind direction is kept constant.
- The jet itself is kept constant, so variability of jets is left out.
- Airlines, and airline terminals are not simulated. All gates and terminals are universal and can be filled by any jet.

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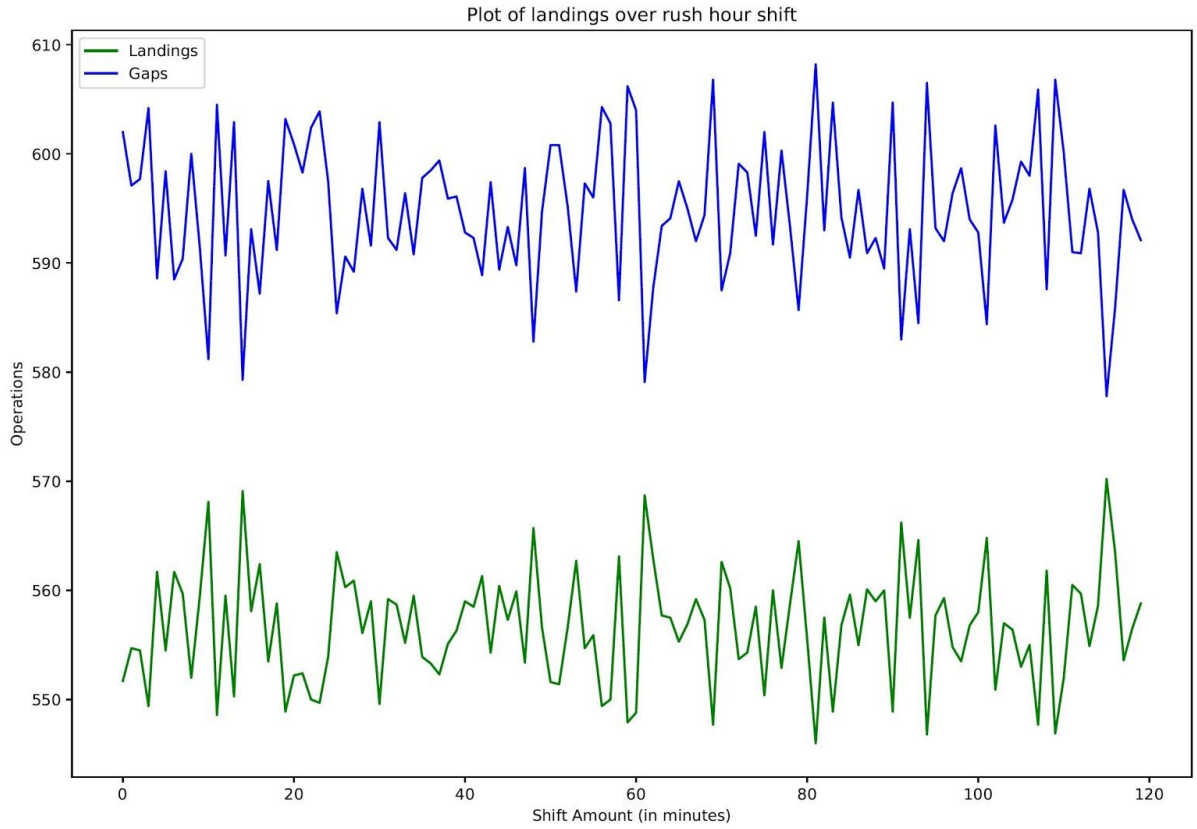
Complete Analysis Questions - Based on Distribution

This analysis was performed by Daniel and was based on the distribution. It is not based on results from our model. Our model does not run. See Team Explanation for more info.

1. How does shifting the rush-hour pattern impact the ground traffic?



- Simply shifting the rush hour pattern, doesn't affect the model.
- The gaps simply complement the landings as usual. There is no change in the behavior of the result, because the amount of time the rush-hour landing-probability will be used is still the same.

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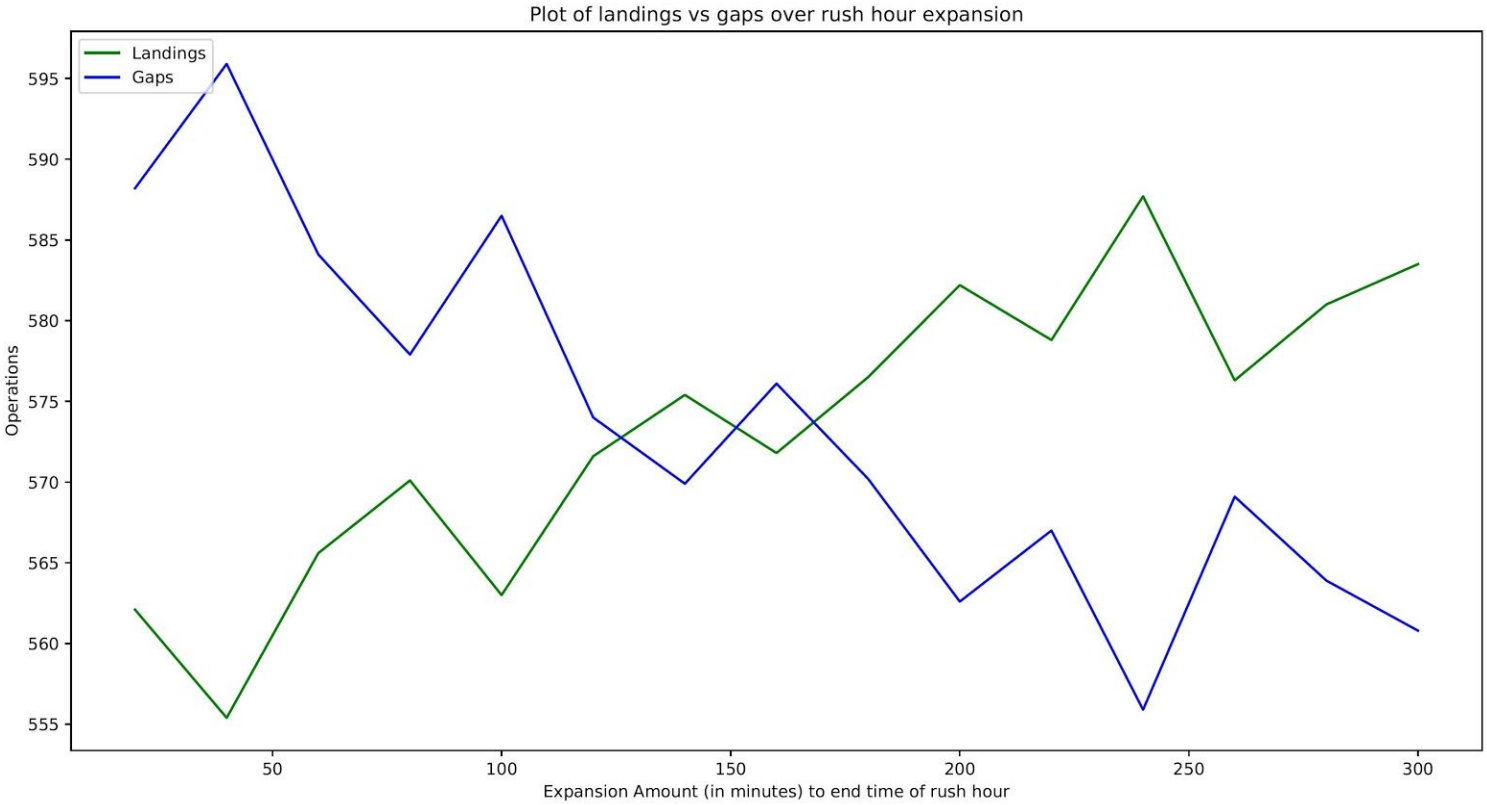
2. What is the impact of expanding the rush-hour ranges?



- As expected, the landing count increases from an initial point of 563 landings per day, to a final point of 583. From a min point of 555 landings, to a max point of 587 landings per day.
- Expanding the rush-hour range keeps introducing landings at a higher probability and as a result limits the gaps. A lower amount of gaps means that takeoffs can not take place at the same rate that planes are coming in.
- However, an expansion of 300 minutes is very extreme, and was done with purpose of analysing the scalability of the distribution.
- The initial morning rush-hour range is from 6AM-10AM, and the evening rush-hour range is from 2PM-8PM. The expansion was applied to these initial ranges. For each expansion, the distribution was ran 100 times, and then averaged to serve as 1 data point.

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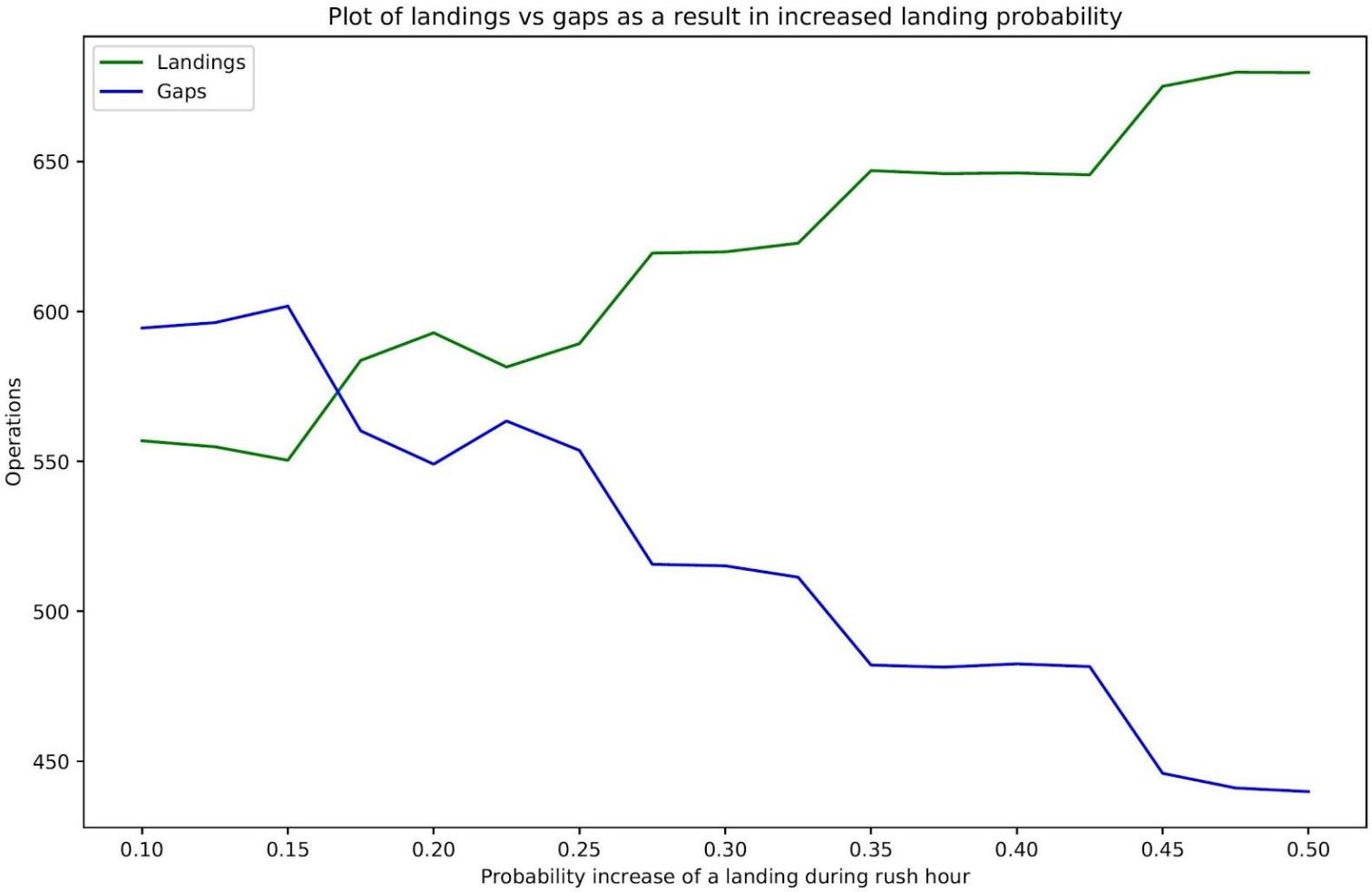
3. What is the impact of increasing the probability of a landing during rush-hour?



- The result of this plot has matched our predictions, and shows the effect of increased landing probability introduced in the distribution.
- Increasing the probability of a landing, directly affects the model by introducing an increase in consecutive landings, which in turn puts a strain on takeoff queues, and results in extensive waiting-lines for each runway. Most of the consumption waste is introduced in these waiting lines, and the solution to freeing these waiting-lines is to introduce slow-down requests for the incoming landing-air-traffic. This in turn expands the range of the rush-hour traffic, but in turn it frees up the ground traffic and enforces takeoffs.
- The initial probability of the rush time was set equal to the regular probability of 0.45, and was increased by the plot x-values. At each point, 100 distributions were generated and averaged to create one data point.

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Intended Analysis Questions - Based on Model

1. What is the result of increasing the number of gates by 1, 2, 3, 4,...10?

2. What is the result of flipping the wind direction, and forcing the model to switch the landing direction? What is the time delay that this transition introduces.

3. What is the result of opening the center runway? How much more traffic is the airport able to handle as a result of this change?

4. How does the change of taxiing speed affect the optimization of the take-offs control?

5. How would the traffic control simulation come out differently if there is an intersection of take-off and landing for take-off/taxiing prioritized versus landing/taxiing prioritize?

6. How would the grid size affect the simulation results of the jet's path? Because it affects the distance of each cell, and the accuracy of path, and potentially the speed per time stamp.

7. What is the effect of introducing emergency planes, and prioritizing their landing?

8. What is the effect of preventing runway crossing when a landing is "in-progress" but not yet on the ground? What is an appropriate proximity-limit to impose on the runway crossing rule?

9. What is the effect of enabling bidirectional taxiways? Is the average stay-time of a jet at the airport improved by this change, in comparison to the one-way taxi?

10. If added different airlines, should they be assigned to a designated terminal or gates? Or a random assignment would produce a quicker flow-in and flow-out?

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Team Contribution

GitHub repository found at: https://github.com/drew-loukusa/CSS458-Team-Flow
Forking should be possible.

Drew - Created initial framework for model and did majority of coding some of which as done as pair programming with other group members. I spent all of my time working on fleshing out features, figuring out how the model was supposed to work and translating those insights into workable code.

Daniel - Contributed with the initial rules and ideas about what the model should do. Came up with the raw image of the airport, which was then edited and aligned by Drew. Was responsible of the landing-distribution implementation, testing, and analysis. Introduced sources for the airport details and general rules of airport ground traffic, and ultimately established the input and output expectations for the model, the purpose. Daniel had a bit of a hard time balancing between 2 other classes and work. One of which class was CSS 422. He invested a lot of his time into the 422 68k-disassembler project and proved it by showing his contribution to the private 422 repository.

Sean - Contributed a lot of early stage and milestone research on how to run the air and ground traffic control model. He read https://stacks.stanford.edu/file/Druid:jh561fd9930/Bloem_dissertation-augmented.pdf and https://www.aviationsystems.arc.nasa.gov/publications/hitl/technical/powerful_combo.pdf to provide insights about the simulation setup and algorithm. After the milestone, Sean did pair programming with Drew and Russ, and Drew eventually pushed the updates and commits on the github. He initiated the development plan, did analysis and questions for the project. He also did many of the commenting and runway, jet and terminal/gate methods.

Russ - Did a majority of the code with pair programming with Drew. He was in charge of writing the pathings for the the runway and labeled the paths. He was suppose to be in charge of testing the simulation but didn't get a chance to due to the simulation not being fully built.. Was responsible for the milestone documents, and documentation in general. Also, had a hard time driving the project because he was was working full time and had 2 other group projects from other classes all due around the same time.

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Team Explanation:

Our team unfortunately did not finish the model, we are very close but we ran out of time because of debugging. We believe we had the right approach but we lacked leadership and time management. We spent a considerable amount of time working on the project towards the end of the due date because we were not coordinated early on. In the end there were about 4000 additions to the base of the repository, a lot of time spent documenting, and scoping.

We know we don't warrant any special treatment or extension but we would just wanted to analyze how we failed to meet the deadline and come up with future solution. All of our group members have jobs some full time while others have part time, and 1 group member is taking 4 classes. That was our first mistake of not being more careful with our time and splitting up the workload. We didn't scope out our project carefully enough, because what we talked about in person, was way more tedious to implement via code. It would have probably been more convenient to pick something directly out of the book so we have a defined scope and direction. Another thing is that our drivers were not fully drivers as they were very occupied with other school projects and we didn't define a set "leader" for our group. Our group member said it perfectly: "Our group was set up to fail. We all should have been in different groups." - Drew

"We were a little ambitious about what we would like to do for the project, but weren't very specific about the details and approaches. I wasn't very positive about the Airport Traffic Control, since I thought it'd be more realistic to try the textbook project question. I have to agree with Drew about the team formation. We were not the best match given each of our availability and personality type. However, we tried to make it work as much as we could. After the milestone check, we spent lots of hours in reorienting the project goal, reframing the simulation, and coming up with good analysis and questions that align with the new simulation." - Sean