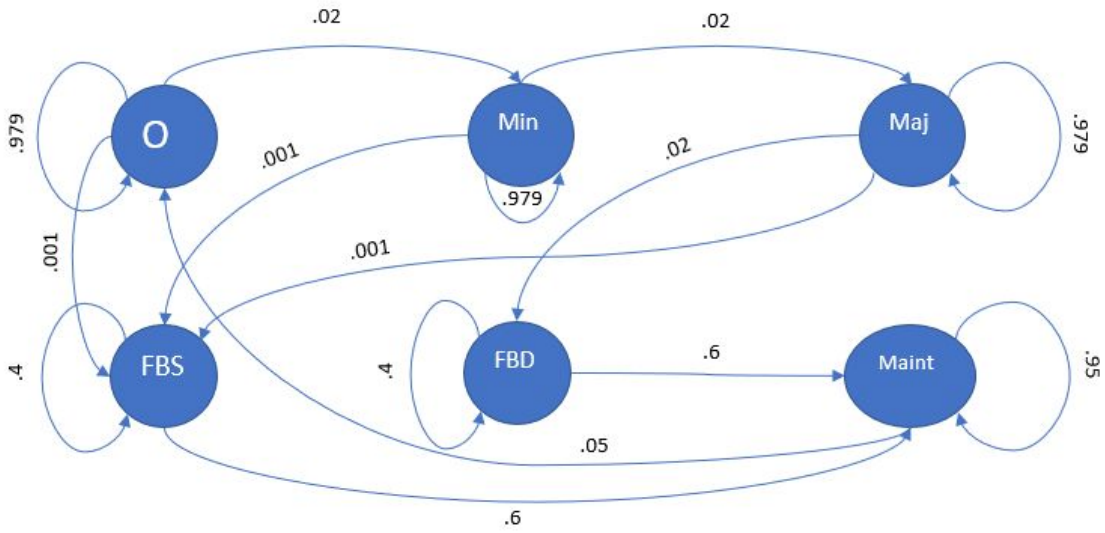
Project Exercise #2: Wind Farm Maintenance Using Markovian Analysis

Team Blue:

Name	**Contribution**
Albert Joseph	Base Method, CPMS, r=.1, Modeling and Methods,
Jonathan Shechter	Base Method, CPMS, r=.99, Modeling and Methods
Jake Miller	Base Method, CPMS, r=.5, Transition diagram, Steady States
Niki Kapasouris	Base Method, CPMS, Modeling of benchmark
Marc Yarkony	Base Method, CPMS, LPMS

Models and Methods:

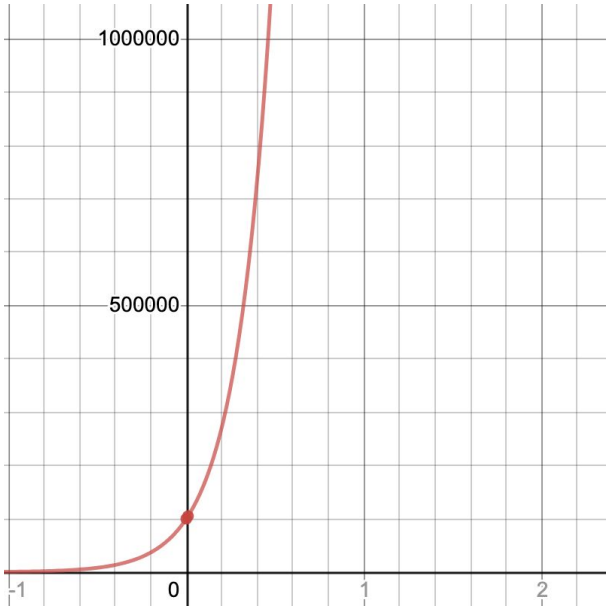
This project involved analyzing wind farm turbine maintenance using Markovian Analysis. We created the one-time step probability matrix then calculated the steady-state solution to find the profit of the wind turbines. The transition matrix in CMS benchmark section was based on the transition diagram below:



The Liberal preventive maintenance strategy (LPMS) changed the value of Major degradation to under maintenance from 0 to .98. This increased our steady-state solution for maintenance by 38.35%, leading to less cost since more turbines are being maintained.

For the reliability factor approach, we noticed that the one-time investment (C_{REL}) increases exponentially, as shown in the graph below. Thus, increasing the value of r toward the maximum value of r would not be the best approach. We tried values of R=0.1. R=0.5, and R=0.99. Overall, we found that a lower R results in higher profit mainly because the cost is minimized in the (C_{REL}) function.

Cost of reliability increase: $100{,}000 * \exp(5*r)$



Modeling of the CMS Benchmark

We modeled our CMS Benchmark by setting up our transition diagram. After calculating every probability outcome from each state we were able to set up our linear equations. We found our steady-state solutions by taking the inverse of the linear equations matrix and multiplying it by our RHS values. Once we had our Steady State solutions we were able to calculate the revenues and costs expected for being in a state for a specific amount of time. Our CMS value resulted in a profit of $951,649. We used this transition diagram as our base diagram and made the necessary changes to model different methods and compare the profit results.

Transition Diagram For CMS Benchmarking:

	O	Min	Maj	Failure By Shock	Failure by Degradation	Maint	SUM
Operational	0.979	0.02	0	0.001	0	0	1
Minor	0	0.979	0.02	0.001	0	0	1
Major	0	0	0.979	0.001	0.02	0	1
Failure by Shock	0	0	0	0.4	0	0.6	1
Failure by Degradation	0	0	0	0	0.4	0.6	1
Maintenance	0.05	0	0	0	0	0.95	1

Final Recommendation

After comparing all of our methods, our final recommendation to the farmer would be to use the liberal preventive maintenance strategy (LPMS). This method had a profit of $1,198,768. Looking at the graph below, it is evident that the LPMS method has a significantly higher profit. The costs were especially the lowest for the LPMS method as they were $60,630 less than the CMS, and significantly lower than the reliability increase with r = 0.9.

Method	Revenue	Costs	Profit
CMS	$2,925,644	$1,973,995	$951,649
CPMS	$2,957,275	$2,844,825	$112,451
LPMS	$3,112,404	$1,913,635	$1,198,768
Reliability Increase (r = 0.1)	$2,949,995	$2,681,426	$268,569
Reliability Increase (r = 0.9)	$3,131,036	$2,702,135	$428,901