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Flying On Time: Reducing Cancellations and Delays Through Goal Programming in Papua New Guinea

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ABSTRACT
Flight delays and cancellations have been identified as persistent problems in PNG, which relies heavily on air transportation because its road network has limited reach and difficult geographical conditions. In this work, Goal Programming is applied to the disruption data provided by the NAC in a 12-month period. Several reasons for delays and cancellations are considered: Technical/Engineering Issues, Fuel Rationing, Crew Shortages, Weather and Infrastructure, Wildlife and Airport Infrastructure, and Aircraft Maintenance. For each category, target values for operations are established along with deviation values that measure the difference between the actual levels and the corresponding targets. As a result of the application of the model, a total deviation value of 100 units was obtained for the entire period. Among the causes, Technical/Engineering Issues caused the greatest deviation (46 units), while Fuel Rationing was second with 34 units. Deviations for other categories included Weather and Infrastructure (9 units), Wildlife and Airport Infrastructure (8 units), Crew Shortages (3 units), and there was no deviation in Aircraft Maintenance. It can be seen how useful Goal Programming is as a decision-making tool for identifying priorities in order to improve operations.

Keywords:
Flight Cancellation,
Flight Delays,
Goal Programming Method,
Optimization,
Papua New Guinea Aviation's

INTRODUCTION

Air transportation is an essential mode of traveling for Papua New Guinea due to its rough landscape and limited access of road connections makes aviation the main usage for traveling. However, the continuously of flight delays and cancellations slows down operations, increases costs for operational matters and gives hard times to passengers/customers. Recent reports highlight that technical issues, fuel rationing and infrastructure limitations are the most common causes of disruptions (PNG Facts, 2023; One Papua New Guinea, 2025).

Airlines worldwide also face the same challenges, but are handled properly with various optimization techniques that help reduce such disturbances. Airline scheduling optimization, for example, it has been identified as a critical area of study in improving reliability (Xu, Wandelt & Sun, 2024). In PNG where we have limited resources that makes problems worse, the method so called Goal Programming gives a way to measure outcomes from operational targets and improve those areas.

In past research, it has been shown that optimization and data science can significantly contribute to minimizing aviation disruptions.

Past research on airline scheduling, airline disruption management, and delay forecasting has shown how inefficiencies can be analysed and overcome using mathematical modelling and decision support. These methods will help airlines to allocate resources better, enhance efficiency, and improve services. Transportation related research has also analysed the impact of problems associated with fuels on transportation operations (Rilwanu et al., 2025). This makes Goal Programming an effective tool for analysis and prioritizing needs in this area.

Therefore, this report project aims to provide a recommendation based on the data to help reduce flight cancellations and delays in Papua New Guinea

Aviation researchers have been studying this issue of flight delays and cancellation. Some researches around the world developed models used to predict outcomes and systems used to find solutions just to help reduce disruptions so schedules could be better followed (Jacyna-Gołda, et al., 2025) displayed a system called Scorecard that can make delay predictions more accurate, while (Zhong, Yu, Huang, & Zhang, 2025) used machine learning algorithms to improve the managing of flight delays in civil aviation.

Even recently, (Queiróz Júnior, Falcão, da Silva, Bezerra, & Machado, 2025) compared with 1000 machine learning studies showing that the two-category classification approach was more effective. Similarly, (Wandelt, Chen, & Sun, 2025) reviewed a global model of delay predictions, show the weather and infrastructure as one of the main causes. These studies show the data-based approaches in improving airline operations.

In the field of Applied Mathematics, the method goal programming has been used widely for transportation systems to balance multiple objectives. (Singh & Yadav, 2025) also reviewed the applications of weighted goal programming in the problem of transportation with multiple objectives and used goal programming to improve how resources are distributed on the network of transportation. These and many more findings show that goal programming works well in such situations where competing goals must be handled simultaneously.

For PNG, it is clearly seen that technical issues, fuel usage and infrastructure management reflect the challenges faced world wide but is worsened due to local (country) conditions. Applying optimization methods such as goal programming provides a structured way to identify which causes of delays contribute most to inefficiency and where interventions will have the greatest impact.

MATERIALS AND METHODS

Data: it was provided by National Airport Corporation (NAC), given the six causes of cancellations and delays. This dataset is real data for a time period of 12 moths (1 year).

The numbers obtained for each category stand for the monthly total of disruption events associated with that particular factor. These six factors were suggested by the National Airports Corporation (NAC), which divided them into independent categories of operational disruption. In this case, we decided to treat delay and cancellation factors as one type of operational disruptions and use their monthly totals in the Goal Programming model.

Why Goal Programming?

Goal Programming is commonly used to measure performance based on various operational goals concurrently. For this research, goal programming is employed as an analysis tool to determine the extent to which these operational goals are being met as well as to find out what the main causes of flight delays and cancellations are (Singh & Yadav, 2025). The objective here is not optimization per se, but analysis.

Monthly data records of six causes of delays and cancellations were analysed:

1. Technical/Engineering Issues
2. Fuel Rationing
3. Crew Shortages
4. Weather and Infrastructure
5. Wildlife and Airport Infrastructure
6. Aircraft Maintenance

Step 1: Define the problem

Each has a target (goal) as:

1. Technical ≤ 60
2. Fuel ≤ 15
3. Crew ≤ 5
4. Weather ≤ 7
5. Wildlife ≤ 3
6. Maintenance ≤ 3

HOW THE TARGETS WERE OBTAINED?

The targets were obtained by getting the monthly averages from each respective causes all through out each month. Each selected target shows the limit where disruptions affect the operations.

1. Technical/Engineering Issues: Target = 60
   - The monthly values range between 60-70.
   - Setting 60 as the target because it shows when the problem becomes uneasily to handle.
2. Fuel Rationing: Target = 15
   - Mid-year values rise as 18-24.
   - Setting it at 15 shows the need of controlling it.
3. Crew Shortages: Target = 5
   - Crew numbers are consistently at 4-5.
   - Target at 5 because it's not that of a bad cause but will be a concern if it goes beyond.
4. Weather and Infrastructure: Target = 7
   - Monthly weather values range at 6-9.
   - Target 7 reflects a realistic operational limit
5. Wildlife and Airport Infrastructure: Target = 3
   - Occurrence is often between 3-4.
   - Target 3 sets a strict safety standard.
6. Aircraft Maintenance: Target = 3
   - Maintenance is always exactly 3.
   - Target 3 confirms it is under control, with no deviations.

In the absence of standard benchmark values set officially by the NAC for operations, target values have been defined based on the operation pattern found in the data and judgments concerning tolerable disruption levels. The target values serve only as benchmarking figures for comparison purposes.

Step 2: Decision Variables

- To measure how far actual values are from the targets

For each cause in each month, we define:

- $d_{i,m}^{-}$: underachievement deviation → how much the actual value is below the target.

- $d_{i,m}^{+}$: overachievement deviation → how much the actual value is above the target.

Where; i – cause (Technical, Fuel, Crew, Weather, Wildlife, Maintenance)

m – month (Jan, Feb, ..., Dec)

The general form of a goal constraint is:

$$\text{Actual Value}_{i,m} + d_{i,m}^{-} - d_{i,m}^{+} = \text{Target}_{i}$$

- If **Actual** > **Target** → $d^{+} = \text{Actual} - \text{Target}, d^{-} = 0$
- If **Actual** < **Target** → $d^{-} = \text{Target} - \text{Actual}, d^{+} = 0$
- If **Actual = Target** → $d^{-} = 0, d^{+} = 0$

Table 1: Monthly Deviations by the Causes

This table displays the monthly deviations from there targets, showing the actual values whether they exceeded the limits or not. Calculations were done using excel.

Formulas used in excel for:

1. d^-: =IF (C2 < D2, D2 - C2, 0)
2. d^+: =IF (C2 > D2, C2 - D2, 0)

Month	**Cause**	**Actual**	**Target**	**d^-**	**d^+**
Jan	Technical/Engineering Issues	62	60	0	2
Jan	Fuel Rationing	18	15	0	3
Jan	Crew Shortages	5	5	0	0
Jan	Weather & Infrastructure	8	7	0	1
Jan	Wildlife & Airport Infrastructure	4	3	0	1
Jan	Aircraft Maintenance	3	3	0	0
Feb	Technical/Engineering Issues	64	60	0	4
Feb	Fuel Rationing	15	15	0	0
Feb	Crew Shortages	5	5	0	0
Feb	Weather & Infrastructure	9	7	0	2
Feb	Wildlife & Airport Infrastructure	4	3	0	1
Feb	Aircraft Maintenance	3	3	0	0
Mar	Technical/Engineering Issues	66	60	0	6
Mar	Fuel Rationing	14	15	1	0
Mar	Crew Shortages	4	5	1	0
Mar	Weather & Infrastructure	9	7	0	2
Mar	Wildlife & Airport Infrastructure	4	3	0	1
Mar	Aircraft Maintenance	3	3	0	0
April	Technical/Engineering Issues	65	60	0	5
April	Fuel Rationing	16	15	0	1
April	Crew Shortages	4	5	1	0
April	Weather & Infrastructure	8	7	0	1
April	Wildlife & Airport Infrastructure	4	3	0	1
April	Aircraft Maintenance	3	3	0	0
May	Technical/Engineering Issues	63	60	0	3
May	Fuel Rationing	20	15	0	5
May	Crew Shortages	4	5	1	0
May	Weather & Infrastructure	7	7	0	0
May	Wildlife & Airport Infrastructure	3	3	0	0
May	Aircraft Maintenance	3	3	0	0
June	Technical/Engineering Issues	61	60	0	1
June	Fuel Rationing	22	15	0	7
June	Crew Shortages	4	5	1	0
June	Weather & Infrastructure	7	7	0	0
June	Wildlife & Airport Infrastructure	3	3	0	0
June	Aircraft Maintenance	3	3	0	0
Jul	Technical/Engineering Issues	60	60	0	0
Jul	Fuel Rationing	24	15	0	9
Jul	Crew Shortages	4	5	1	0
Jul	Weather & Infrastructure	6	7	1	0
Jul	Wildlife & Airport Infrastructure	3	3	0	0
Jul	Aircraft Maintenance	3	3	0	0

Aug	Technical/Engineering Issues	64	60	0	4
Aug	Fuel Rationing	17	15	0	2
Aug	Crew Shortages	5	5	0	0
Aug	Weather & Infrastructure	7	7	0	0
Aug	Wildlife & Airport Infrastructure	4	3	0	1
Aug	Aircraft Maintenance	3	3	0	0
Sep	Technical/Engineering Issues	67	60	0	7
Sep	Fuel Rationing	13	15	2	0
Sep	Crew Shortages	5	5	0	0
Sep	Weather & Infrastructure	8	7	0	1
Sep	Wildlife & Airport Infrastructure	4	3	0	1
Sep	Aircraft Maintenance	3	3	0	0
Oct	Technical/Engineering Issues	66	60	0	6
Oct	Fuel Rationing	15	15	0	0
Oct	Crew Shortages	5	5	0	0
Oct	Weather & Infrastructure	8	7	0	1
Oct	Wildlife & Airport Infrastructure	4	3	0	1
Oct	Aircraft Maintenance	3	3	0	0
Nov	Technical/Engineering Issues	65	60	0	5
Nov	Fuel Rationing	15	15	0	0
Nov	Crew Shortages	5	5	0	0
Nov	Weather & Infrastructure	8	7	0	1
Nov	Wildlife & Airport Infrastructure	4	3	0	1
Nov	Aircraft Maintenance	3	3	0	0
Dec	Technical/Engineering Issues	63	60	0	3
Dec	Fuel Rationing	19	15	0	4
Dec	Crew Shortages	5	5	0	0
Dec	Weather & Infrastructure	7	7	0	0
Dec	Wildlife & Airport Infrastructure	3	3	0	0
Dec	Aircraft Maintenance	3	3	0	0

Table 2: Total Deviations

This table displays the total of each cause in every month and their contribution to the total in values.

Cause	Total d^-	Total d^+	Total Deviation
Technical/Engineering Issues	0	46	46
Fuel Rationing	3	31	34
Crew Shortages	3	0	3
Weather & Infrastructure	0	9	9
Wildlife & Airport Infrastructure	0	8	8
Aircraft Maintenance	0	0	0

Step 3: Constraints

Now, each target is turned into a goal constraint. The general form is:

$$\text{Actual Value}_{i,m} + d_{i,m}^- - d_{i,m}^+ = \text{Target}_i$$

This equation ensures that deviations are explicitly tracked for every cause and month.

January

- $62 + d_{Tech,Jan}^- - d_{Tech,Jan}^+ = 60$
- $18 + d_{Fuel,Jan}^- - d_{Fuel,Jan}^+ = 15$
- $5 + d_{Crew,Jan}^- - d_{Crew,Jan}^+ = 5$
- $8 + d_{Weather,Jan}^- - d_{Weather,Jan}^+ = 7$
- $4 + d_{Wild,Jan}^- - d_{Wild,Jan}^+ = 3$
- $3 + d_{Maint,Jan}^- - d_{Maint,Jan}^+ = 3$

February

- $64 + d_{Tech,Feb}^- - d_{Tech,Feb}^+ = 60$
- $15 + d_{Fuel,Feb}^- - d_{Fuel,Feb}^+ = 15$
- $5 + d_{Crew,Feb}^- - d_{Crew,Feb}^+ = 5$
- $9 + d_{Weather,Feb}^- - d_{Weather,Feb}^+ = 7$
- $4 + d_{Wild,Feb}^- - d_{Wild,Feb}^+ = 3$
- $3 + d_{Maint,Feb}^- - d_{Maint,Feb}^+ = 3$

March

- $66 + d^{-}_{Tech,Mar} - d^{+}_{Tech,Mar} = 60$
- $14 + d^{-}_{Fuel,Mar} - d^{+}_{Fuel,Mar} = 15$
- $4 + d^{-}_{Crew,Mar} - d^{+}_{Crew,Mar} = 5$
- $9 + d^{-}_{Weather,Mar} - d^{+}_{Weather,Mar} = 7$
- $4 + d^{-}_{Wild,Mar} - d^{+}_{Wild,Mar} = 3$
- $3 + d^{-}_{Maint,Mar} - d^{+}_{Maint,Mar} = 3$

April

- $65 + d^{-}_{Tech,Apr} - d^{+}_{Tech,Apr} = 60$
- $16 + d^{-}_{Fuel,Apr} - d^{+}_{Fuel,Apr} = 15$
- $4 + d^{-}_{Crew,Apr} - d^{+}_{Crew,Apr} = 5$
- $8 + d^{-}_{Weather,Apr} - d^{+}_{Weather,Apr} = 7$
- $4 + d^{-}_{Wild,Apr} - d^{+}_{Wild,Apr} = 3$
- $3 + d^{-}_{Maint,Apr} - d^{+}_{Maint,Apr} = 3$

May

- $63 + d^{-}_{Tech,May} - d^{+}_{Tech,May} = 60$
- $20 + d^{-}_{Fuel,May} - d^{+}_{Fuel,May} = 15$
- $4 + d^{-}_{Crew,May} - d^{+}_{Crew,May} = 5$
- $7 + d^{-}_{Weather,May} - d^{+}_{Weather,May} = 7$
- $3 + d^{-}_{Wild,May} - d^{+}_{Wild,May} = 3$
- $3 + d^{-}_{Maint,May} - d^{+}_{Maint,May} = 3$

June

- $61 + d^{-}_{Tech,Jun} - d^{+}_{Tech,Jun} = 60$
- $22 + d^{-}_{Fuel,Jun} - d^{+}_{Fuel,Jun} = 15$
- $4 + d^{-}_{Crew,Jun} - d^{+}_{Crew,Jun} = 5$
- $7 + d^{-}_{Weather,Jun} - d^{+}_{Weather,Jun} = 7$
- $3 + d^{-}_{Wild,Jun} - d^{+}_{Wild,Jun} = 3$
- $3 + d^{-}_{Maint,Jun} - d^{+}_{Maint,Jun} = 3$

July

- $60 + d^{-}_{Tech,Jul} - d^{+}_{Tech,Jul} = 60$
- $24 + d^{-}_{Fuel,Jul} - d^{+}_{Fuel,Jul} = 15$
- $4 + d^{-}_{Crew,Jul} - d^{+}_{Crew,Jul} = 5$
- $6 + d^{-}_{Weather,Jul} - d^{+}_{Weather,Jul} = 7$
- $3 + d^{-}_{Wild,Jul} - d^{+}_{Wild,Jul} = 3$
- $3 + d^{-}_{Maint,Jul} - d^{+}_{Maint,Jul} = 3$

August

- $64 + d^{-}_{Tech,Aug} - d^{+}_{Tech,Aug} = 60$
- $17 + d^{-}_{Fuel,Aug} - d^{+}_{Fuel,Aug} = 15$
- $5 + d^{-}_{Crew,Aug} - d^{+}_{Crew,Aug} = 5$
- $7 + d^{-}_{Weather,Aug} - d^{+}_{Weather,Aug} = 7$
- $4 + d^{-}_{Wild,Aug} - d^{+}_{Wild,Aug} = 3$
- $3 + d^{-}_{Maint,Aug} - d^{+}_{Maint,Aug} = 3$

September

- $67 + d^{-}_{Tech,Sep} - d^{+}_{Tech,Sep} = 60$
- $13 + d^{-}_{Fuel,Sep} - d^{+}_{Fuel,Sep} = 15$
- $5 + d^{-}_{Crew,Sep} - d^{+}_{Crew,Sep} = 5$
- $8 + d^{-}_{Weather,Sep} - d^{+}_{Weather,Sep} = 7$
- $4 + d^{-}_{Wild,Sep} - d^{+}_{Wild,Sep} = 3$
- $3 + d^{-}_{Maint,Sep} - d^{+}_{Maint,Sep} = 3$

October

- $66 + d^{-}_{Tech,Oct} - d^{+}_{Tech,Oct} = 60$
- $15 + d^{-}_{Fuel,Oct} - d^{+}_{Fuel,Oct} = 15$
- $5 + d^{-}_{Crew,Oct} - d^{+}_{Crew,Oct} = 5$
- $8 + d^{-}_{Weather,Oct} - d^{+}_{Weather,Oct} = 7$
- $4 + d^{-}_{Wild,Oct} - d^{+}_{Wild,Oct} = 3$
- $3 + d^{-}_{Maint,Oct} - d^{+}_{Maint,Oct} = 3$

November

- $65 + d^{-}_{Tech,Nov} - d^{+}_{Tech,Nov} = 60$
- $15 + d^{-}_{Fuel,Nov} - d^{+}_{Fuel,Nov} = 15$
- $5 + d^{-}_{Crew,Nov} - d^{+}_{Crew,Nov} = 5$
- $8 + d^{-}_{Weather,Nov} - d^{+}_{Weather,Nov} = 7$
- $4 + d^{-}_{Wild,Nov} - d^{+}_{Wild,Nov} = 3$
- $3 + d^{-}_{Maint,Nov} - d^{+}_{Maint,Nov} = 3$

December

- $63 + d^{-}_{Tech,Dec} - d^{+}_{Tech,Dec} = 60$
- $19 + d^{-}_{Fuel,Dec} - d^{+}_{Fuel,Dec} = 15$
- $5 + d^{-}_{Crew,Dec} - d^{+}_{Crew,Dec} = 5$
- $7 + d^{-}_{Weather,Dec} - d^{+}_{Weather,Dec} = 7$
- $3 + d^{-}_{Wild,Dec} - d^{+}_{Wild,Dec} = 3$
- $3 + d^{-}_{Maint,Dec} - d^{+}_{Maint,Dec} = 3$

Step 4: Objective Function

General Form:

$$\text{Minimize } Z = \sum_{i,m} (d_{i,m}^{-} + d_{i,m}^{+})$$

Where;

- i = cause
- m = month

from step 2 summary table (Table 2) is what we want to minimize. We minimize the sum of deviations (d^{-} and d^{+}) across all causes and months.

Objective function:

$$Z = (0 + 46) + (3 + 31) + (3 + 0) + (0 + 9) + (0 + 8) + (0 + 0)$$

$$Z = 100$$

So, the objective function value = 100, meaning the total deviation across all causes and months is 100 units.

A practical meaning for PNG's Aviation is that 100 units gives a sign that the system is far from its operational goals.

Step 5: Conclusion

Process Recap:

1. Targets were set based on typical values in the dataset (e.g. Technical at 60, Fuel at 15, etc)
2. Deviation variables (d^{-}, d^{+}) were introduced to measure shortfalls and excesses against those targets.
3. Limits were set for each month and cause connecting actual values, targets and differences
4. The objective function was set as the total of all deviations, providing one overall measure of how far the system is form reaching its goal.
5. The largest contributors shown is Technical (46) and Fuel (34). These two causes are a big impact towards the total deviation (100)

RESULTS AND DISCUSSION

The causes contribution (breaking down of the 100 units):

- Technical/Engineering issues: 46
- Fuel Rationing: 34
- Crew Shortages: 3
- Weather & Infrastructure: 9
- Wildlife & Airport Infrastructure: 8
- Aircraft Maintenance: 0

Interpretation:

From the above results:

- Technical/Engineering issues (46) and Fuel Rationing (34) with the most contributed to the deviation.
- Smaller deviations come from Weather (9) and Wildlife (8).
- Crew Shortages (3) are minor.
- Maintenance (0) is fully under control.

So, the areas that needs improvement as clearly seen is Technical/Engineering and Fuel Rationing due to its major contribution to the problem.

The deviation of 100 units shows a significant inefficiency in PNG's aviation system. This value leads to high costs for operational purposes, reducing of schedule flights and more unsatisfied passengers. PNG depend on air transportation the most because of our rough geography and limited road networks, but this main problem has its own challenges that it faces and so it affects the country. The application of goal programming with transportation and allocation of resource problems has been documented (Singh & Yadav, 2025), showing that it is suitable for Papua New Guineas aviation operations.

From what was measured or found is that Technical/Engineering and Fuel rationing are two of the biggest contributors and that is clearly seen from the aging aircrafts and fuel supply systems. So, this two causes the need attention and improvement as fast as possible.

Weather and Wildlife are environmental challenges which are a moderate deviation but still needs better communications and management. Where as Crew shortages are more of a minor along with Aircraft Maintenance they both show effective control.

However, there are also certain limitations that apply to this paper. First, the research utilizes only one year's worth of data concerning aviation operations, and it does not take into account seasonal variation, uncertainty, or fluctuations in disruptions throughout the years. Furthermore, this research concentrates on identifying deviations from operational plans rather than on making optimal operational decisions. It is expected that future researchers will make use of more advanced methods like predictive analytics or machine learning.

Recommendations

1. For Fuel Rationing/ Management: monitor the fuel usage regularly, secure fuel suppliers. Keeping up to date to fuel storage would be better instead of facing difficulties.
2. Technical Issues: strengthen aircraft maintenance by doing regular check ups/inspections, having access to suppliers for spare parts so damaged ones can be replaced immediately and ensuring professional engineers to avoid failures and distributions.
3. Weather: improve weather monitoring and forecasting systems, having a better communication with meteorological services to reduce distribution by bad weather

4. Wildlife Control: by conducting regular inspections(runway) and try create a system for keeping wildlife away.
5. Crew Management: is good so far but best to have back-ups in case of emergencies or expanding workforce.

Overall, these recommendations would help PNG's aviation operations reduce delays and move them closer to their desired targets.

CONCLUSION

The Goal Programming model was successful in identifying those areas within the operation which were causing the delay or cancellations, and gave a structure for prioritization. As from what has been studied above it has shown that Technical Issues and Fuel Rationing as the urgent matter and needs to be attended to immediately. While weather and Wildlife need a moderate improvement to avoid it getting into a big issue. Crew shortages are good but things may happen at anytime and should keep backups for emergencies. For the safety and satisfaction of passengers, taking these issues into consideration and improve them will surely help the country.

By performing the recommendations mentioned above would be an improvement and an achievement. If the deviation value (100 unit) decreases in the years to come then it would show that the progress of reducing flight delays is applied and aviation operation will be at a very good stage. And most importantly, this study illustrates that mathematical modelling can solve/guide problems towards solutions to support and develop Papua New Guinea.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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