**END 395 - Operations Research II**

**2023-2024 Spring**

**PROJECT**

**Cargo Plane Fuel Optimization**

**Group 09**

Ali Berk KARAARSLAN

Ahmet Salih KAYA

Mustafa TUFAN

**ABSTRACT**

Our project focuses on loading pallets onto aircraft in a way that minimizes fuel consumption while ensuring weight limits, cumulative weight limits, pallet type compatibility and “Blue Envelope” restrictions. We developed an integer model that successfully loads the aircraft with pallets in a way that minimizes fuel consumption. Our approach divides the project into 4 parts. First, we loaded the pallets into a suitable position on the plane. Then we arranged the pallets so that they did not overlap. It then includes cumulative weight limits. Finally, we calculated the total weight of the system and ensured that it was kept within regular Blue Envelope limits. We then tested these constraints according to 4 different Center of Gravity Intervals and from the results we obtained, we chose the model that kept our fuel consumption lowest. Our model effectively optimizes cargo allocation within the aircraft, maximizing payload capacity and minimizes fuel consumption based on the provided pallet list.

**Keywords:** Blue Envelope, Maximization, Constraints, Weight Limits, Fuel

1. **Introduction and Overview of Approach**

This project is a continuation of our previously developed model that maximizes the number of pallets placed on the aircraft. We rearranged our model to minimize the fuel consumption by preserving the constraints of the model we had previously developed.

We used 4 types of Center of Gravity (CG) Intervals to minimize the fuel we spent. In our previous model, we had single cumulative weight limits and would adjust our model accordingly. In our new model, we have 4 types of cumulative limits to minimize the fuel we consume. The fuel consumption order of these limits is 2 - 1 - 3 - 4. In other words, the model that complies with the type 2 cumulative limits is the model that consumes the least fuel.

The model we just created reruns the model for each Center of Gravity Interval. It selects the one that minimizes fuel consumption from the results it finds. In this way, our aircraft not only places all pallets in accordance with the constraints, but also carries these pallets in the most fuel efficient way.

1. **Method**

Our model is as follows

***Sets:***

*= Set of Main Deck position indexes sorted by h-arm values*

*= Set of Lower Deck position indexes sorted by h-arm values*

*= Set of position indexes which is PM concatenated by PL*

*S = pallet indexes*

***Parameters:***

*= Lock1 position of Main Deck position i*

*= Lock2 position of Main Deck position i*

*= Lock1 position of Lower Deck position i*

*= Lock2 position of Lower Deck position i*

*=* *h-arm value of Main Deck position i*

*= h-arm value of Lower Deck position i*

*= cumulative weight of Main Deck position i*

*= cumulative weight of Lower Deck position i*

*= coefficient of Main Deck position i*

*= coefficient of Lower Deck position i*

*= type of Main Deck position i*

*= type of Lower Deck position i*

*= weight of pallet j*

*= type of pallet j*

*Dry Operating Weight*

*Dry Operating Index*

*= weight limit of Main Deck position i*

*= weight limit of Lower Deck position i*

***Decision Variables:***

*= weight of position i*

*= index of position i*

*= total weight*

*= total index*

***Objective Function:***

***Constraints:***

*Part 1:*

*//Ensures That At Max 1 Pallet Could Be Assigned To Each Position*

*//Ensures That Pallets Do Not Exceed The Weight Limit For Each Position.*

*//Ensures That A Pallet Could Be Assigned Only One Positions*

*//Main Deck PAG And PMC control*

*Part 2:*

*//Collision control*

*Part3:*

*//Cumulative limit control*

*Part4:*

*//Calculates Weights And Indices Of Each Position.*

We are running this model for each Center of Gravity Interval. Then we achieve the optimal solution by checking each solution and choose the one that places all pallets correctly and minimizes fuel consumption.

This flow chart outlines our models implementation on Python.

1. **Results and Discussion,**

**Pallets 4**

|  |  |
| --- | --- |
| CG-Interval | Interval 2 |
| Solution Time | 22 seconds average |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Pallets** | **Positions** |  | **Pallets** | **Positions** |
| PMC24 | ABR(96) |  | PMC4 | PSL(96) |
| PMC9 | ABL(96) |  | PMC27 | STR(96) |
| PMC32 | BCL(96) |  | PMC5 | STL(96) |
| PMC20 | BCR(96) |  | PMC16 | SS |
| PMC37 | CER(96) |  | PMC11 | TT |
| PMC10 | CEL(96) |  | PMC36 | UU |
| PMC1 | EFR(96) |  | PMC2 | VV |
| PMC21 | EFL(96) |  | PMC25 | 11P(96) |
| PMC34 | FHR(96) |  | PMC7 | 12P(96) |
| PMC35 | FHL(96) |  | PMC19 | 21P(96) |
| PMC28 | HJR(96) |  | PMC3 | 22P(96) |
| PMC29 | HJL(96) |  | PMC23 | 23P(96) |
| PMC26 | JKR(96) |  | PMC33 | 24P(96) |
| PMC30 | JKL(96) |  | PMC31 | 31P(96) |
| PMC17 | KMR(96) |  | PMC18 | 32P(96) |
| PMC6 | KML(96) |  | PMC15 | 33P(96) |
| PMC22 | MPL(96) |  | PMC12 | 41P(96) |
| PMC13 | MPR(96) |  | PMC8 | 42P(96) |
| PMC14 | PSR(96) |  |  |  |

**Pallets 5**

|  |  |
| --- | --- |
| CG-Interval | Interval 2 |
| Solution Time | 18 seconds average |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Pallets** | **Positions** |  | **Pallets** | **Positions** |
| PMC4 | ABR(96) |  | PMC3 | PP |
| PMC19 | ABL(96) |  | PMC32 | RR |
| PMC18 | BCL(96) |  | PMC11 | SS |
| PMC31 | BCR(96) |  | PMC30 | TT |
| PMC16 | CER(96) |  | PMC29 | UU |
| PMC2 | CEL(96) |  | PMC14 | VV |
| PMC5 | EFR(96) |  | PMC25 | 11P(96) |
| PMC33 | EFL(96) |  | PMC24 | 12P(96) |
| PMC13 | FHR(96) |  | PMC7 | 21P(96) |
| PMC15 | FHL(96) |  | PMC6 | 22P(96) |
| PMC20 | HJR(96) |  | PMC23 | 23P(96) |
| PMC12 | HJL(96) |  | PMC8 | 24P(96) |
| PMC28 | JKR(96) |  | PMC26 | 31P(96) |
| PMC9 | JKL(96) |  | PMC22 | 32P(96) |
| PMC27 | KMR(96) |  | PMC17 | 33P(96) |
| PMC1 | KML(96) |  | PMC10 | 41P(96) |
| PMC21 | MM |  |  |  |

1. **Conclusions**