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THE AEROPLANE MASS AND BALANCE AS AN IMPORTANT FACTOR OF THE FLIGHT SAFETY

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Summary. The balancing aircraft is a very broad topic. Because in this diploma thesis it is not possible to disassemble the whole issue, therefore content of the work focuses on a selected portion of the field of balancing. The first part discusses the various factors affecting weight and balance of aircraft and describes the procedures and processes to ensure the balance of the aircraft. The core thesis describes a specific proposal for solution of enlisted passengers on board of the aircraft to achieve the most ideal balance. In conclusion, the results of the calculations are assessed and the specific cases of air accident importance of this area of air traffic are demonstrated.

Keywords: center of gravity, mean aerodynamic chord, moment, weight, load

1. INTRODUCTION

The airplane, to safely perform each phase of flight (takeoff, climb, cruise, descent and landing), has to have every moment of mass and center of gravity calculated within the acceptable range that is specified in the AFM (AFM - Flight Manual) or Operations Manual (OM - Operating Manual). The weight and center of gravity location varies during each phase of flight. These changes are mainly due to fuel consumption during the flight, the transfer of individual tanks, changing the configuration of the airplane and also to change location of cargo and passengers. Therefore, it is necessary to evaluate the current position of the mass towards the center of gravity in different phases of flight, pay attention already during the pre-flight preparation.

Basic knowledge of problems of mass and balance then possible to avoid overloading the airplane, its uproperly loaded and dangerous situations.

Weight and balance issues described ICAO Annex 6 and derived there from prescription L-6 and further European Regulation JAR - OPS 1, Part J.

2. PROPOSED SOLUTIONS OF PASSENGERS DEPLOYMENT

The essence of the proposal is the use of actual passengers´ weights, rather than tabulated values. Table values are often inaccurate and therefore represent a potential risk in the balance of the aircraft.

Accurate weights are derived from passenger floor scales that are placed on the floor in front of tripping the counter. These values are then processed by a program included in the calculation of the center of gravity position.

2.1. Floor scales and Airbus A 318.

Floor Scales are placed before the check-in desk or counter self check-in. Passengers receive a boarding pass with a given seat after they have been already weighed and their weight is assigned to the seat.

2.2. The components

The program begins to work when it comes to traveling to a triggering counter where their weight is recorded. If a particular passenger requires the seat in the aircraft and this site is free, the space program shall allocated and transfer the given seat not to effect the mass conversion on the resulting center of gravity of the aircraft. If the passenger does not require a specific seat, the program he himself assigned to seat and the calculation is carried out.

Automatic deployment of passengers is subjected to two rules. The program places passengers always on the lighter side of the aircraft in order to balance the torque to the left and right sides of the plane, and also the moment of the most straight to the front and rear of the aircraft, so that the center of gravity as close as possible.

2.3. Constants seats

The constants are calculated and measured in technical drawings. Inside the source code of the program seats are divided into four sections, namely:

1. The seats A, B, C with the numbers 1 to 11 represent a section of the left front of the center of gravity

2. Seats A, B, C with numbers 12 to 22 represent the left rear section of center of gravity

3. The seats D, E, F with the numbers 1 to 11 represent a section of the front right of the center of gravity

4. The seats D, E, F, with the numbers 12 to 22 represent a section of the right rear of the center of gravity

The center of gravity is located between the groups of seats ABC and DEF. Constants are displayed as a dimension in the picture number 1.

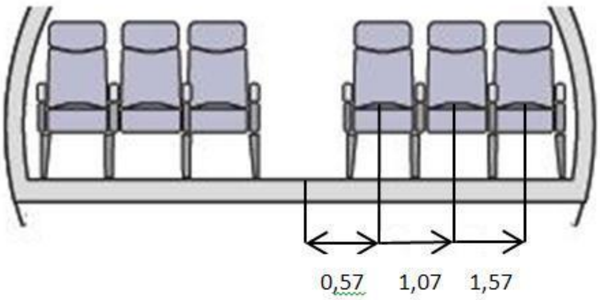

Figure 1
Distances between the seats

All distances between the seats are the same as for seats in row 9 and 10. Between these rows is an emergency exit. Dimension distances between the seats are shown in Figure number 2.

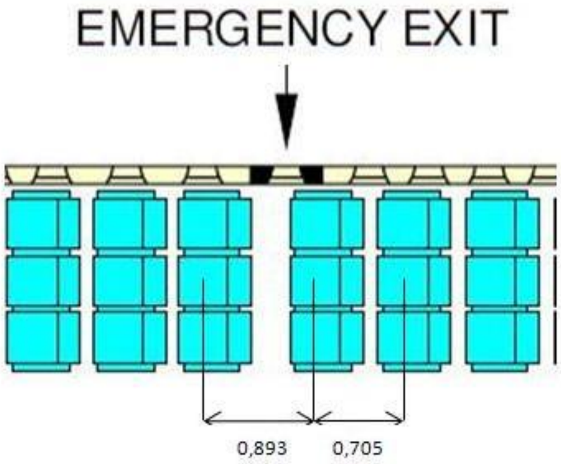

Figure 2
Distances between the seats with an emergency exit

As the reference plane is determined by the nose of the aircraft. Using these constants, the program calculates the new center of gravity and, consequently, the percentage of the position of the mean aerodynamic chord. These calculations are converted continuously with the addition of another passenger. The overall footprint of the aircraft along with the distance from the reference plane from the first row of seats is pictured in Figure number 3.

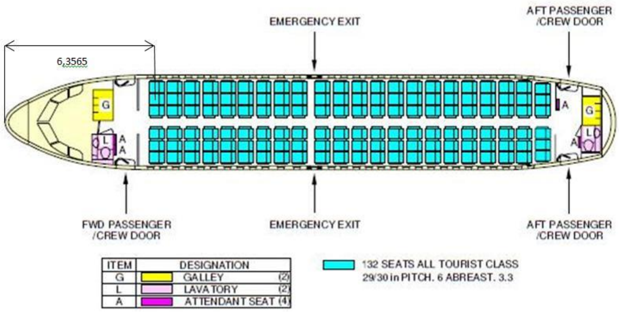

Figure 3
Footprint of the cabine

2.4. Constants for calculating the center of gravity

A constant that is used for calculating the center of gravity in the program and the percentage of the mean aerodynamic chord are shown in Figure No. 4. Dimensions are in meters. At the empty aircraft the mean aerodynamic chord is at 26%.

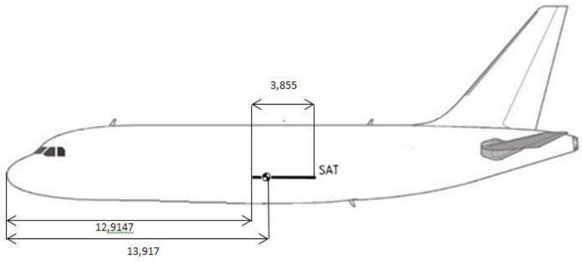

Figure 4
The center of gravity position of the aircraft

2.5. Computation

After loading the weight of the passenger the program first compares the moment of left and right sides of the aircraft and prepares a place for easier the passenger side. If the moments are equal, the program prepares location to any passenger seat as close to the center of gravity. Subsequently, the moment compares the front and rear of the aircraft where passengers are located on the lighter side as close to the center of gravity which is vacant. If the passenger is requested to sit on the selected seat and the seat is vacant, he can settle on the seat and the program continues to work as if he himself sat on the seat.

3. VISUAL PROGRAM

The staff have facilitated work in the processing of passengers who have a requirement to sit in a particular place and to be able to recognize immediately that the place is already occupied, the program has a graphical page shown in Figure number 5.

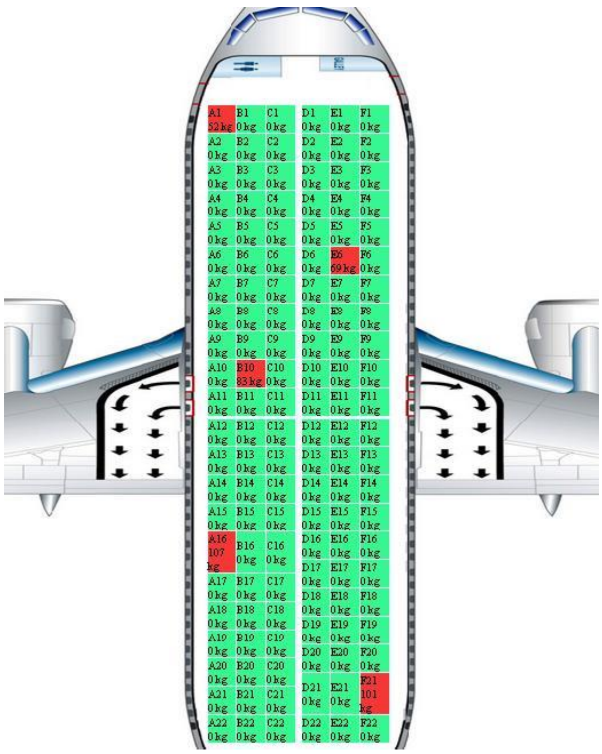

Figure 5
Graphical page of the program

3.1. Inputs

Since it is not realistic to have floor scales the simulation program must be carried out to simulate the inputs. Weight is simulated by selected random numbers from 50 to 110 kg. To occupy one seat a passenger who does not require a specific location the program the button Sit for a passenger is used. Simulation program carries out weighing the passenger seated on the most appropriate place for the center of gravity. To accelerate the simulation of filling the aircraft by passengers who do not require a specific location is determined by a key: fill the plane. This program button cycles through the function key Sit passenger until it fills the whole plane. If a passenger has a request to seat on the specific place, use the button: Sit passenger on the selected place. But in front of the window next button is for choosing required seat.

The program settles selected and assign simulated weight into the passenger seat. After completing the simulation and evaluation the results the simulation can be repeated. We use the Delete button and the program empties the whole plane and are waiting for further input. Input buttons are shown in Figure number 6.

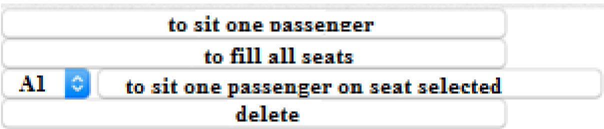

Figure 6
Input buttons

3.2. Outputs

- The total sum of moments of the passengers on the left side of the aircraft center of gravity.
- The sum total moment of passengers on the right side of the aircraft center of gravity.
- ACG reader- total moment of passengers and empty aircraft from the reference plane.
- ACG denominator- total mass of passengers and empty aircraft.
- ACG- center of gravity distance from the reference plane.
- % SAT center of gravity is expressed as a percentage of the mean aerodynamic chord.
- Seating- rank order of randomly simulated passenger weights.

3.3. Simulation

For comparison, calculations and possible errors were performed by 50 simulations, which are recorded in the table.

Table 1 Simulation outputs

	%SAT			%SAT
1	26,623		26	26,253
2	24,972		27	24,801
3	25,649		28	24,575
4	25,160		29	25,862
5	26,296		30	25,428
6	25,489		31	25,665
7	25,114		32	25,582

8	25,607		33	25,915
9	26,402		34	25,874
10	26,107		35	24,749
11	25,816		36	25,331
12	26,188		37	25,694
13	25,171		38	25,287
14	25,755		39	25,739
15	24,978		40	25,923
16	26,125		41	25,900
17	25,908		42	25,460
18	25,101		43	25,693
19	26,418		44	25,199
20	26,608		45	25,463
21	25,532		46	26,196
22	26,134		47	26,537
23	25,120		48	25,522
24	25,239		49	25,681
25	25,722		50	26,052

After the 50-s simulations the average occupancy of the aircraft passengers shift MAC% to 25,673%, a shift of the center of gravity only about 0.327% to the front. With the largest shift backwards is 26.623%, which is a shift of 0.623%. The biggest shift forward is 24,575%, this is offset by 1,425%.

The forward movement is greater because of uneven distribution of seats to the aircraft center of gravity. The lines 1 to 9 from the center of gravity of the aircraft are more remote than lines 14 to 22, since the row 9 and 10 are the emergency exits and there is a gap greater than in the other rows.

4. CONCLUSION

The mass and balance of aircraft is an important pre-flight activity. If improperly balanced aircraft maneuverability is impaired, which can lead to tragic accidents. The proposed program replaces the real tabular values, which helps to minimize errors in the actual balancing.

The program currently covers only the issue passenger distribution, but has the potential to be further extended. The program can be further supplemented by calculating the moments of individual containers used to transport cargo and baggage, as well as moments of individual tank with fuel.

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