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Optimization of The Ground Roll Distance of Boeing 747 Aircraft Using Fuzzy Logic Approach

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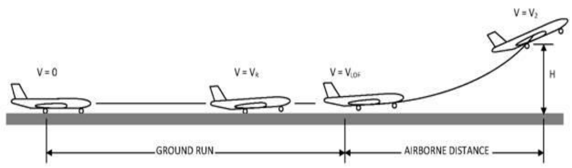
ABSTRACT

A new take off method for Boeing 747-400 passenger aircraft is hereby suggested in this paper which is based on a mathematical model using optimization technique. In this paper, the ground roll distance is minimized using linear programming model, and validated by using fuzzy decisive set method [10] with the concept that as the consumption of fuel increases on account of increased thrust could be saved by reduction of distance [1]. It is also show that the total travel time of Boeing 747-400 passenger aircraft may be reduced. To improve the accommodation of air transportation frameworks, Short Take-Off and Landing (STOL) is an advantageous trademark for any size of the plane [9]. Applying fueled high-lift frameworks is a powerful strategy for accomplishing this objective. Notwithstanding, such frameworks normally require plane wings to be furnished with uncommonly planned streamlined fueled gadgets to accomplish the adequate lift [4]. Thus new method has been proposed to decrease ground-run distance using optimization technique.
Keywords : Ground Roll Distance, Optimization Technique, Linear Programming, and Fuzzy Decisive Set Method.

I. INTRODUCTION

During ancient period transportation was by walk [4]. Later evolved the transportation modes like cycles, motors, bikes, bus, tram, and trains. Theses modes had very limited speed which led to invention of aircraft. Aircraft [9]; in the present scenario is the fastest mode of transport available for passenger and cargo transportation for the people to commute various places. This however requires a certain runway length for it to gain optimal velocity and lift. Here we optimize (minimize) the ground roll distance and ensure that air service be available to people of different topographic locations [1]. As well as it will be minimize the consumption of the fuel of the aircraft.



OPTIMIZATION TECHNIQUE

Operation research is the study of have to form mathematical models of complex engineering and management problems and have to analyze them to gain insight about possible solutions. The optimization problem comprises of expanding or limiting a genuine capacity by deliberately picking information esteems from inside a permitted set and processing the estimation of the capacity. The speculation of enhancement hypothesis and systems to different details includes an enormous territory of applied arithmetic. All the more, by and large, improvement incorporates discovering "best accessible" estimations of some target work given a characterized area, including a wide range of sorts of target capacities and various kinds of spaces. It deals with decision problems that concerned three fundamental issues they are decisions variables, constraints, objectives. Decision Variables: It is open to decision makers. The values of the variables are not known when you start the problem. The factors, as a rule, speak to things that you can alter or control, for instance, the rate at which to produce things. The goal is to find values of the variables that provide the best value of the Objective function. Constraints: It is limiting decision choices. Scientific articulations that consolidate the factors as far as possible on the potential arrangements.

FACTORS INVOLVED IN THE GROUD ROLL DISTANCE

- LIFTOFF VELOCITY
- STALL VELOCITY
- LIFT COEFFIENT
- THRUST TO WEIGHT RATIO

Data collection

Stall velocity	223km/h
Take off velocity	268km/h
Thrust to weight ratio	0.26
Coefficient of lift	2.6

Objective function

Minimize,

$Z=3x_1+3.29x_2+0.41x_3+4.17x_4$

Subjected to,

$X_1>=223$

$X_2>=268$

$X_3>=2.6$

$X_4>=0.26$

$X_1, x_2, x_3, x_4,>0$

The above objective function is obtained using the equation shown below.

$$S_g = \frac{1.21(\frac{W}{S})}{g\rho(Cl)\max\left[\frac{T}{W}-\frac{D}{W}-\mu\left(1-\frac{L}{W}\right)\right]} + 1.1N\sqrt{\frac{2}{\rho}\frac{W}{S}\frac{1}{CL}}$$

SUMMARY OF OUT PUT

SOLUTION BY USING SIMPLEX METHOD

Optimal solution found

Minimum Z = 2213.56m

Variable	Value
X1	320.61
X2	385.31
X3	2.7
X4	0.41

FINDING

From the above observation it is inferred that the ground roll distance of Boeing 747-400 reduced to 2213.56m from 2990m.

FUZZY DECISIVE SET METHOD

Algorithm

Step one. Set λ= 1 whether a feasible set satisfying the constraints of the Problem exists or not using phase one of the simplex method. If a feasible set exists, set λ = 1; Otherwise, set λ^L = 0 and λ^R = 1 and go to the next step.

Step two. For the value of $\lambda = (\lambda^L + \lambda^R) / 2$; update the value of λ^L and λ^R using the Bisection method as follows:

Equivalent non-linear programming problem:

Min λ Objective function,

$$\frac{3x1 + 3.29x2 + 0.41x3 + 4.17x4}{2213.56} \geq \lambda$$

Sub to,

$$\frac{223 - x1}{3x1 + 3.29x2 + 0.41x3 + 4.17x4} \geq \lambda$$

$$\frac{268 - x2}{3x1 + 3.29x2 + 0.41x3 + 4.17x4} \geq \lambda$$

$$\frac{2.6 - x3}{3x1 + 3.29x2 + 0.41x3 + 4.17x4} => \lambda$$

$$\frac{0.26 - x4}{3x1 + 3.29x2 + 0.41x3 + 4.17x4} => \lambda$$

$$0 <= \lambda <= 1$$

x1, x2, x3, x4,>=0

That is, Min λ Objective function,

$3x1 + 3.29x2 + 0.41x3 + 4.17x4 >= \lambda (2213.56)$

Sub to,

$(1+3\lambda)\, x1 + \lambda(3.29x2 + 0.41x3 + 4.17x4) >= 223$

$(1+3.29\lambda)\, x2 + \lambda(3x1 + 0.41x3 + 4.17x4) >= 268$

$(1+0.41\lambda)\, x3 + \lambda(3x1 + 3.29x2 + 4.17x4) >= 2.6$

$(1+4.17\lambda)\, x4 + (3x1 + 3.29x2 + 0.41x3) >= 0.26$

Let's solve the problem by using the fuzzy decisive set method.

For λ = 1, the problem can be written as,

Minλ, Objective function,

Z= $3.76x1 + 3.13x2 + 0.0039x3 + 15.05x4$

Sub to,

$4\, x1 + 3.29x2 + 0.41x3 + 4.17x4 >= 223$

$4.29x2 + 3x1 + 0.41x3 + 4.17x4 >= 268$

$1.41\, x3 + 3x1 + 3.29x2 + 4.17x4 >= 2.6$

$5.17\, x4 + 3x1 + 3.29x2 + 0.41x3 >= 0.26$

x1, x2, x3, x4,>=0

And since the feasible set is empty, by taking λ^L = 0 and λ^R = 1; the new value of λ = (0+1)/2 = 1/2 is tried.

Objective function,

$Z = 3x_1 + 3.29x_2 + 0.41x_3 + 4.17x_4$

Sub to,

$2.5x_1 + 1.64x_2 + 0.20x_3 + 2.08x_4 >= 223$

$1.5x_1 + 2.64x_2 + 0.20x_3 + 2.08x_4 >= 268$

$1.5x_1 + 2.64x_2 + 1.20x_3 + 2.08x_4 >= 2.6$

$1.5x_1 + 1.64x_2 + 0.20x_3 + 3.08x_4 >= 0.26$

$x_1, x_2, x_3, x_4, >= 0$

And since the feasible set is empty, by taking λ^L = 0 and λ^R = 1; the new value of λ = (0+1)/2 = 1/2 is tried. If the feasible set is empty, the λ^L value is same and λ^R value changes, since the feasible set is non empty λ^L changes, and λ^R is same. The following values of λ are obtained in the next iterations

λ =0.125

λ =0.0625

λ =0.3125

λ =0.01562

λ =0.0078125

λ =0.00390625

λ =0.001953125

λ =0.0009765625

λ =0.000488281

λ =0.0002441406

λ =0.0001220703

λ =0.0000610351

λ *=0.0000305175

Consequently, we obtain the optimal value of λ at the 15th iteration by using the set method.

II. COMPARISON

Comparison between simplex and Fuzzy decisive methods			
Simplex method		**Fuzzy decisive set method**	
Variable	**Value**	**Variable**	**value**
Stall velocity	320.61km/h	Stall velocity	320.68km/h
Lift off velocity	385.31km/h	Lift off velocity	385.40km/h
Coefficient of lift	2.73	Coefficient of lift	2.74
Thrust to weight ratio	0.41	Thrust to weight ratio	0.37
Ground roll distance= **2213.56m**		Ground roll distance=**2212.32m**	

III. CONCLUSION

The actual ground roll distance is 2990m. From the obtain results we could conclude that we can minimize the ground roll distance to 2232.33m (approximately). Thus from this paper it can be concluded that .The fuel consumption can be reduced, because during the takeoff aircraft needs more Amount of thrust. Accidents can be prevented at the time of takeoff. The total travel time of the aircraft form source to destination can also be reduced.

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