Geometric Parameters Selection of a Multirole Fighter Aircraft

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Abstract: Our project is to design a multirole fighter jet aircraft. A multirole fighter jet aircraft is an aircraft designed to perform different roles in warfare. The air-to-air combat role has been normally performed by fighter aircraft. In addition, a multirole fighter jet aircraft has secondary roles such as air-to-surface attack, intercepting, reconnaissance, escorting and air cover. The term multirole has been reserved for aircraft designed with the aim of using a common airframe for multiple tasks where the same basic airframe is adapted to a number of differing roles. The main motivation for developing multirole aircraft is cost reduction in using a common airframe. The project report comprises of a literature survey of about 10 fighter aircrafts. After this an appropriate aerofoil is selected and its important parameters are computed. Then, performance graphs are drawn and a 3-view diagram of the aircraft is drawn. Finally, model is made and tested.

Keywords: Fighter, Multirole, Span, Thrust to weight.

I. Introduction

A multirole fighter jet aircraft is an aircraft designed to perform different roles in warfare. The air-to-air combat role has been normally performed by fighter aircraft. So a multirole fighter jet aircraft with air combat role and other secondary role such as air-to-surface attack is as often called a multirole fighter. The term has been reserved for aircraft designed with the aim of using a common airframe for multiple tasks where the same basic airframe is adapted to a number of differing roles. Originally the term was used for a common airframe built in a number of different variants for different roles. Multirole has also been applied to one aircraft:

- Primary air-to-air combat role,
- Secondary role like air-to-surface attack.

More roles can be added, such as air reconnaissance, forward air control, and electronic warfare. Attack missions include the subtypes air interdiction, Suppression of Enemy Air Defence (SEAD), and Close Air Support (CAS). The main motivation for developing multirole aircraft is cost reduction in using a common airframe.

II. Procedure

A. Design of an Aircaft: Aircraft design is both an art and a science. It's the intellectual engineering process of creating on paper (or on a computer screen) a flying machine to meet certain specifications and requirements established by potential users (or as perceived by the manufacturer). This process is rather specified one that is tempered by good intuition developed via by attention paid to successful aircraft designs that have been used in the past, and by (generally proprietary) design procedure and databases (hand books etc.) that are a part of every aircraft manufacturer.

B. *Phases of Aircaft Design:* The complete design process has gone through three distinct phases that are carried out in sequence. They are:

- Conceptual design
- Preliminary design
- Detailed design

C. Conceptual Design: The design process starts with a set of specifications (requirements) for a new aircraft, or much less frequently as the response to the desire to implement. The first steps towards achieving that goal constitute the conceptual design phase. Here, within a certain somewhat fuzzy latitude, the overall shape, size, weight and performance of the new design are determined.

The product of the conceptual design phase is a layout on a paper or on a computer screen) of the airplane configuration. But one has to visualize this drawing as one with flexible lines, capable of being slightly changed during the preliminary design phase. However, the conceptual design phase determines such fundamental aspects as the shape of the, the wings related to the

fuselage, the shape and location of the horizontal and vertical tail, the use of an engine size and placement etc., the major drivers during the conceptual design.

Structural and context system considerations are not dealt with in any detail. However, they are not totally absent. During the conceptual design phase the designer is influenced by such qualitative as the increased structural loads imposed by a high horizontal tail location trough the fuselage, and the difficulties associated with cut-outs in the wing structure if the landing gear are to be retracted into the wing rather than the fuselage or engine nacelle. No part of the design is ever carried out in a total vacuum unrelated to the other parts.

D. Preliminary Design: In the preliminary design phase, only minor changes are made to the configuration layout indeed. It is in the preliminary design phase that serious structural and control system analysis and design take place.

E. Detail Design: The detail design phase is literally the nuts and bolts phase of airplane design. The aerodynamic, propulsion, structures performance and flight control analysis have all been finished with the preliminary design phase. For detail design the airplane is now simply a machine to be fabricated.

F. The Seven Intellectual Pivot Points for Conceptual Design: The design process is an art of creativity and like all creative creatures, there is no one correct and absolute method to carry it out. However conceptual design can be imagined at an array of the seven points at strategic locations in some kind of intellectual space, and these pivot points are connected by a verb of detailed approaches.

G. Design Sequence

1. Collection of existing similar aircraft data.
2. Retrieval of data.
3. Design graphs.
4. Preparation design data sheet.
5. Mission specification.
6. Weight estimation.
    - Mission fuel weight estimation
    - Operating tentative weight estimation
    - Operating empty weight estimation
    - Empty weight estimation
    - Payload weight estimation
    - Overall take-off weight estimation
7. Aerofoil selection.
8. Wing loading estimation.
    - Based on stall velocity
    - Based on landing distance
    - Calculation of wing area
9. Thrust to weight ratio estimation.
    - Based on take-off distance
    - Based on max rate of climb
    - Based on max velocity
    - Calculation of thrust
10. Power plant selection.
11. Performance curves.
12. Three view diagram of aircraft.

III. Results

A brief study of different types of aircraft is studied and students are given one aircraft for design. The aircraft are studied based on:

- Engine used
- Passenger or fighter (use of the aircraft)
- Type of controls
- Fuselage and avionics arrangement
- Aerodynamic data

A. Purpose and Scope of Aircraft Design

The process of design in general involves use of knowledge in diverse fields to arrive at a product. Airplane design involves synthesizing knowledge in areas like aerodynamics, structures, propulsion, systems and manufacturing techniques, to arrive at the configuration of an airplane that will satisfy requirements regarding functional aspects, operational safety and cost.

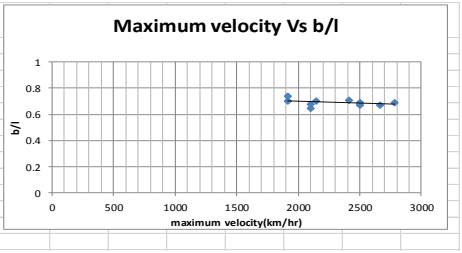
The design of an airplane is a complex engineering task. It generally involves the following:

- Obtaining the specifications and determining the geometric parameters.
- Selection of power plant.
- Details structural design of construction.
- Fabrication of prototype.
- Aircraft performance, load, stability and structural integrity from flight test.

Thus the configuration of different types of aircraft is studied.

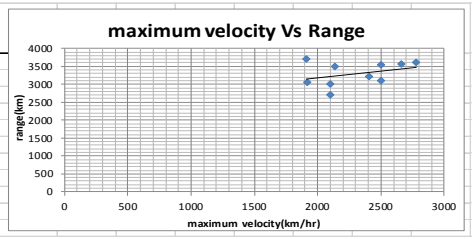
Graph – 1

Maximum velocity(km/hr)	b/l
2100	0.68
2500	0.67
2780	0.69
2665	0.67
1915	0.74
2410	0.71
2100	0.65
2500	0.69
1912	0.7
2140	0.7



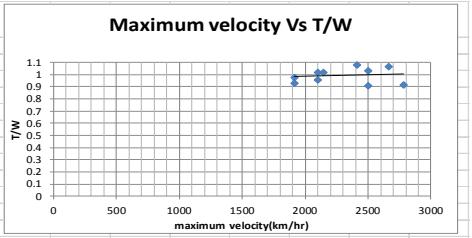
Graph – 2

maximum velocity(km/hr)	Range (km)
2100	3000
2500	3530
2780	3600
2665	3570
1915	3055
2410	3220
2100	2700
2500	3100
1912	3700
2140	3500



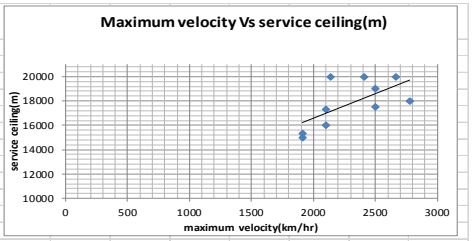
Graph – 3

Maximum velocity(km/hr)	T/W
2100	0.96
2500	0.91
2780	0.92
2665	1.07
1915	0.93
2410	1.08
2100	1.02
2500	1.03
1912	0.98
2140	1.02



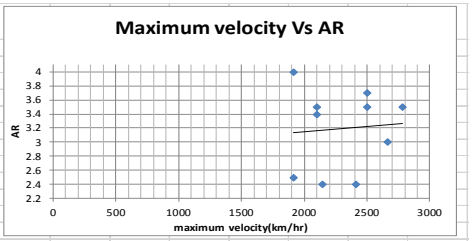
Graph – 4

Maximum velocity(km/hr)	Service ceiling(m)
2100	17300
2500	19000
2780	18000
2665	20000
1915	15000
2410	20000
2100	16000
2500	17500
1912	15325
2140	20000



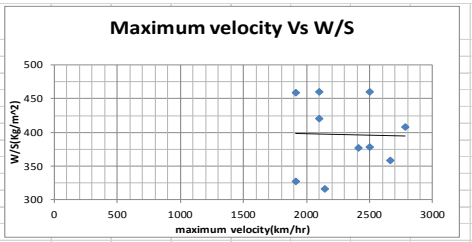
Graph – 5

Maximum velocity(km/hr)	AR
2100	3.5
2500	3.5
2780	3.5
2665	3
1915	4
2410	2.4
2100	3.4
2500	3.7
1912	2.5
2140	2.4



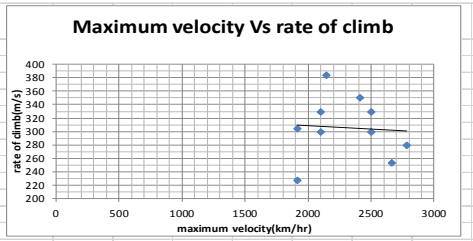
Graph – 6

Maximum velocity(km/hr)	W/S(kg/m^2)
2100	421
2500	378
2780	408
2665	358
1915	459
2410	377
2100	460
2500	460
1912	328
2140	317



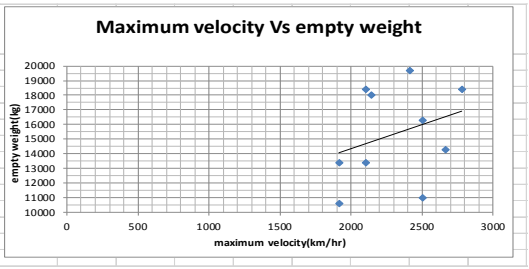
Graph - 7

Maximum velocity(km/hr)	Rate of climb(m/s)
2100	300
2500	300
2780	280
2665	254
1915	228
2410	350
2100	330
2500	330
1912	305
2140	384



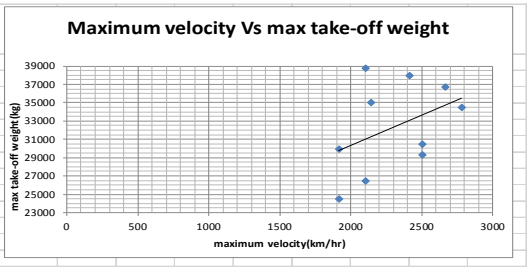
Graph -8

Maximum velocity(km/hr)	Empty weight(kg)
2100	18400
2500	16300
2780	18400
2665	14300
1915	13387
2410	19700
2100	13380
2500	11000
1912	10600
2140	18000



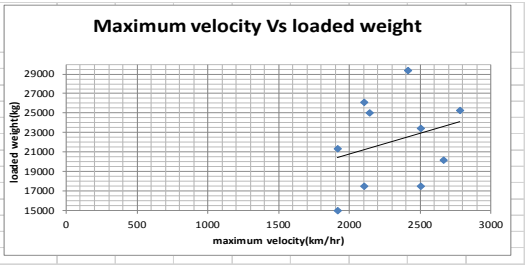
Graph -9

Maximum velocity(km/hr)	Max take-off weight(kg)
2100	38800
2500	30450
2780	34500
2665	36700
1915	29937
2410	38000
2100	26500
2500	29300
1912	24500
2140	35000



Graph - 10

Maximum velocity(km/hr)	Loaded weight(kg)
2100	26090
2500	23430
2780	25300
2665	20200
1915	21320
2410	29410
2100	17500
2500	17500
1912	15000
2140	25000



B. Selection of Parameters

The comparative data for different aircrafts were studied and the following fundamental design parameters were selected (Graphs for comparative data are enclosed).

TABLE I: DATA RETRIEVED FROM COMPARATIVE STUDY OF GRAPH

Main parameters

Sl.no.	Parameters	Values
1	Maximum velocity	2600 km/hr
2	Span to length ratio (b/l)	0.67
3	Aspect Ratio (AR)	3.25
4	Range	3400
5	Wing loading (W/S)	390 kg/m^2
6	Thrust to weight ratio (T/W)	1.06
7	Service ceiling	18200 m
8	Rate of climb	300
9	Maximum take off weight	31000 kg

IV. CONCLUSIONS

In this work a parametric study was done for multi roller aircraft. From study it was decide to design for an aircraft with following parameters:

Maximum velocity	2600 km/hr
Span to length ratio (b/l)	0.67
Aspect ratio (AR)	3.25
Range	3400
Wing loading (W/S)	390 kg/m^2
Thrust to weight ratio (T/W)	1.06
Service ceiling	18200 m
Rate of climb	300
Maximum take off weight	31000 kg

Other details like weight estimation, performance calculation, wing geometric selection, drag estimation, airfoil selection and stability details will be given in next publication.

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