A configuration plan for an aircraft engineering essay

Environment, Air

As due to time limitations the maximum number of attempts allowed is 2. There will be 3 missions as: mission 1, mission 2, and mission 3. During each mission the aircraft must take off and fly 3 laps. LAP1= 360 left. LAP2= 360 right. LAP3= 360 vertical. MISSION 1: (Without payloads)In this mission there is no payload attached internally or externally to plane. The plane must takeoff at a distance of 100 feet. The aircraft must complete 3 laps as listed above. MISSION 2: (with external payloads)When the plane successfully completes its 1st mission and lands safely then ground crew loads the external payloads on both the wings. There are two payloads on each side of the wing, as whole 4 payloads are attached on wings and their weight must not be less than 8-lbs. After that again the plane have to takeoff from 100m distance and complete 3 laps. MISSION 3: (with internal payloads)After completing 2nd mission successfully the plane lands for its 3rd mission. Again the ground crew remove the external payloads and load payloads internally whose weight must not be less than 6-lbs. Same above again it has to complete 3 laps. FLIGHT COURSE: PAYLOAD: The payload is made up of PVC pipes which was 12 inches long and 3 inches wide. Further payloads are divided into sub categoriesExternal Payloads: Externally 4 payloads are attached on both sides of the wings. Total weight of these 4 payloads was 8-lbs or more. Internal payloads: According to DBFC- VI requirements 1 or 2 payloads whose weight should be 6-lbs. These have to be loaded into the fuselage section during 3rd mission. AIRCRAFT STORAGE: Aircraft must fit in a box of 2-ft wide, 1-ft high and by 3-ft long. These parameters should be kept for dimensions of box internally. PROPULSION SYSTEM: According to our design of engine powered plane we used tractor assembly formation with propeller. These propellers are available easily in the market. AIR CRAFT COST CONSIDERATIONS: These calculations have been taken in keeping in view all calculations which are finalized for our plane. It include all items like engine, wooden sheets, servos and other miscellaneous items. Following table shows the detail of all items used. ComponentType of componentNo. of components and quantity usedcost of individual itemTotalEngineServoswoodPush rodsFiber clothPropellerLanding gearsGlow plugMiscellaneousAIRCRAFT CONFIGURATIONS REGARDING MISSIONS: Conceptual aircraft design features specially the wings, empennage, landing gears, fuselage, propulsion system and tail boom. FIGURES OF MERIT (FOM): Numerical FOMs were used to compare various aircraft features on a scale of 1(poor) to 5 (excellent). Each figure was calculated on basis of: PerformanceConstructionReliabilityStability and control (S&C)CostWING CONFIGURATION: As there are five members so everyone gave his opinion about wing selection. Five different configurations were considered : Bi-plane, low wing, high wing, mid wing and flying wing. The Bi plane wing was considered due to high lift but here the drawbacks are weight and cost issues. The low wing and mid wing fall in same FOM and both are reliable and stable and easily controllable. Flying wing has higher volumetric capacity for payload storage but it is more difficult for balancing and during takeoff. High wing is the most suitable wing for our design as it weights as that of low & mid wing but the high wing is located above vertical center of gravity so it’s less stable as compared to low wing but it’s maneuverability is great. Sketch: TypePerformanceConstructionS&CReliabilityCostTotal (avg)Bi-plane32431Low wing54444Mid wing54444High wing55544Flying wing45123EMPENNAGE CONFIGURATION: Again five tail sections were considered. The FOM are shown in table. Tail section discussed was: Conventional, H-tail, T- Tail, Y-tail and cruciform tail. The conventional tail was considered and got highest FOM because of its ease of construction and high reliability. T-tail was considered but it was not selected due to stability and reliability as it's performance is not satisfactory on high angle of attacks. H-tail is reliable but was rejected due to weight issues and manufacturing. Y-tail is highly stable and controllable but as hard to construct and its reliability was not up to mark. Cruciform tail giving the appearance of cross when viewed from front it avoids many disadvantages of T-tail but still low in FOM. Sketch:

TypesPerformanceConstructionS&CReliabilityCostTotalConventional45354T-tail33223H-tail34354Y-tail43433Cruciform34334LANDING GEAR: There are usually two types of landing gears fixed or retractable. Fixed type is further subdivided into many categories but we considered only two. That was: maroon type and custom aluminum. Retractable landing gears are not reliable during landing and due to cost reasons it was rejected. However fixed types are of great reliability. Marooned type was very difficult to use in fabrication process and is not easily available commercially. So the best option was of using custom aluminum type and they are easily available commercially and highly reliable. Hence got highest FOM. Sketch:

TypePerformanceConstructionS&CReliabilityCostTotalRetractable52412Fixed 35245Custom aluminum34555Marooned23423FUSELAG CONFIGURATION: Three types of fuselage were considered: lifting, blended and conventional. Blended body has itself a large lifting surface under some angle of attack however the stall speed is very high thus ignored. Lifting body has some control issues during high wing. However conventional body was considered to be the best option as it's stability for high wing. Sketch: TypePerformanceConstructionS&CReliabilityCostTotalBlended41321Conventional43555Lifting14224PROPULSION CONFIGURATION: Two types of propulsion systems considered were: PusherPusher system when used with conventional body, the center of gravity will pass through the neutral point thus cause instability. TractorIn tractor based system the center of gravity is far away from that point and this system produces more thrust and is more suitable for mission requirements. Sketch: TypePerformanceConstructionS&CReliabilityCostTotalPusher24225Tractor44435TAIL BOOM: For the weighting issues and payload configuration we decided to use tail boom for our plane. So 2 types were considered: Single tail boom. 2 tail booms. As 2 tail booms are concerned it was most suitable with design of pusher system conventional fuselage. Hence as tractor system got highest FOM so in this configuration we have to use single tail boom for joining the fuselage section with empennage one. Sketch: TypePerformanceConstructionS&CReliabilityCostTotalSingle55445Double23354CONCEPT WEIGHTENING OF DIFFERENT DESIGNS: After examining the different types of configurations of wings, tail section, fuselage and landing gears the next step was to combine these configurations to form a best and most suitable design for DBFC-VI. So four different types of configurations are considered and analyzed. Bi-plane with conventional fuselage , single tail boom and H-tail: Advantage: Bi-planes can give a lift of 20% more than mono planes and helps in great maneuverability. On the other hand H-tail is more useful as if unfortunately one tail damages then other tail remain functional. Conventional fuselage with single tail boom ensures great stability. Disadvantage: One of the main disadvantages of this plane was that in bi-plane configurations both the wings negatively interferes their respective aerodynamics. This will cause more drag and less lift than a monoplane. Talking on the empennage section, H-tail increases its weight two times and such type of configuration will be useful when there are two fuselages instead of one. So this configuration was rejected due to weight issues and due to less lift. Sketch: Flying wing with twin tail: Advantage: Flying wing is the most efficient aircraft configuration due to its light weight and fuel efficient structure. It has the lowest drag among all the planes. Disadvantage: The main negative point in this configuration was that it has no payload storage and no fuselage section which was the top priority by keeping in view the missions regarding competition. Other drawback was that wings are fixed , very unstable and difficult to control and also this configuration doesn't gives satisfactory pitch and yaw control. So this design was rejected because of many drawbacks. Sketch: High wing with conventional fuselage, twin tail boom and twin tail: Advantage: This type of configuration helps in short distance landing, and have good maneuverability. With high wings we can use landing gears on the lower side of fuselage. Disadvantage: The one most significant disadvantage of this design was stalling speed as its lift coefficient decreases with large angle of attack and not reaches up to Cl max values. Sketch: High wing with conventional fuselage , single tail boom and conventional tail: Advantage: High wing is very useful for maneuverability. Conventional fuselage is an ideal configuration regarding internal payloads. Single tail boom is used to reduce the weight of the plane and to stabilize it. Further conventional tail is easy to construct and got highest FOM above thus it is preferred. So a tractor based configuration is used to produce more thrust as the center of gravity of plane is far apart from that. Disadvantage: A high wing is less stable on ground as well as in the air as compared to low wing but the main reason to select this wing was its maneuverability that is very much important regarding mission. Sketch: CONCEPTUAL CONFIGURATIONS AND DESIGN FINALIZATION: Now all these four conceptual design configurations were considered and allotted different FOM to choose a best final design which is suitable for completing missions. These FOM are considered on the basis of: Stability and control. (10 points)Performance. (10 points)Payload storage.(10 points)Manufacturing time.(10 points)Cost.(10 points)FOMCRITERIAType-1Bi-plane with conventional fuselage(10 points)Type-2Flying wing with twin tail(10 points)Type-3High wing with conventional fuselage, twin tail boom and twin tail(10 points)Type-4High wing with conventional fuselage , single tail boom and conventional tail(10 ponts)Stability & control7368performance5656Payload storage8288Manufacturing time4436Cost5545Total(50 points)292026

33

Final configuration selection: The FOM of all these configurations are considered but the plane with high wings, conventional fuselage, single tail boom and conventional empennage section got highest FOM and is considered to be the best design for DBFC-VI.