Multi-Disciplinary Senior Design I Winter 2010

P11232 – Systems Design Review

UAV Airframe X-4

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1. Systems Design Review Goal

Meeting Date: January 14, 2011

Meeting Location: Gleason Hall Room 09-2030

Meeting Time: 3:30 – 5:00 pm

Meeting Goal: The goal of this meeting is to inform the customer of the team's progress and to obtain approval to move towards a detailed design of the selected concepts. The attendees will also provide critical feedback of the concepts to help determine that the best concepts have been selected.

2. P11232 Project Description

The goal of the UAV Airframe X-4 project is to provide a robust aerial platform that will be integrated with aerial imaging systems. The airframe must be capable of an extended lifecycle with minimum maintenance to cater to less experienced users. The aircraft is expected to meet the payload capabilities and flight duration required by the aerial imaging systems. This is the third generation airframe, with proven flight capabilities established by the previous group P10232, UAV Airframe B Senior Design Project. The work of UAV Airframe X-4 will expand upon the success of UAV Airframe B to create a reliable, slow moving aircraft that incorporates scientific research as its principal goal.

3. P10232 Design Review

UAV Airframe X-4 is the third generation of airframes designed by senior design teams in the vehicles and technology track. The previous senior design team P10232, UAV Airframe C, designed a conventional monoplane. The models for the plane predicted that the required payload weight of fifteen pounds would be able to be lifted and that a flight time of twenty minutes could be attained. Airframe C was flight tested in an unloaded condition. The heavily cambered airfoil under minimum loading along with a fifteen mile per hour breeze made landing the plane extremely difficult. The team decided to make a forced landing resulting in an end over end flip that ripped the motor out of the nose of the plane. It was determined that a more robust plane is needed to improve the longevity of the plane, and a less cambered airfoil is needed to allow for easier landings under minimum loading conditions.

4. Customer Needs

Outlined below are the customer needs for the design of a robust aerial platform. The following customer concerns were summarized to conform to those expressed in the project proposal.

1. Iterate the design of Airframe C (P10232) to obtain a new airframe that incorporates minimal design deviations but is primarily robust and still able to achieve UAV flight requirements.
2. The new design, Airframe X-4, must be designed to be a test mule for future testing, experimentation and research projects for remote aerial imagery.
3. Airframe X-4 must possess the ability to withstand testing and flight exercises with minimum maintenance.
4. Airframe X-4 must be capable of flight in an adequate R/C airfield under reasonable weather conditions.
5. Airframe X-4 must have flight characteristics similar to that of a trainer style aircraft.
6. Airframe X-4 must be capable of at least 100 hours of total flight time.
7. Airframe X-4 must be capable of sustaining a controlled steady flight for at least 30 minutes.
8. Airframe X-4 must be capable of reaching an altitude of 400ft while complying with AMA regulations.
9. Airframe X-4 must be capable of supporting a 15 lb payload with relative ease.
10. Airframe X-4 must be capable of easy integration with the imaging system payload designed by P10231.
11. The total weight of the aircraft including all components and payload must not exceed 50 lbs.
12. The budget costs associated with the design and construction of Airframe X-4 must not exceed $3,000.
13. Design deviations from Airframe C for Airframe X-4 must be justified.

5. Engineering Specifications

Metric No.	Need Nos.	Metric – Engineering Specification Description	Imp.	Units	Marginal Value	Ideal Value	Preferred Direction
General							
1	11	Total aircraft weight	5	lbs	50	45	Down
3	7	Single flight time	4	min	20	30	Up
4	2, 6	Total flight life cycle	5	hrs	100	100	Up
5	8	Flight altitude	3	ft	400	400	Target
6	4, 7	Aircraft speed	2	mph	45	40	Target
Structure							
7	1, 2, 3	Aircraft structure shall resist deformation	5	boolean	1	1	Target
8	9	Imaging system payload weight	5	lbs	15	15	Target
	2, 10	Integrate & secure payload	5	boolean	1	1	Target
9	10,13	Payload bay dimensions	3	in^3	16x6.5x5	16x6.5x5	Target
Wings							
10	4, 5	Wing geometry	5	curvature		Camber	Down
11	5	Wing location relative to fuselage for roll stability	3	location	High	High	Up
12	5	Sweep for stability	2	deg	10		Target
13	1,3,5	Wing loading capacity	4	g	+4/-2	+4/-2	Target
Propulsion							
14	7,11	Number of batteries capable of providing uninterrupted power	4	count	4	6	Up
15	7, 11	Power to weight ratio	4	watts/lb	75		Target
16	11,13	Total electric propulsion system weight	1	lbs	7.5		Target
Flight Controls							
17	5	Control system channels capable of actuating all control surfaces	3	count	6	4	Down
Landing/Take-Off							
18	4	Landing gear to hold plane at an optimal angle of attack for take off	4	boolean	1	1	Target
19	4	Take-off/Landing distance	2	ft	250		Down

6. Aerodynamic Concept Generation

Airfoil

- NACA 9412- Airfoil used by UAV Airframe C
- NACA 7412- Less cambered airfoil
- NACA 5412- Less camber then 7412
- E423- Heavily cambered airfoil
- Other cambered airfoil

Wing

- Candy Bar Wing- Flat rectangular wing
- Dihedral- Wing has a slight upward angle
- Swept Wings- Wing tips are behind the wing's root
- Tapered Wing- Wing with a longer cord at wing root than at the tip.
- Aspect Ratio- Ratio of the wing cord to span.

7. Material Concept Generation

Fuselage

- Stringer- Balsa formers with stringers and a monokote covering
- Sheeting- Balsa formers with sheeted sides and monokote covering
- Fiberglass- Balsa formers with sheeted sides and fiberglass covering

Wings

- Balsa Build-up- Balsa ribs with stringers and monokote covering
- Balsa Sheeting- Balsa ribs with balsa sheeting and monokote
- Balsa Fiberglass- Balsa ribs with sheeting and fiberglass covering
- Foam Fiberglass- Foam core with fiberglass covering
- FOLSA- Pro- Foam core with balsa sheeting and fiberglass covering
- Foam Carbon Fiber- Foam core with carbon fiber covering
- Hybrid- Foam leading edge with balsa sheeting back and fiberglass covering

8. Aerodynamic Concepts Selection

The aerodynamic concept selection is still on going but general selections have been made to change the wing. These are as follows:

- A less aggressive cambered airfoil – Better control under minimal loading conditions
- Sweeping of the leading edge – Adds stability in similar fashion of dihedral
- Increased Aspect Ratio – Increases the efficiency of the plane

9. Material Concepts Selection

Fuselage

	Weight	Stringer	Sheeting	Fiberglass
Machinability	3	0	0	-1
Cost	1	0	-1	-1
Weight	3	0	-1	-2
Strength	9	0	1	2
Time of Build	1	0	0	-1
Support Wing	9	0	1	2
Total		0	15	25
Rank		3	2	1

Wing

	Weight	Build-Up	Sheeting	Balsa/FG	Foam/FG	FOLSA-Pro	Foam/CF	Hybrid
Machinability	3	0	0	0	-1	-1	-1	-2
Cost	1	0	-1	0	0	-1	0	-1
Weight	3	0	-1	-1	0	-2	-2	-1
Strength	9	0	1	1	1	2	2	2
Time of Build	1	0	0	-1	-	-	-	-2
Wing Flex	9	0	0	1	1	2	1	2
Total		0	5	14	14	25	17	24
Rank		6	5	4	4	1	3	2

10. Risk Management

Risk Item	Effect	Cause	Likelihood	Severity	Imp.	Mitigation	Owner
Failure to meet deadlines	Project deliverables unmet	Poor Planning and execution	3	5	15	Proper Time Management	Team
X-4 Damaged Parts	Reconstruct parts	X-4 mishap during testing	3	5	15	Test under proper conditions	PM
Lead Time Factor	Parts not showing up on time	Poor time management	3	4	12	Plan ahead	Team
Wing Failure	Unable to fly & test	Poor construction or design	2	5	10	Review calculations and construction methods	Team
Laser Cutter Failure	Unable to cut parts	Equipment failure	3	3	9	Preventative maintenance	Team

Airfield Delays	Testing schedule delayed	Weather or schedule conflicts	4	2	8	Plan ahead with multiple test days	PM
Damaged Goods From Airframe C	Purchase new parts	Mishap by P11231	2	4	8	Emergency fund	Team
Over budget	Loss of funds to other areas of the project	Poor financial management	3	2	6	Plan budget and keep to it	PM
Computer Crash	Unable to access designs	Component Failure	1	5	5	Backup Files	Team
AWOL Pilot	Plane Crash or unable to test	Illness	2	2	4	Multiple test days and test only with pilot	PM
Change of Customer Needs	Redesign Project	Uncertainty in customer	1	4	4	Say no	PM
Landing Gear Failure	Structural Damage	Test mishap	4	1	4	Design for gear failure	Team
Loss of Funding	Unable to purchase required materials	Poor communication with customer	1	3	3	Communicate with customer	PM
Aircraft Component Failure	Unable to test or fly	Cheap components or improper use	1	3	3	Review proper handling of components	Team
Electrical Failure	Loss of flight control ability	Poor electrical connections	1	2	2	Review electrical connections	Team
Propulsion/ Battery Failure	Loss of power during flight	Batteries not fully charged	1	1	1	Charge batteries in advance	Team

11. Project Timeline

Task ID	Task	Previous Tasks	Start Date	End Date
1	Mission Statement	-	12/3/10	12/10/10
2	Staffing Requirements	-	12/3/10	12/10/10
3	Intellectual Property Considerations	-	12/3/10	12/10/10
4	Team Values and Norms	-	12/3/10	12/10/10
5	Required Resources	-	12/3/10	12/10/10
6	Identify Customer Needs	1	12/10/10	12/17/10
7	Establish Engineering Specifications	6	12/17/10	12/24/10
8	Generate Aerodynamic Concepts	7	12/24/10	12/31/10
9	Generate Material Concepts	7	12/24/10	12/31/10
10	Select Aerodynamic Design	8	12/31/10	1/14/11
11	Select Material Design	9	12/31/10	1/14/11
12	Conceptual Design Review	10, 11	1/14/11	1/14/11
15	Detailed Structural Design	12	1/14/11	2/8/11
16	Detailed Design Review	15	2/11/11	2/11/11
17	Set Final Specifications	16	2/11/11	2/23/11
18	Project Management Review	16	2/25/11	2/25/11
19	Order Materials	17	3/7/11	3/21/11
20	Build Airframe	19	3/21/11	4/8/11
21	Test Airframe	20	4/8/11	4/12/11
22	Revise Airframe	21	4/12/11	4/15/11
23	Test Airframe	22	4/15/11	5/20/11
24	Poster Publication	20	4/12/11	4/29/11
25	Managerial Design Review	23		
26	Imagine RIT	23	5/7/11	5/7/11