Unmanned Air Vehicle (UAV) Designed For The Future Flight Design 2013

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Aim of the Project

ABSTRACT

In this study; we present an Unmanned Air Vehicle (UAV) designed for The Future Flight Design 2013 competition. The Future Flight Design 2013 is an international competition and based on portable UAVs. This UAV is specially designed to ensure the competition rules and missions. The UAV can carry up to 2 kg payload and it can drop bombs (bottles) separately. It can fly up to 15 minutes by base configurations but also it can fly up to 60 minutes by modification. The UAV is made in the Erciyes University Civil Aviation School laboratories. The aircraft is introduced in this study.

Introduction

This paper presents the design and manufacturing processes of an UAV designed for the Future Flight Design 2013 competition. It also covers competition rules, score analysis, design, and final design performance to date. The team's aim is to produce an airplane that maximizes the total score according to the rules provided by the contest organizers.

Objective of the Project

Erciyes Aviation Team determines that the winning aircraft would be one built to complete all three missions with the lightest possible empty weight. There is no way that focusing completely on one mission or empty weight alone could win the competition. Therefore, during designing our aircraft model we try to focus on aircraft which is the lightest and has the minimum dimension values. We decide to create an empty fuselage and dimensioning of it is based on requirements of mission 3. Therefore, we choose the dimensions of fuselage as follows: 128.55 cm in longitudinal direction, 11 cm in lateral direction and 11 cm in vertical direction. Since the dimension values of fuselage are large, in order to decrease weight of aircraft we did cover the fuselage.

Objective of the Project

In order to satisfy carrying missions (i.e. second and third missions) requirement that bottles must be secured and positioned such that they could be released down one by one, we design a bomber mechanism in the fuselage. For tail cone any supporting part is not used, since it does not experience any additional loading. In order to carry this fuselage and also satisfy take-off in a prescribed area, we focus on useful wing structures. Wing is manufactured using foam and carbon/epoxy rods and by that way it is also satisfied that wing deals with huge flight loads. To satisfy the requirement of mission 3 we designed a bomber mechanism that drops bottles one by one with one servo. In order to obtain a stable flight, we decide to use conventional tail. During manufacturing tail, to decrease weight, its inside is made empty and outside is covered with the material which is also used to cover outside of our aircraft. The competition aircraft and some of its important features are shown Figure 1.

Aircraft Features

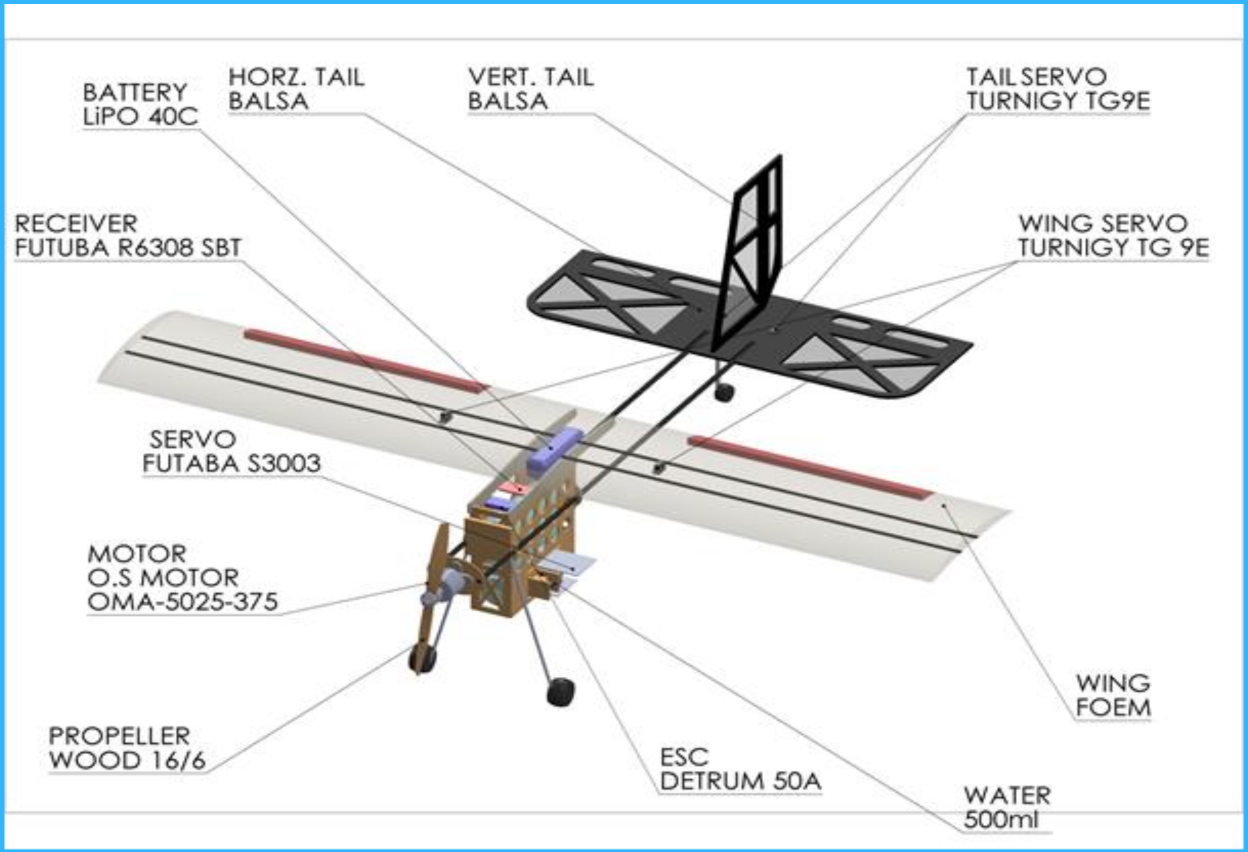


Figure 1. The competition aircraft and its important features

Objective of the Project

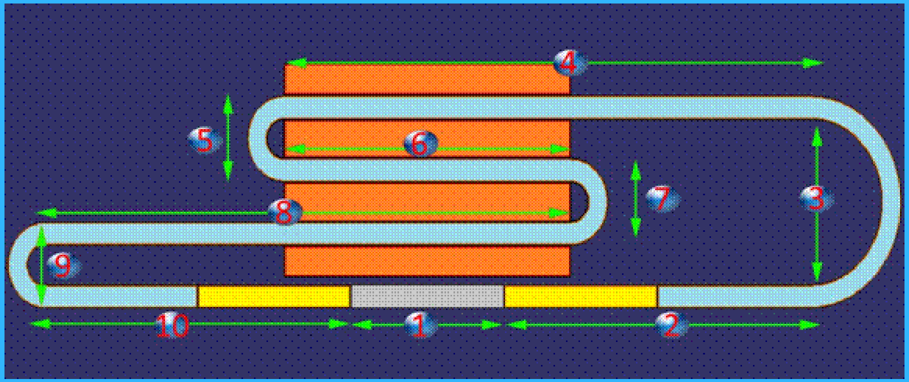
After manufacturing aircraft, Erciyes Aviation Team makes some tests on propulsion system in order to increase performance values of aircraft. After considering results of tests, the best engine-propeller-battery combination is chosen. This combination is as follows: OS OMA-5025-375, 16”x6” wood series propeller for missions, and one LiPO 3300 mAh 22.2 V Allign 40C batteries. Moreover, aerodynamic and structural analyses are thoroughly done. Finally, flight tests are applied and results of flight phase are carefully examined.

Conceptual Design

Conceptual Design:
Rules which restrict the design are given below and detailed rules are at the FFD 2013 webpage [1].
* Modular structure is available except the fuselage and power plant. Team may change the configuration of a UAV including wing, tail cone, and tail surfaces during mission flight periods.
* Motors and batteries will be limited to a maximum of 40 Amp current draw by means of a 40 Amp fuse (per motor or battery pack) in the line from the positive battery terminal to the motor controller. Only ATO or blade style plastic fuses may be used.
* Battery packs must weigh less than 3 kg.
* As payloads, common type of 500 ml bottles of water is used

Objective of the Project

All missions are carried out on the flight course, shown in Figure 2. The course consists of 8 maneuvers for which take-off and landing are only preformed once per mission.



1. Take-off.
2. Climb

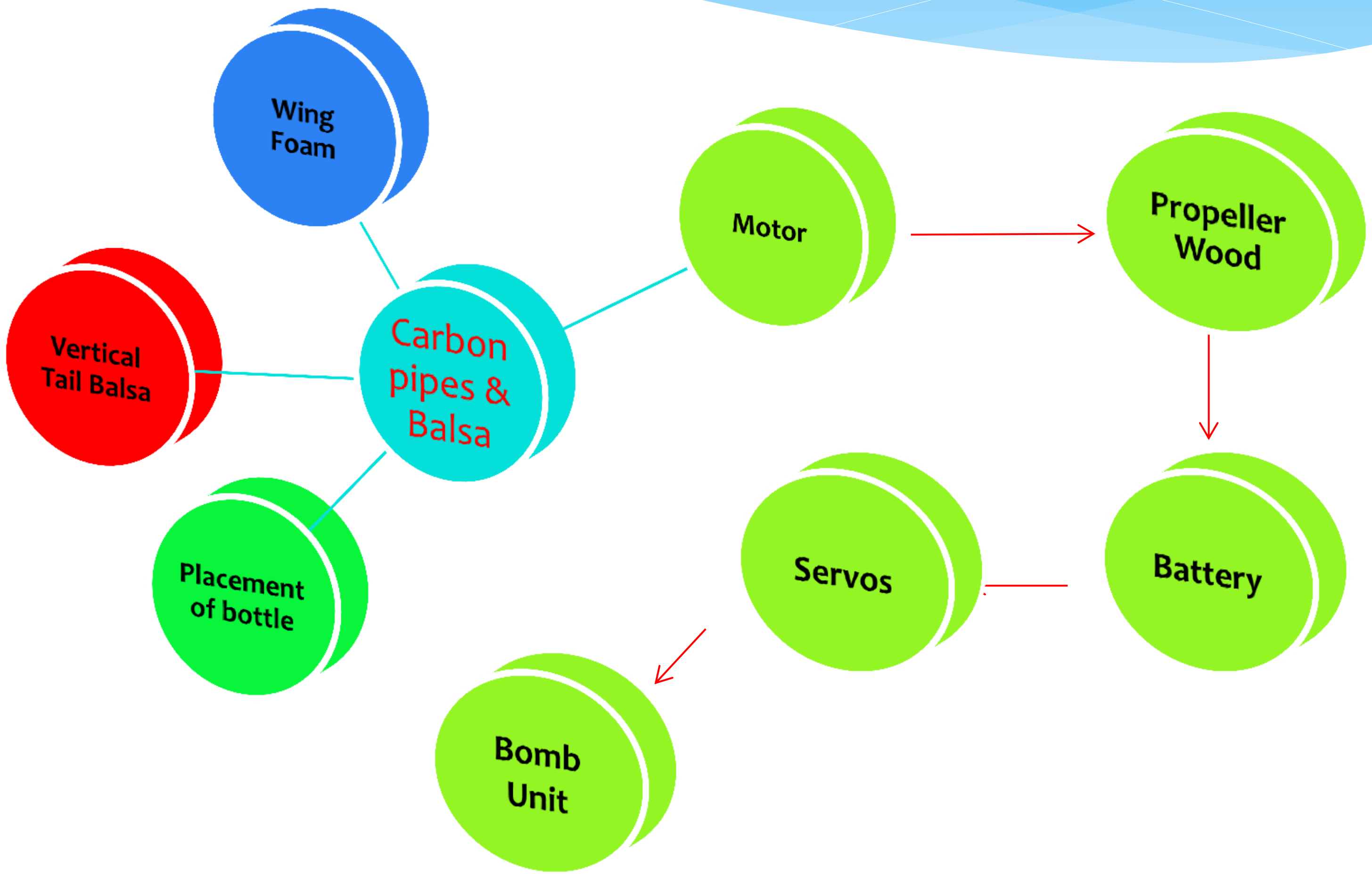
10 Landing

4, 6, 8 Cruise and payload releasing

3, 5, 7, 9 Turn

Figure 2. Representation of FFD course

Main Components



Alternative Configuration

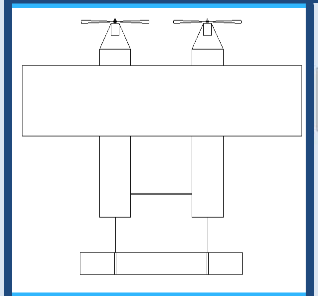
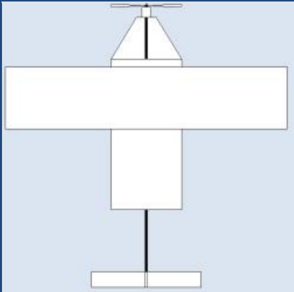
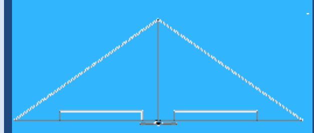
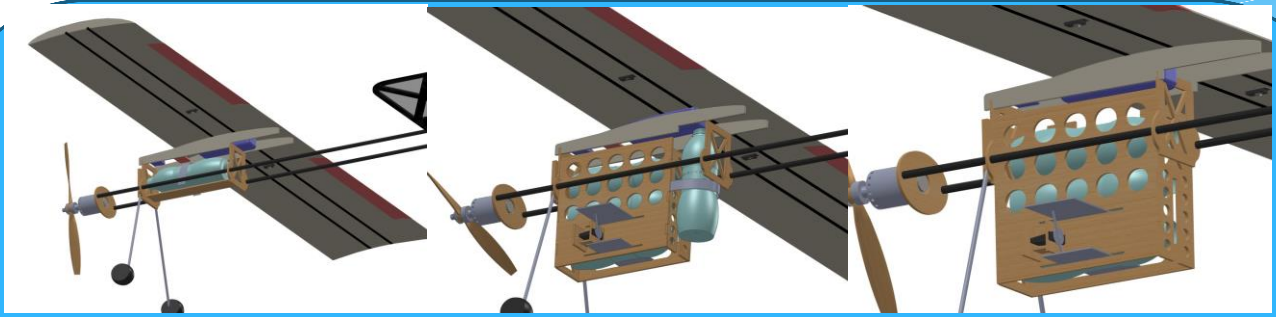
Configuration		Twin Boom		Single Boom		Flying Wing	
							
FOM	Weight Factor	Scoring					
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Drag	0.2	-2	-0.4	-1	-0.2	0	0
System weight	0.3	-4	-1.2	-2	-0.6	-4	-1.2
Stability	0.2	2	0.4	5	1	0	0
Total	1		-1.2		**0.2**		-1.2

Table 1: Fuselage configurations and figure of merit (FOM)

Bottle Placements



(a) (b) (c)

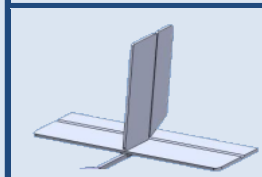
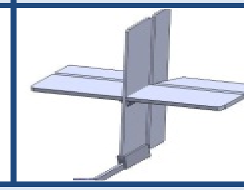
Figure 3. Bottle placements for the missions

a)Placement of one bottle, **b)**Placement of four bottles,

c)Placement of three bottles

Choosen Tail Configuration

Table 2: Weighted decision matrix for empennage configuration

Configuration		Conventional		T-Tail		Cruciform	
							
FOM	Weight Factor	Scoring					
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
System Weight	0.2	-2	- 0.4	-3	-0.6	-3	- 0.6
Control Effectiveness	0.25	3	0.75	2	0.5	1	0.25
Complexity	0.15	4	0.6	1	0.15	-1	- 0.15
Stability	0.25	4	1	3	0.75	2	0.5
Design & Manufacturability	0.15	5	0.75	3	0.45	1	0.15
Total	1		2.7		1.25		0.15

In Table 2 it can be seen that conventional tail configuration is light and it has not complex structure. Its control surfaces can be easily moved and it is also stable and easy to manufacture. Therefore, we choose conventional tail configuration for this competition.

Gear Configuration

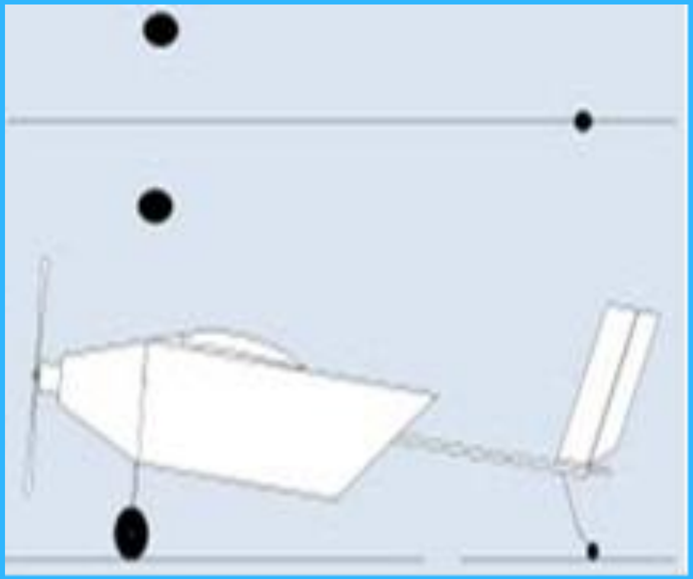


Figure 4. Landing gear configuration and propulsion system placement

Prototypes

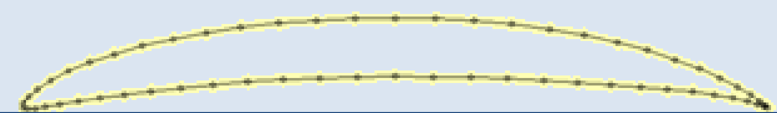
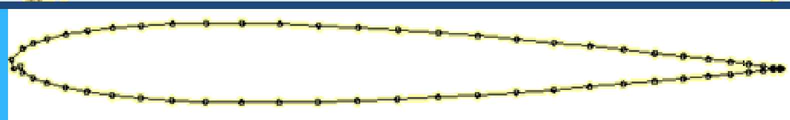
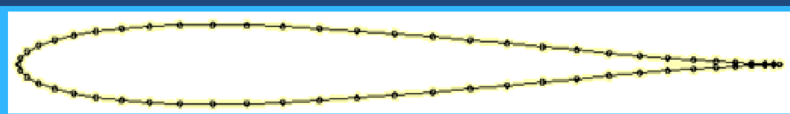
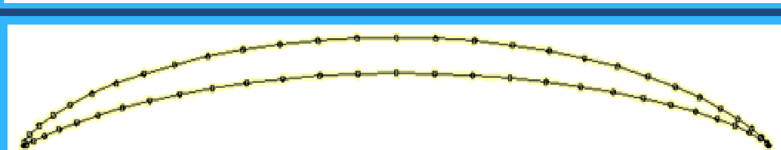
(a) (b) (c)

Figure 5. Fuselage shapes and bottles,

(a) first prototype, (b) second prototype, (c) third prototype,

Chosen Airfoils

Table 3: Available airfoils (chosen one NACA 07-1508)

	NACA 07-1508	0,02434	2,044	83,975
	NACA 60009	0,0075	0,518	83,2
	Joukovsky	0,01493	0,467	65,5061
	NACA 07-1904	0,04676	2,216	47,3909

Although NACA 07-1904 airfoil has better lift coefficient than the airfoil we chose NACA 07-1508 can be easily manufactured and light, and also durable.

Moment Distributions

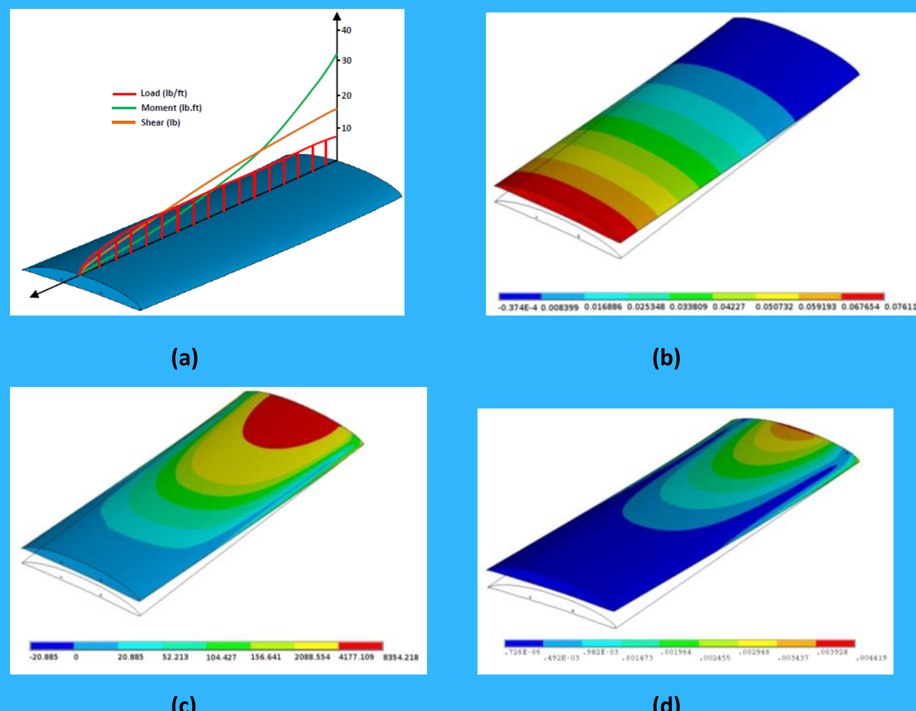


Figure 6. a) Load, shear force and bending moment distribution over the wing span, **b)** Deformations over the semi-wing span, **c)** Von mises stress distribution over the semi wing span, **d)** Von mises strain distribution over the semi wing span

Placement of the Bottle

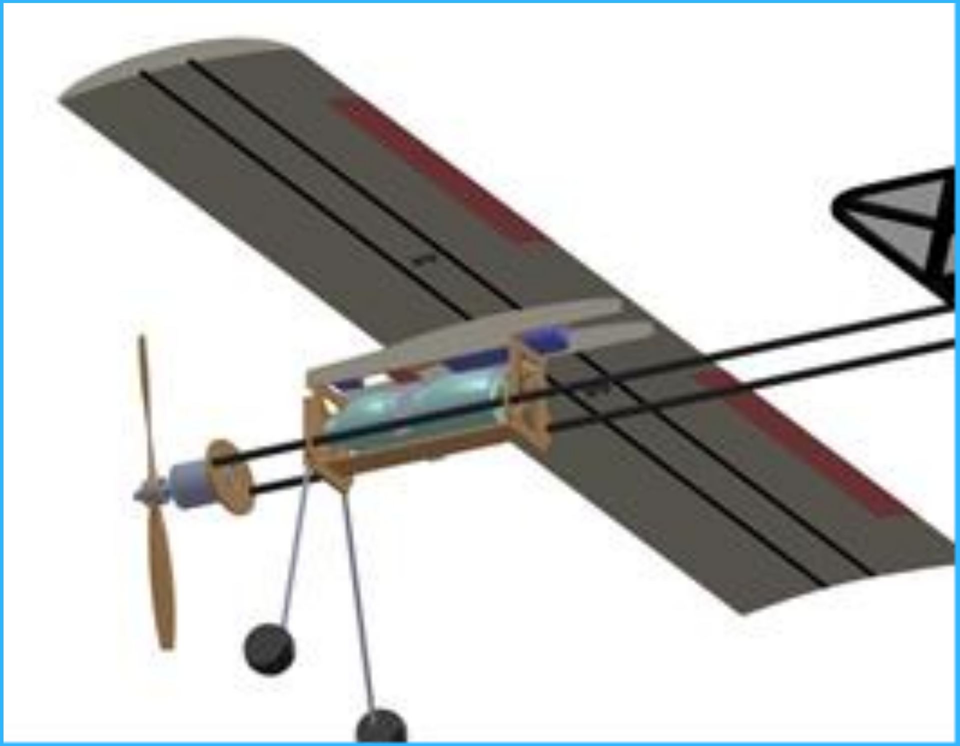


Figure 7. Placement of the bottle

Four Bottles

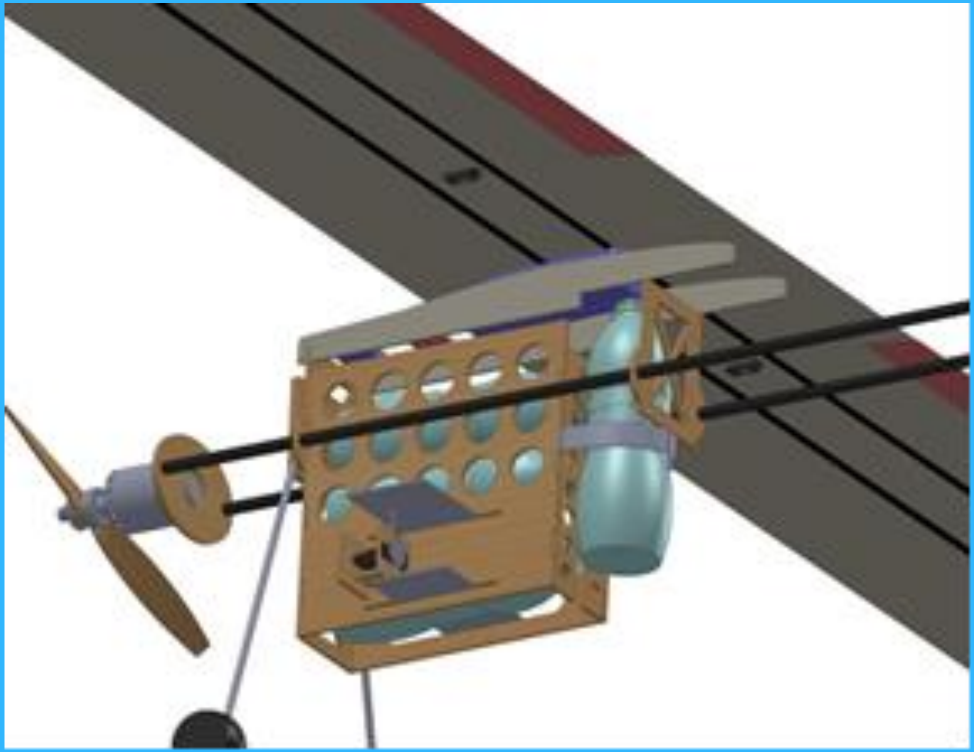
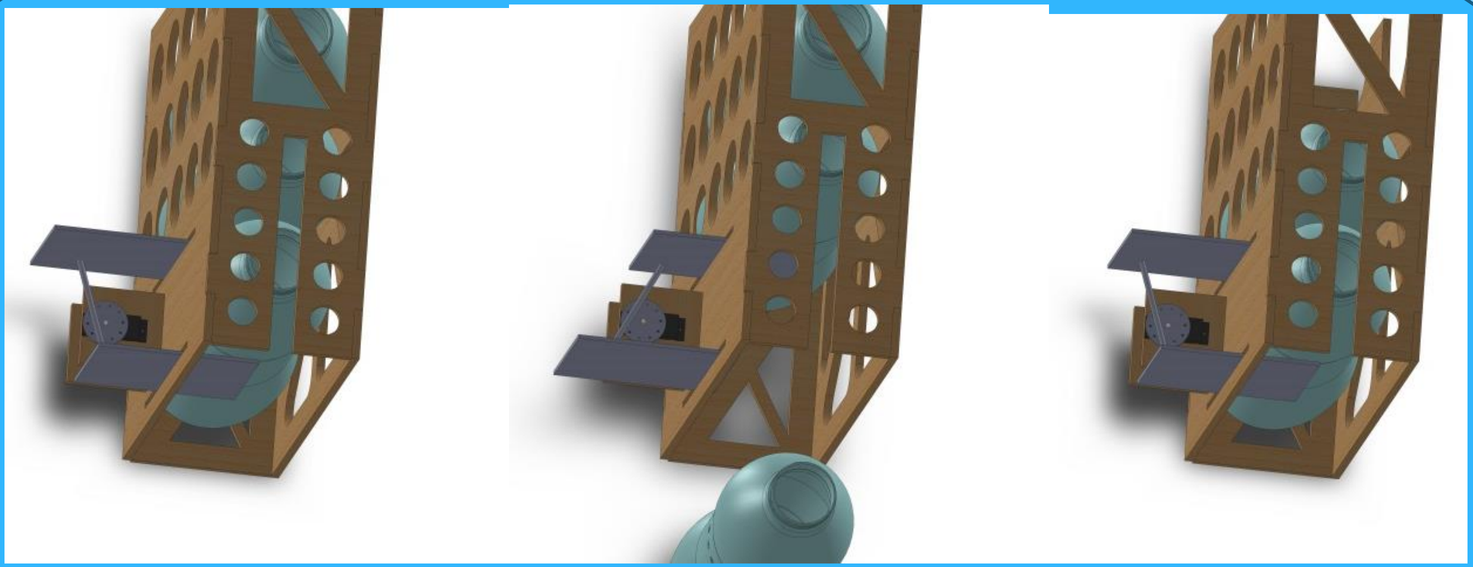


Figure 8. Placement of the four bottles

Releasing Mechanism



(a) (b) (c)

Figure 9. Bottle releasing mechanism for mission 3

Tests

(a) **(b)**

Figure 10. (a)Wing test, (b) Semi-wing test

Gear Test

Figure 11. Landing gear test

Wind Tunnel

Figure 12. Wind tunnel

Conclusion

CONCLUSION

The aircraft introduced in this study ; namely Mission based designed unmanned air vehicle (UAV) which has been designed & developed by Erciyes University Civil Aviation School laboratories already participated to the international “The Future Flight Design 2013” competition in May 2013 . Our UAV was capable to carry out all the missions of the race except the third mission . In the third mission owing to beyond of our control « sun effect « the mission was not performed in a proper way , Therefore our UAV selected by the comitte as the FIFTH BEST SCORE in the said competition by taking into account of only first and second missions scores. We are sure that our UAV will be getting better scores in the forthcoming next competitions.