ALLIANCE UNIVERSITY

RAKSHAK

ALLIANCE UNIVERSITY

Alliance College of engineering and design
Department of Aerospace Engineering
Alliance University
Bengaluru, KARNATAKA-562106
INDIA

In response to the 2015 American Helicopter Society
Student design competition-undergraduate category
July 27, 2015

Team Members Details:

1) BALU K S **UG** Signature:
(Team leader)
E-mail:baluk@ced.alliance.edu.in

2) VISHNUVARDHAN S **UG** Signature:

E-mail:vishnuvardhans@ced.alliance.edu.in

3) VIMALATHITHAN R **UG** Signature:

E-mail: vimalathithanr@ced.alliance.edu.in

Under the supervision of external guide:

Mr. S. Muralidharan,
Helicopter engineer,
Freelancer.

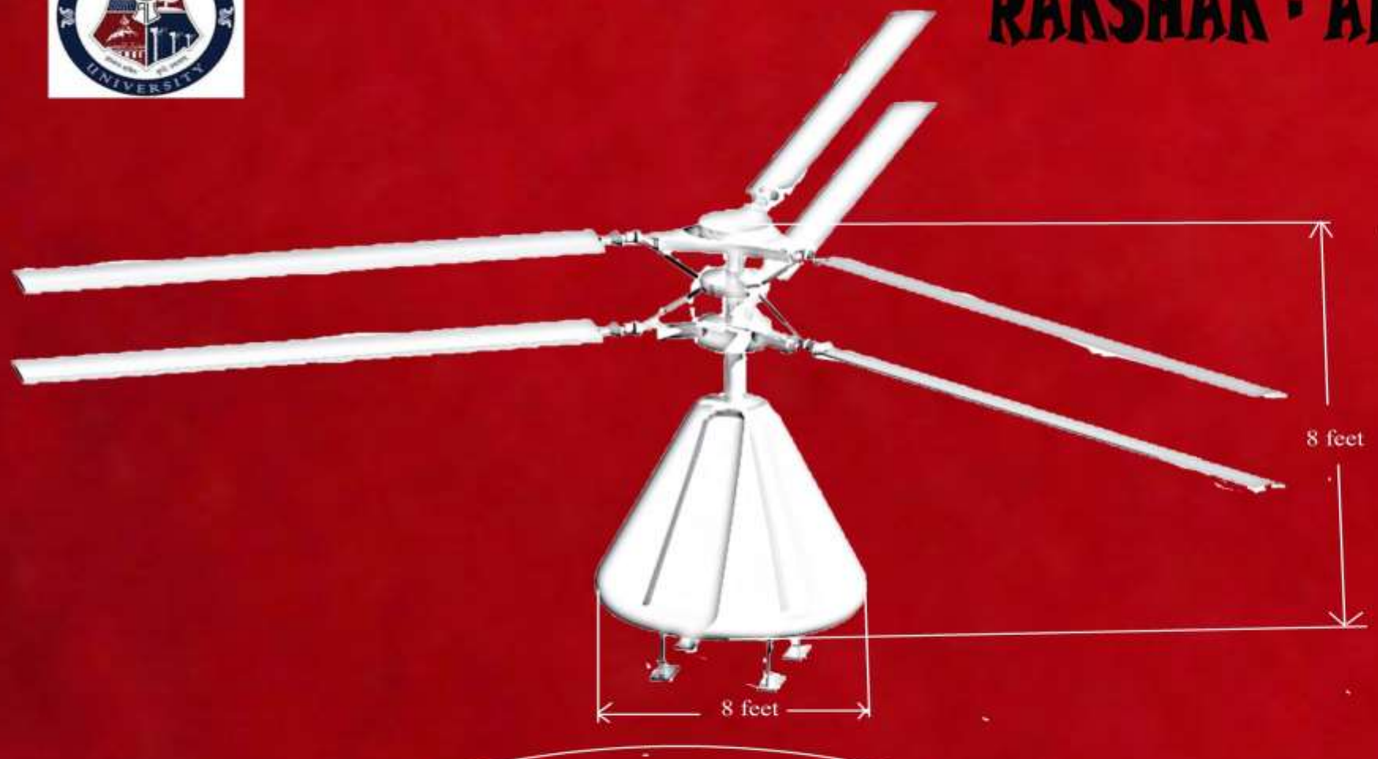
INTRODUCTION:

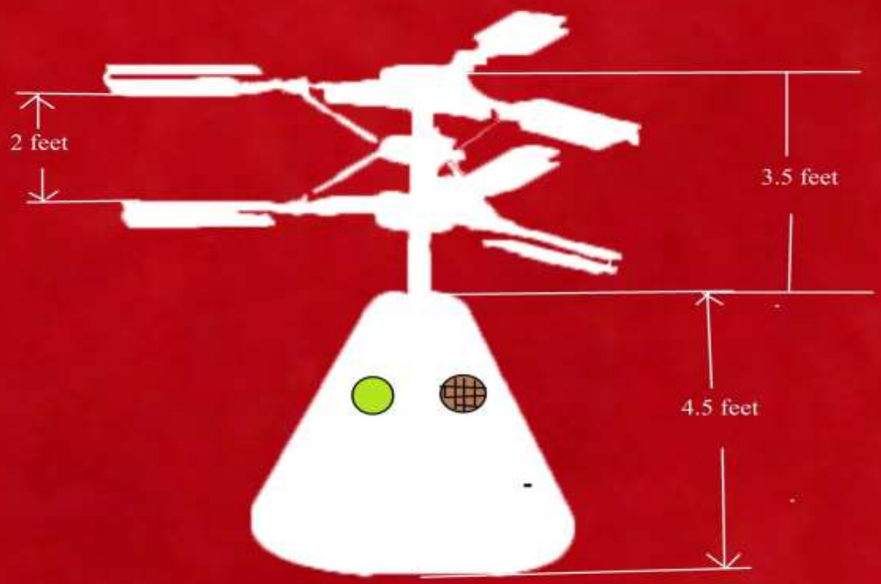
In response to the 33rd annual student design competition, AHS 2015 Request For Proposal for a "Air Launched Disaster Relief Delivery Vehicle" sponsored by Bell Helicopter, three aerospace engineering undergraduate students of Alliance University are presenting a design of a unique shaped and efficient unmanned rotor craft. The RFP requires an unmanned rotor craft which is capable of carrying a minimum of 500 lbs payload, bottled water in shrink wrapped cases to the earth quake relief site. There are so many challenges faced by the disaster management in providing the required goods to the people in the relief site because of lack of dedicated rotorcrafts for this purpose. Rakshak is specially designed to fulfill this task.

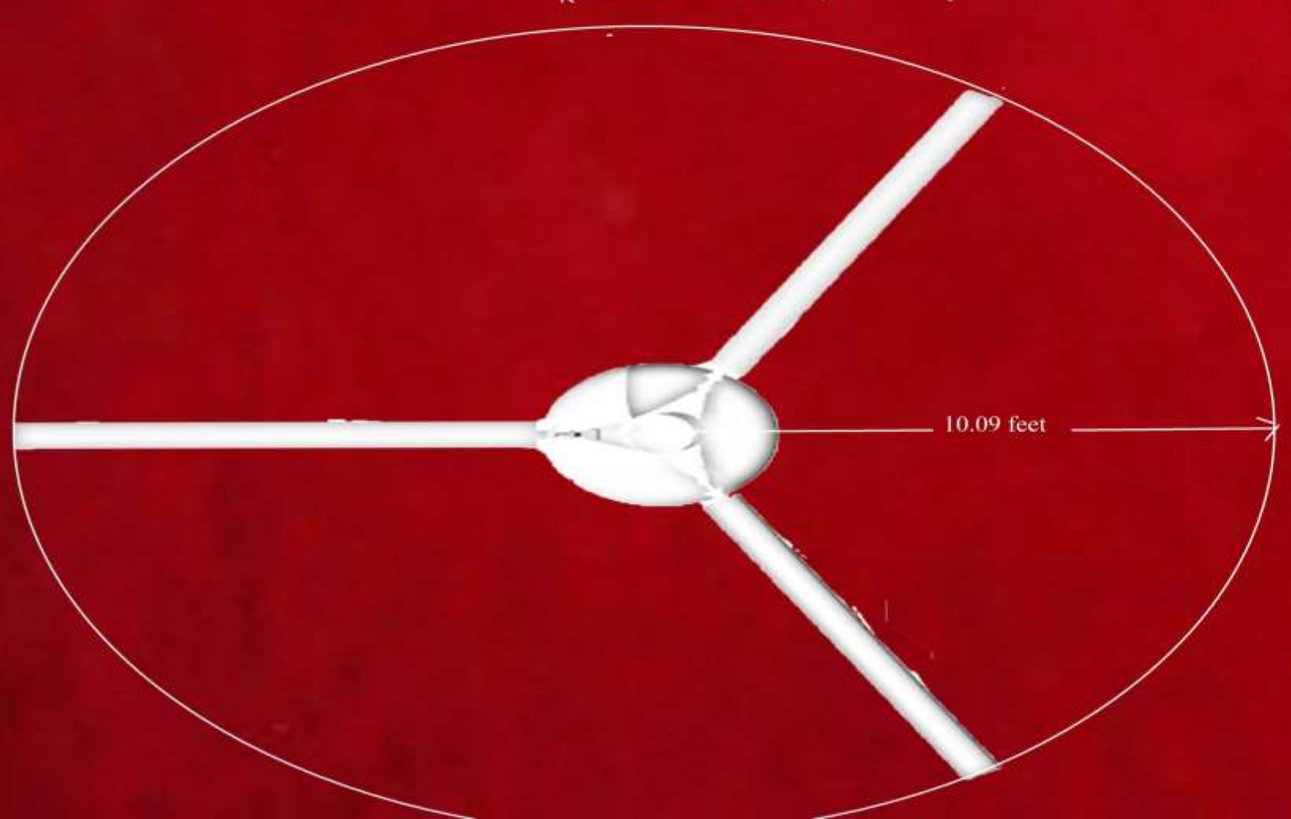
The RAKSHAK is a deployable autonomous helicopter designed to meet the tasks stated in the RFP comprehensively. The RAKSHAK is an innovative, very compact design and practically applicable. It is accommodated with technically advanced sensors which are capable of accomplishing tasks more than what is specified in RFP, like mapping and taking real time pictures. Deployment of the helicopter is totally new concept, stabilization of the vehicle is very important so mechanisms and controlling should be highly reliable. RAKSHAK has advanced and pre-programmable mechanisms which are highly reliable.

FOLDOUTS 1.1

RAKSHAK - AIRFRAME 4-VIEW







ALLIANCE UNIVERSITY

RAKSHAK SYSTEM DESCRIPION:

WEIGHT ESTIMATION:

GROSS WEIGHT	**4346.45 lbs**
EMPTY WEIGHT	2428.24 lbs
WEIGHT OF ROTOR BLADES	199.717 lbs
WEIGHT OF THE CO–AXIAL HUB AND HINGES	92.98 lbs
WEIGHT OF THE FUSELAGE	547.907 lbs
WEIGHT OF THE PROPULSION SYSTEM	544 lbs
WEIGHT OF THE FLIGHT CONTROLS	156.545 lbs
WEIGHT OF THE ELECTRICAL SYSTEMS	156.54 lbs.
WEIGHT OF THE FIXED EQUIPMENTS	730.54 lbs.
USEFUL LOAD	1504.20 lbs.
WEIGHT OF THE FUEL	414 lbs.

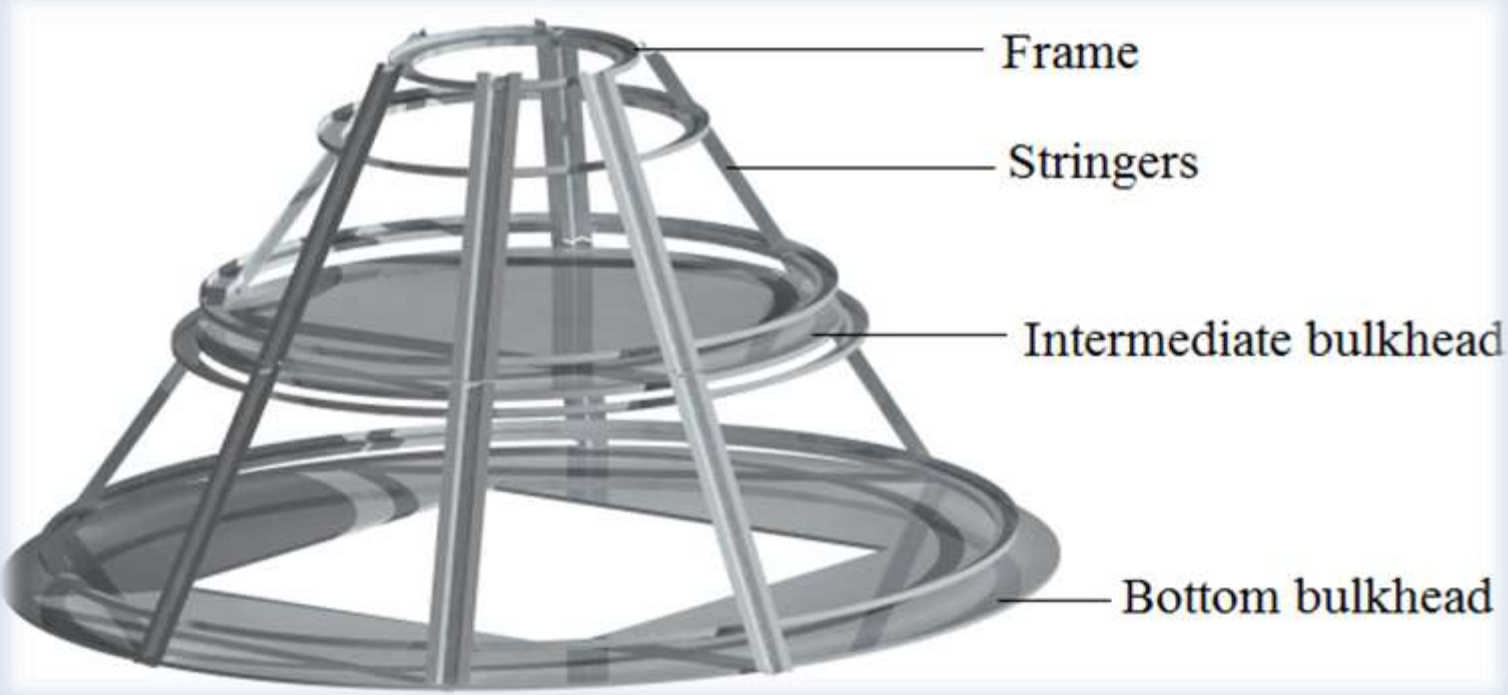
RADIUS	**10.088 ft**
DISC LOADING	6.8 lbs/ft^2
VELOCITY$_{<max-tip>}$	453.247 ft/sec
MAX ANGULAR VELOCITY (Ω)	44.927 rad/sec
C$_{<thrust>}$	0.00698
C$_{<lift>}$	0.33
DISC AREA	639.36 ft^2
ADVANCE RATIO(μ)	0.441
SOLIDITY(σ)	0.12699
BLADE LOADING	0.055
NUMBER OF BLADES	6
ASPECT RATIO	15.04666
Cd$_0$	0.007

RAKSHAK MISSION PLAN

ALLIANCE UNIVERSITY

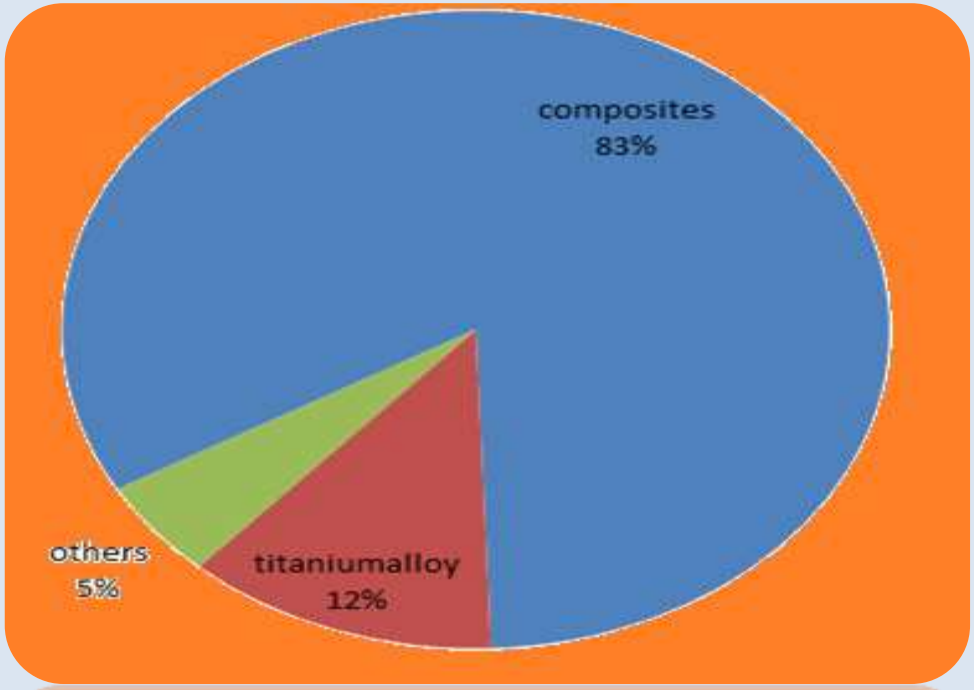
STRUCTURAL DESIGN

Structure of the Rakshak is most reliable and simple. The typical view of the structure is shown below. Structure consists of fuselage and rotor system. Airframe is a semi-monocoque design and it consists of bulkheads, frames, stringers and skin. Two rigid bulkheads will give strength to the airframe. Frames are provided at suitable such that it will give required strength to the skin and to whole airframe. To the bulkhead whole rotor system is rigidly attached via mast system. Stringer is of hat section, frame is of z-section.

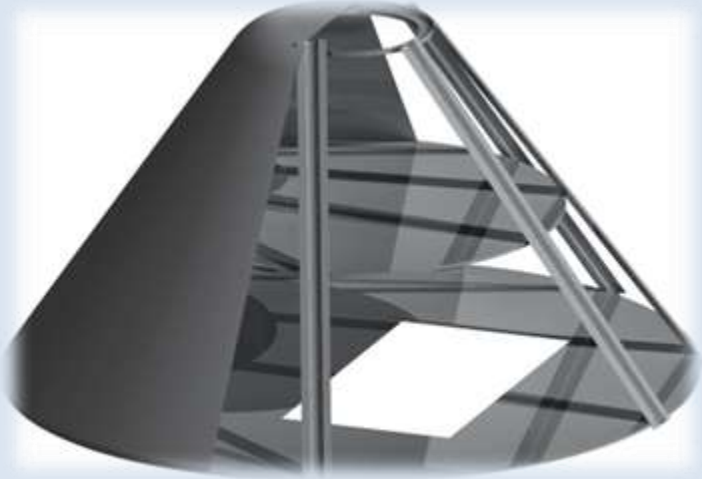


MATERIAL USED IN RAKSHAK:

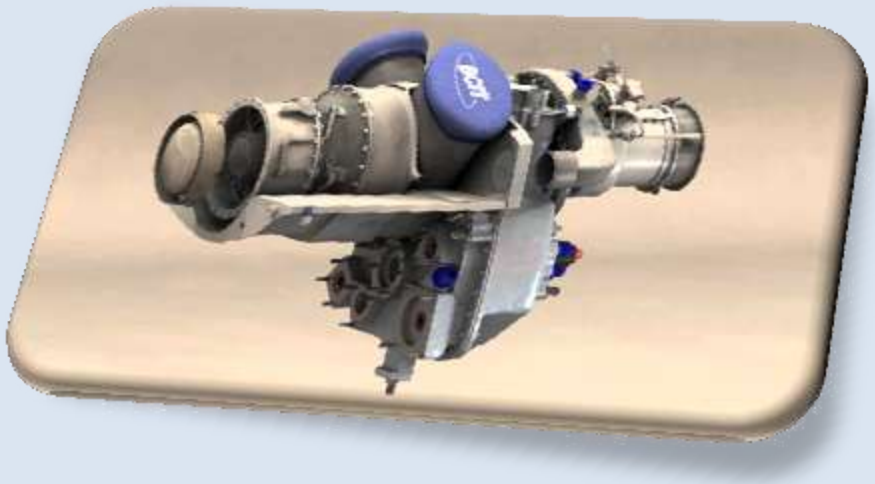
RAKSHAK is mostly constructed by composite material and small amount of titanium Alloy, Aluminum alloy are used in airframe. The whole fuselage is constructed by composites and selected composite material is carbon-epoxy. Hub of the rotor craft is constructed from titanium alloy and blade is made of carbon-epoxy composite.



Titanium alloy has higher stiffness value which gives strength to the hub. Carbon-epoxy composites have high stiffness to weight ratio therefore it is used in fuselage and blade.



Engine selection

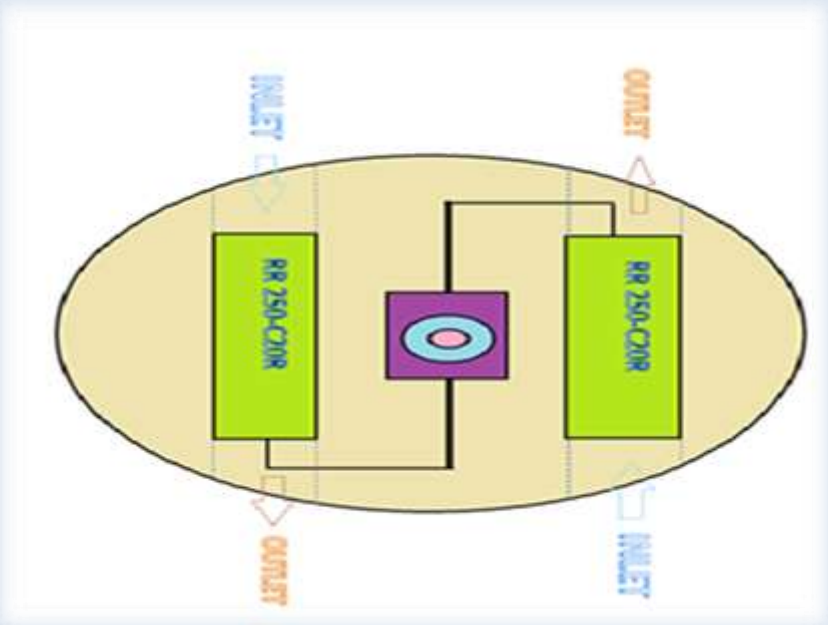


In the preliminary calculations of power we got maximum required shaft horse power as 708.182 shp. And we should have at least 20% extra power in the engine. Hence we selected two Rolls Royce 250-C20R engines.

Specifications of the RR 250-C20R:

Maximum Takeoff Rating (shp)	**450**
Maximum Continuous Power (shp)	450
Fuel consumption (lbf/shp)	.608
Weight (lbs)	173
Dimensions (Inches) (LxWxH)	38.8x20.8x23.2

Engine layout:



Why twin engine?

If there is engine trouble with one engine in a twin engine helicopter, the second engine will be there to ensure the flight continues to go smoothly. If the same happens in a single engine helicopter, the pilot has to perform an autorotation, trying to keep the blades moving by replacing the height of the aircraft with the speed of the blades.

HELICOPTER TRANSMISSION

6000 rpm

Engine 1

2812.93 rpm

454.61 rpm

1250.19 rpm

15-tooth

Reduction ratio 2.133

32-tooth

16-tooth

Reduction ratio 2.25

36-tooth

Engine 2

Solid Shaft

Hollow Shaft

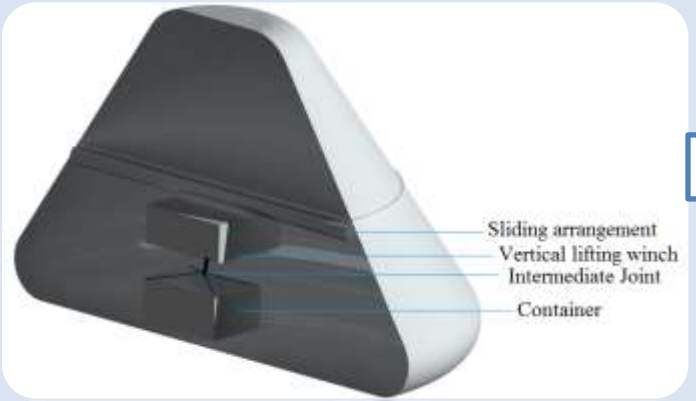
Reduction ratio 2.75

36-tooth

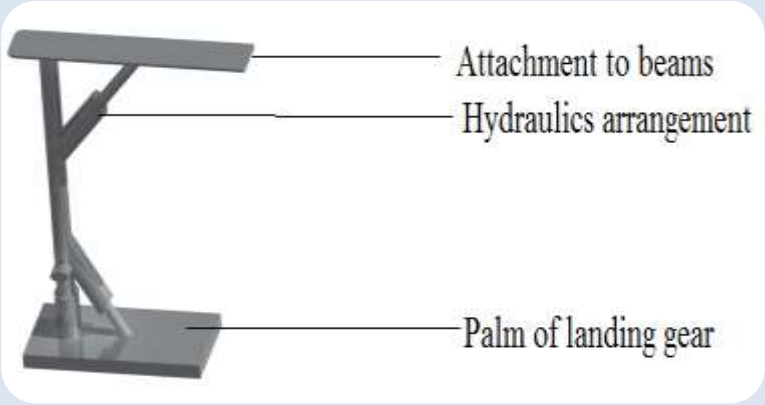
16-tooth

36-tooth

Mechanisms involved in Rakshak: Mechanisms used in Rakshak are unique in design and working. Each mechanism is fixed at different position on the rotorcraft. There are main six mechanisms used in the design.



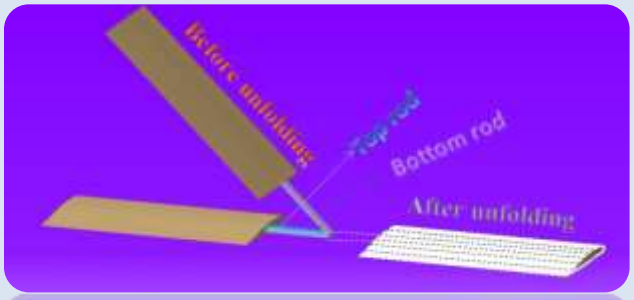
PAYLAOD DEPLOYMENT



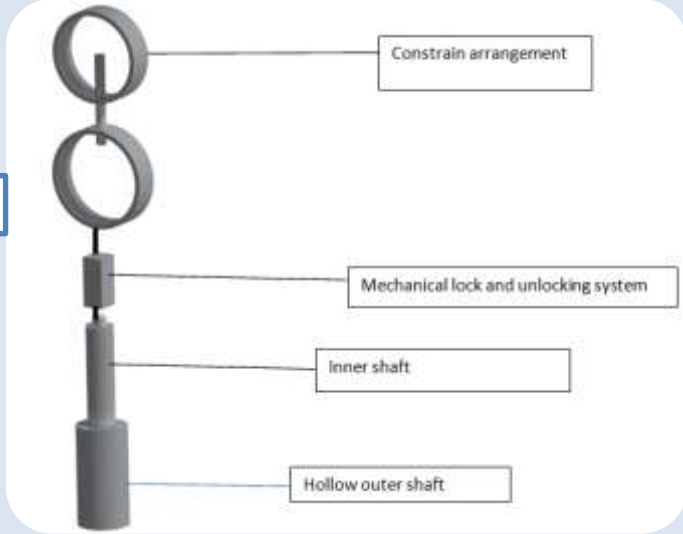
LANDING GEAR MECHANISM

BLADE INCLINING

PARACHTE DEPLOYMENT



BLADE UNFOLDING



Avionics of the Rakshak:

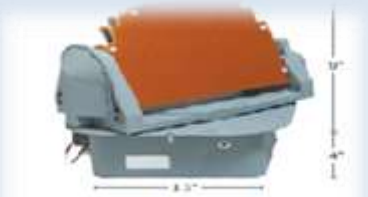
Sigma 95N INS

The primary navigation of the helicopter is accomplished by Sigma 95N inertial navigation system. Sigma 95N provides high-grade navigation performances, accuracy and flexibility. Sigma 95 incorporates highly accurate 32cm Ring Laser gyros.

The Enhanced Software Configurable Air Data Unit (ESCADU) is intended to be primary supply of air data parameters to the aircraft systems. ESCADU is able to counter this using electronic filtering to negate this effect.
The main purpose of this mission is to provide food and other required payloads to the people in the disaster relief site so our helicopter should autonomously find where the people are. This task is accomplished by Euroflir 410 SP Electro Optical System.
The AC-21 common data link is a low swamp antenna which supports tactical military communications. The compact high gain system provides highly co-efficient operations. With the deployment kit integration, the antenna system can also support ground based tactical communication.

ESCADU

Euroflir 410 SP EOS

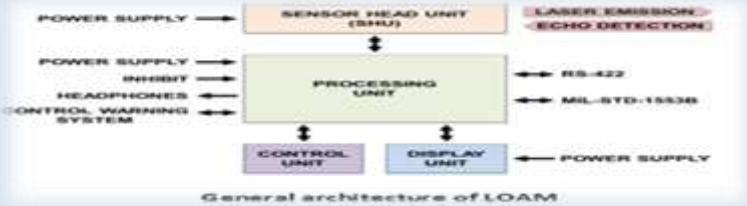


AC-27 CDL Antenna System

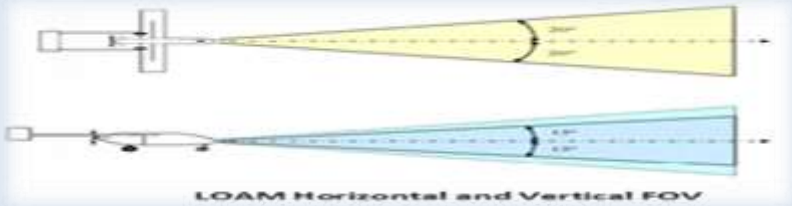
LIDAR Obstacle Warning and Avoidance System of the Rakshak:

Low level navigation and terrain –following operations with unmanned aircraft are challenged by a variety of natural and manmade obstacles, as well by adverse weather conditions that can significantly reduce the obstacles visibility.

To deal with this problem we are using an equipment called LOAM (Laser Obstacle Avoidance Marconi), is a low weight /volume navigation aid system for rotary wing /UA platform specially designed to detect potentially dangerous obstacle placed in or near by the flight trajectory and to warn the crew in suitable time to implement effective avoiding maneuvers.



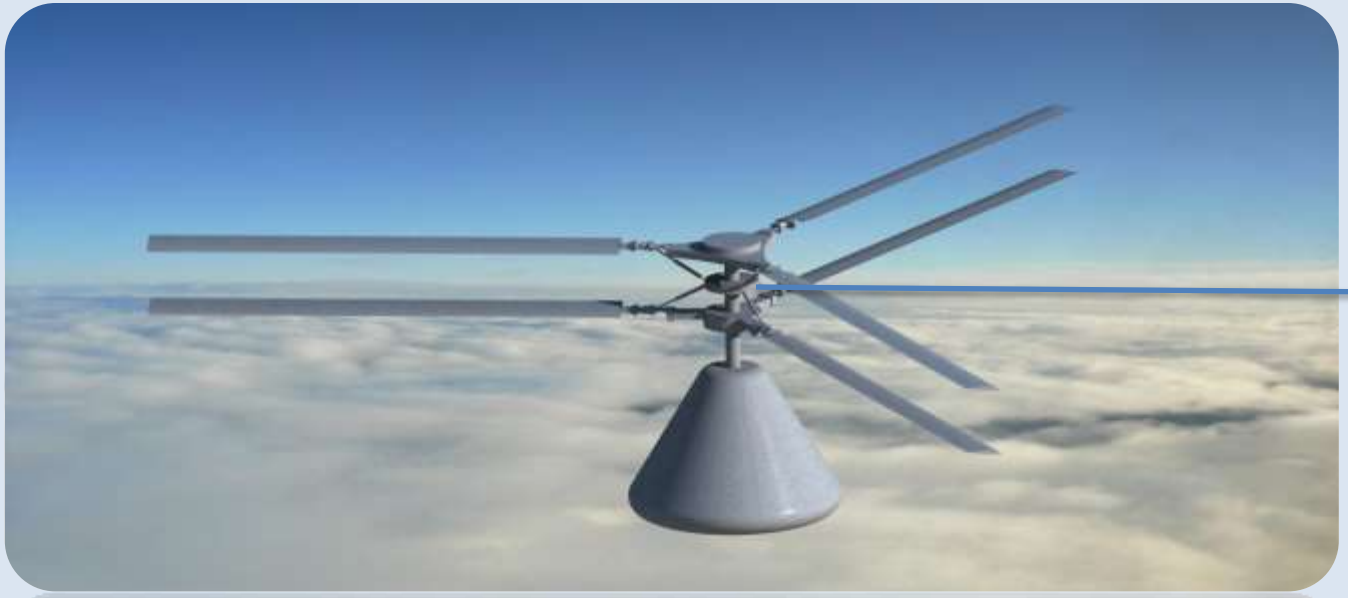
General architecture of LOAM



LOAM Horizontal and Vertical FOV

AUTOPILOT SYSTEM OF RAKSHAK:

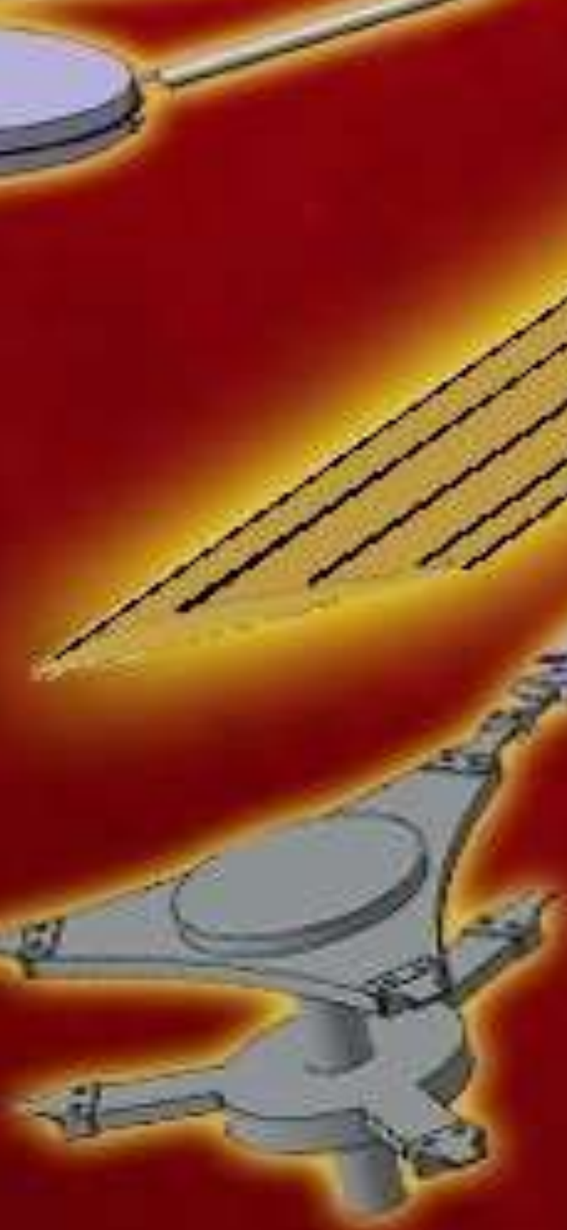
Autopilot system used in Rakshak is unique and it is new to rotorcraft industry. The controlling of the attitude of the Rakshak is fully automated and it is controlled by actuators movement. Control system will send signals to the actuators, according to the input signals information the pitch of rotorcraft will be controlled.



Controlling actuators

Sagem's autopilot system

RAKSHAK – AIRFRAME FUSELAGE LANDING GEAR



ALLIANCE UNIVERSITY

PERFORMANCE:

The maximum power engine shaft horse power required is 708.182 shp for figure of merit .834, with the till loss of .98607. We calculated induced, profile and parasite power for different airspeeds and it is shown in graph and graph. Power for airspeed 118.906 knots is given in table.

Maximum rate of climb: The maximum rate of climb we obtained is 63.5 ft/s and power required for this rate is given in table.

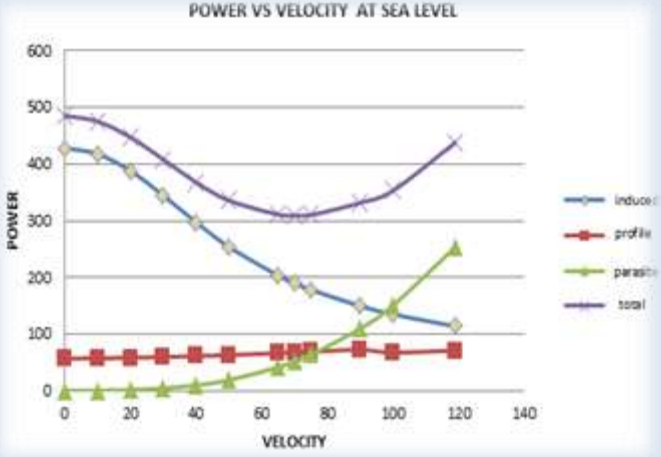
Power curves of the Rakshak:

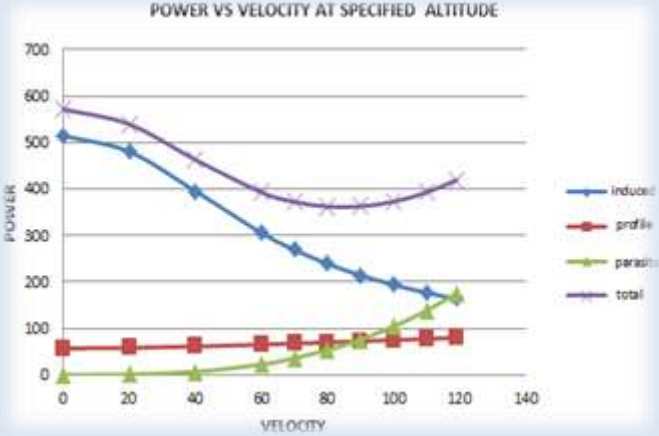
The obtained power graph for the Rakshak is agreeable with the standard theoretical power graph at both sea level and at specified altitude.

ALTITUDE	INDUCED (shp)	PROFILE (shp)	PARASITE (shp)	TOTAL (shp)
SEA LEVEL	113.8406	70.77470307	253.0498338	437.6651
AT SPECIFIED HEIGHT	163.7558	79.88633107	175.4495882	419.0917

RATE OF CLMB (ft/s)	AIR SPEED (konts)	INDUCED (shp)	PROFILE (shp)	PARASITE (shp)	CLIMB POWER (shp)	TOTAL (shp)
63.5	70	158.9777	67.40929	67.39066	501.8176	795.5952

.





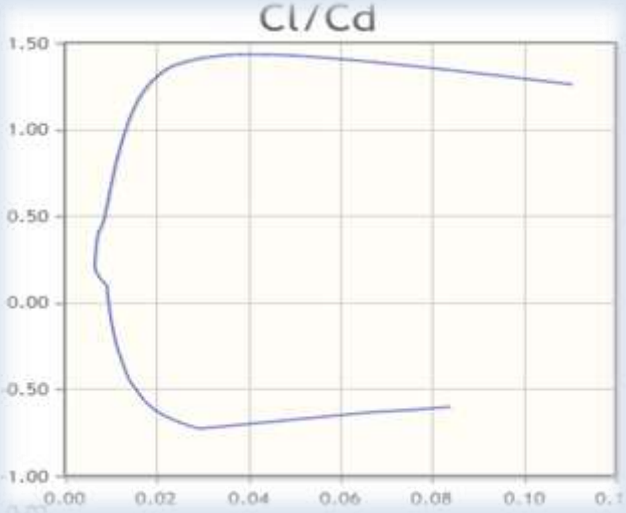
The performance parameters of the Rakshak are given in the table. The maximum angle of attack at 270^0 point or stalling angle is -14.2114^0 for Rakshak.

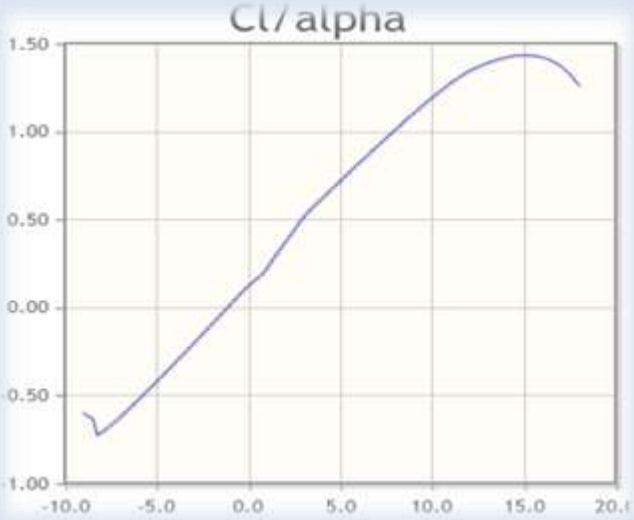
SERVICE CEILING	**41000 ft.**
MAX HOVER CEILING	58000 ft.
α<270>	-14.2114
MAX RANGE VELOCITY	116 ft/s
MAX ENDURANCE VELOCITY	80 ft/s
RSHP(max-endurance)	496.7082 shp
WEIGT OF THE FUEL (max-endurace)	251.8453 lbs
RSHP(cruise)	514.4592 shp
WEIGHT OF CRUISE	260.8455 lbs

AIRFOIL SELECTION:

The selected airfoil for the inboard section of the blade is **NASA RC (5)-10**

- $Cl_{max} > 1.4$ at M=0.4 and Re≈$5x10^6$
- $Cl_{max} > 1.2$ at M=0.5 and Re≈$6x10^6$
- $M_{dd} >$ 0.7 at Cl=0 with C_m<.0.015
- (t/c)max= 0.1

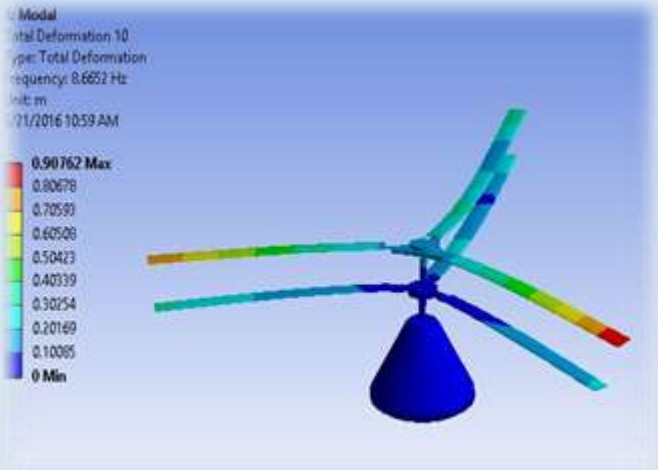


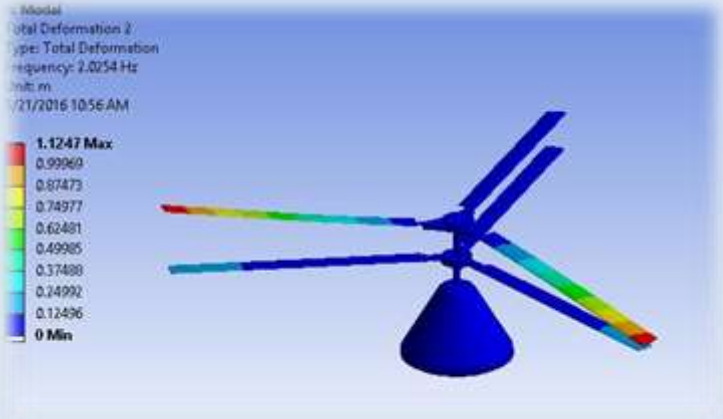


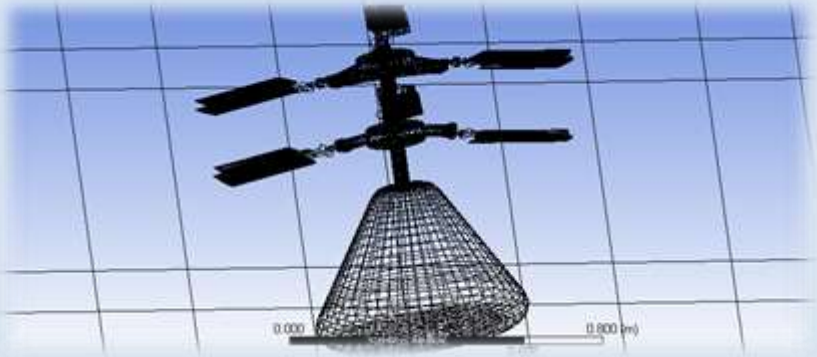
The selected airfoil for the outboard section of the blade is **NASA RC (6)-8**

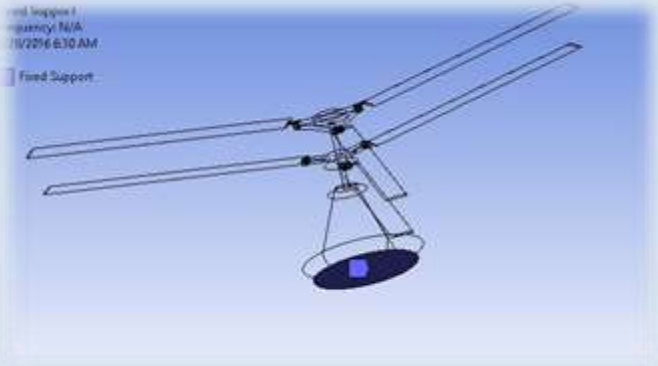
- $Cl_{max} \geq 1$ at M=0.4 and Re≈$5x10^6$
- $M_{dd} \geq 0.85$ at Cl=0 and -0.1
- $C_{m,0} \leq -0.02$ at $0.8 \leq M \leq 0.85$
- $Cl_{max} \geq 0.95$ at M=0.5 and Re≈ $7x10^6$

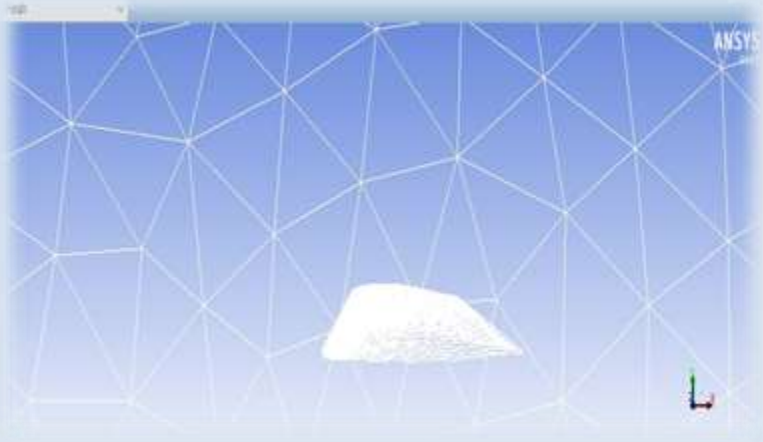
MODAL AND CFD ANALYSIS

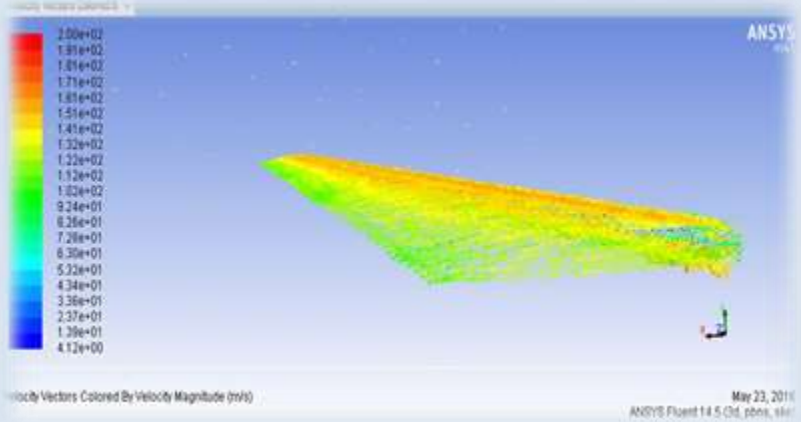






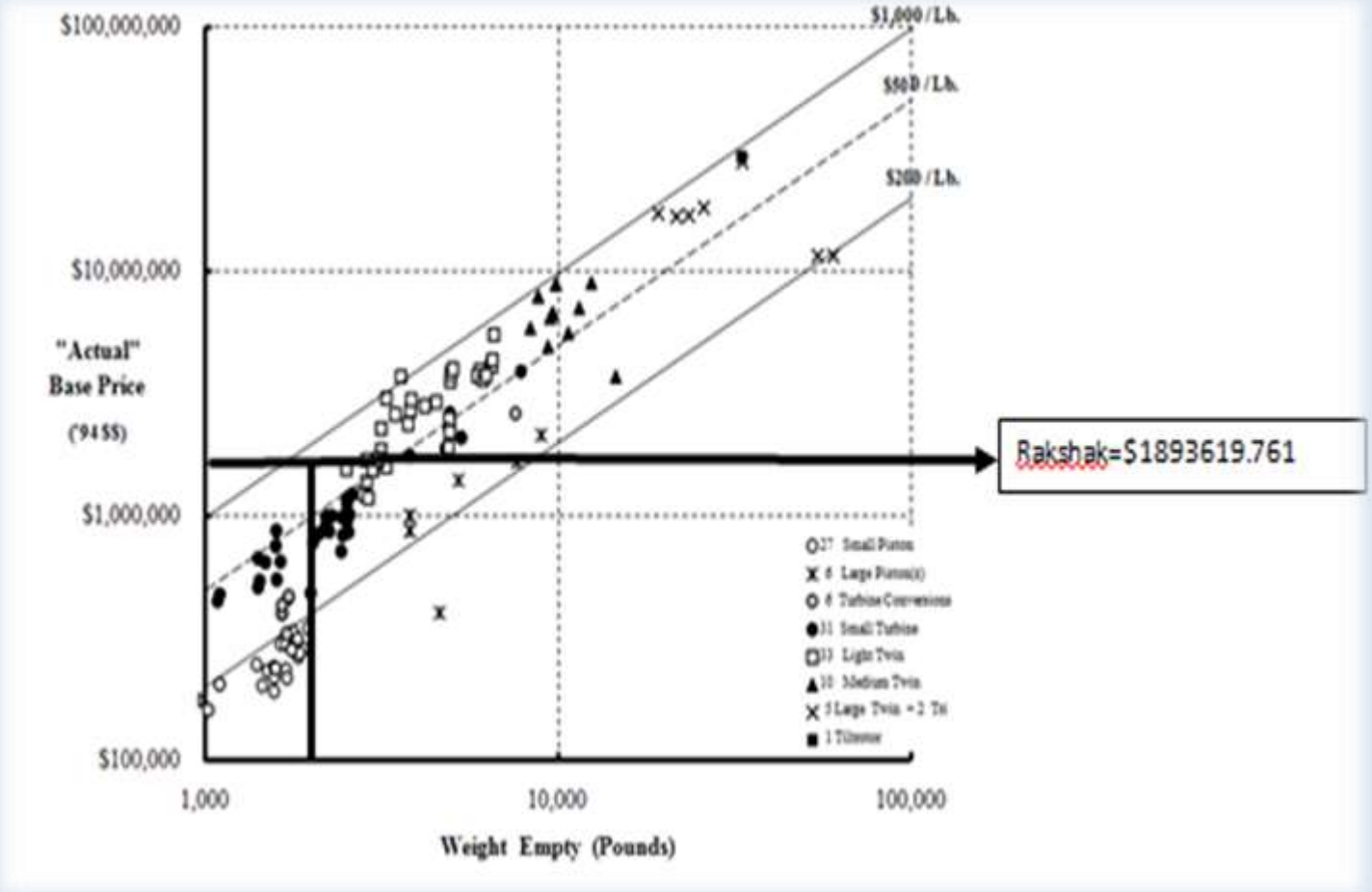






COST ANALYSIS:

Basic unit price of helicopter is found to be $1893619.767, this value is comparable with most of modern helicopter unit cost.



CONCLUSION

Overall conclusion is that Rakshak is an advanced designed rotorcraft which is compact, reliable and agile and it can carry large amount payload. Therefore we can surely conclude that **RAKSHAK is the most suitable rotorcraft design for the mission prescribed in the competition.**

THANK YOU