



the

Dropplet

Luke Storey

Bill Koffler

Amaury Pigeon

Kevin Muck

Hui Feng

Adam Mohammed

Bryce Connelly

Meghan Kaminski

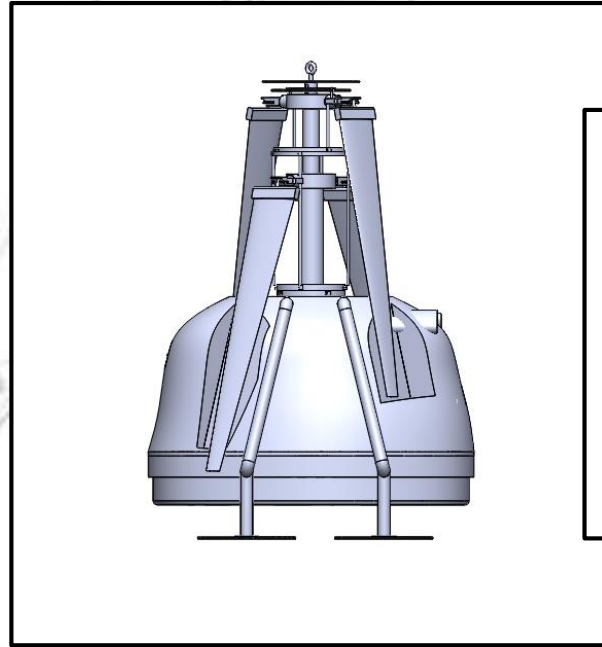
Andrew Willard

The Droplet Pod

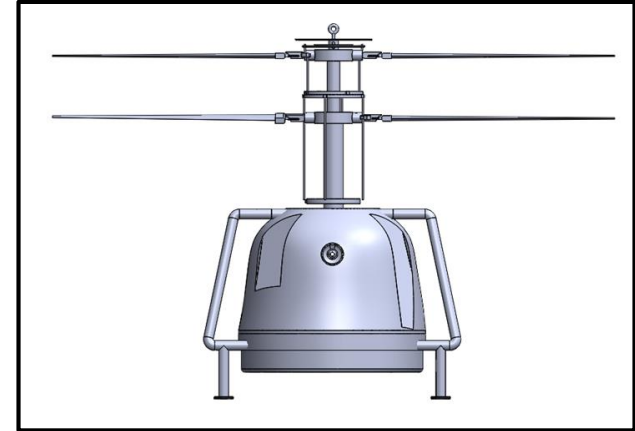
Dimensions	
Weight	2100 lb
Height	112 in
Width	80 in
Length	77 in

C-130J Cargo Bay Dimensions	
Height	108 in
Width	119 in
Length	40 ft

**3 Droplets to be placed in C130J
Cargo Bay**

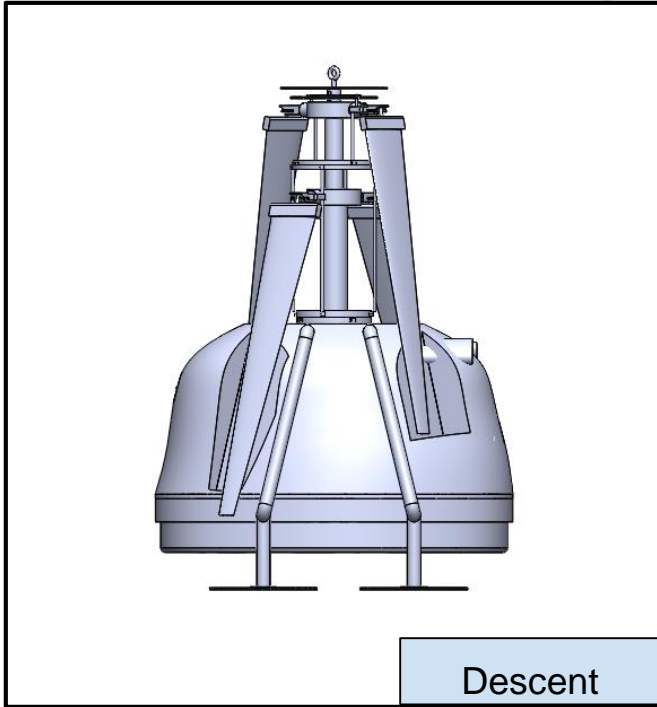


Side View

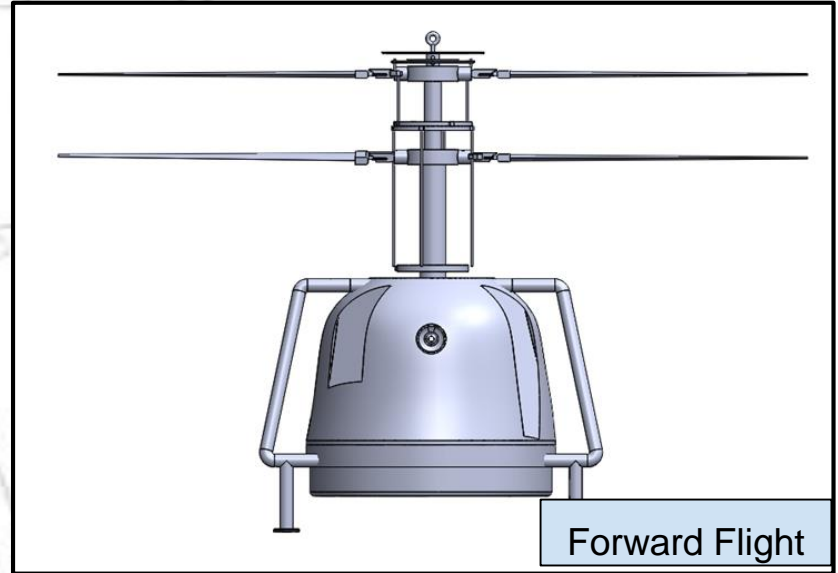


Front View

Blades: Folded vs. Extended

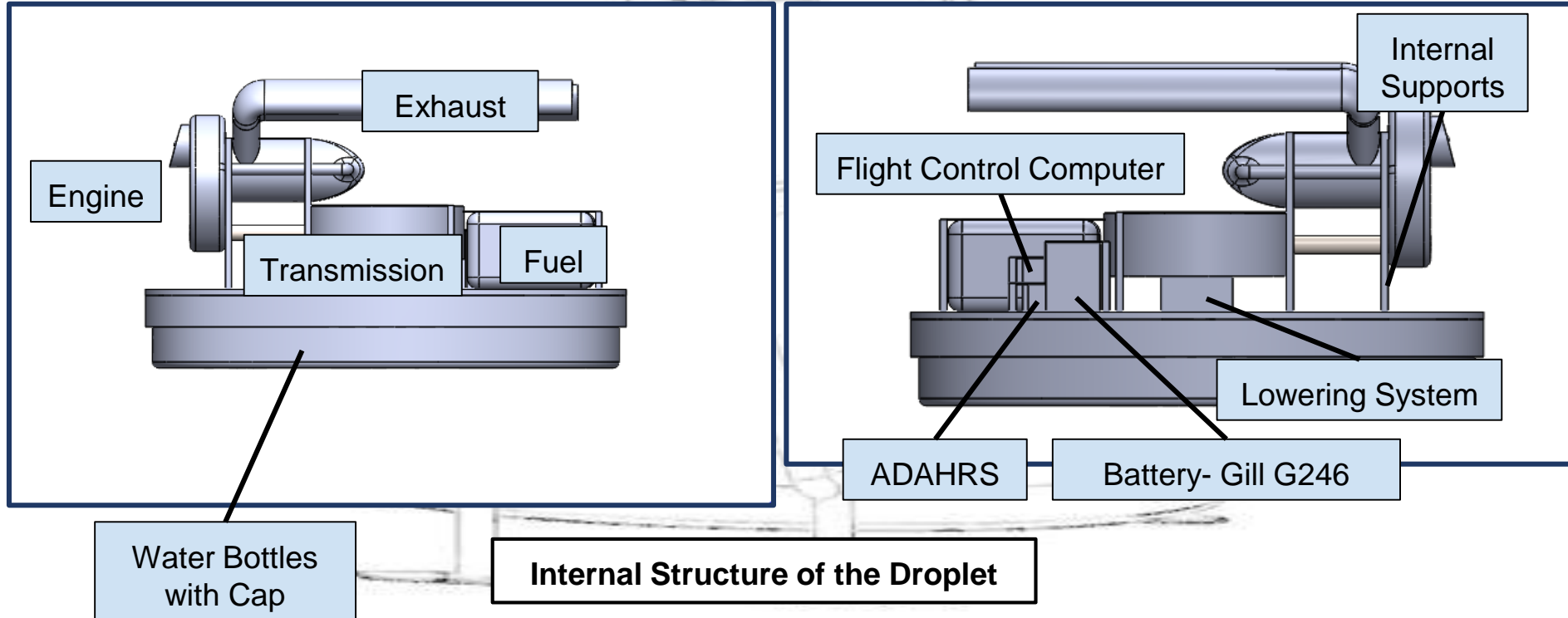


Blades Closed
Fuselage Width: 80 inches



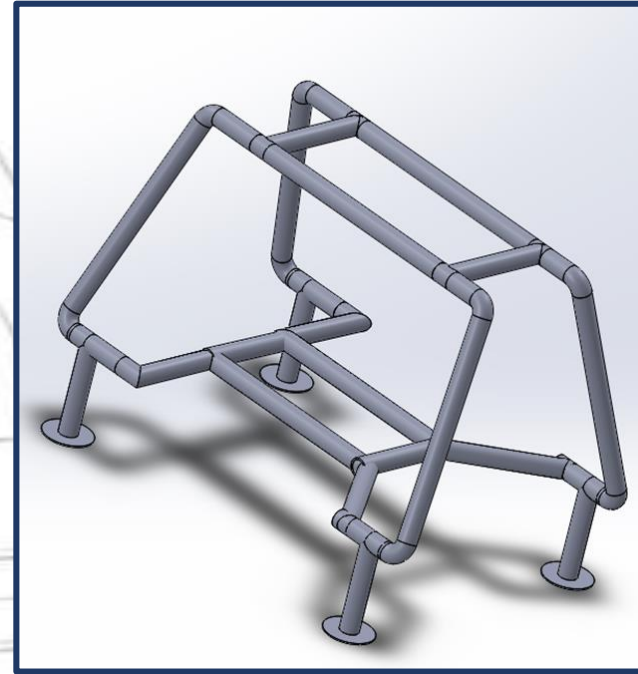
Blades Open
Blades Open Diameter: 171 inches

Droplet Internal Layout



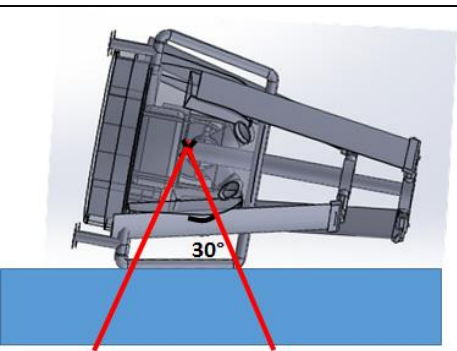
Internal Structure, Landing Gear and Rails

- Structure made of Aluminum 6061-T6
- Safety Factors
 - Crash Safety: 10 g's
 - Parachute: 4.5 g's
 - Safety Loading Factor: 1.2
- All Outer Diameters: 3 inches
- Inner Diameters based on Buckling/Yielding
 - Landing Gear Inner Diameter: 2.2 inches
 - Rails Inner Diameter: 2.5 inches
 - Internal Structure Inner Diameter: 2.6 inches
- Total Structure Weight: 120 lbs

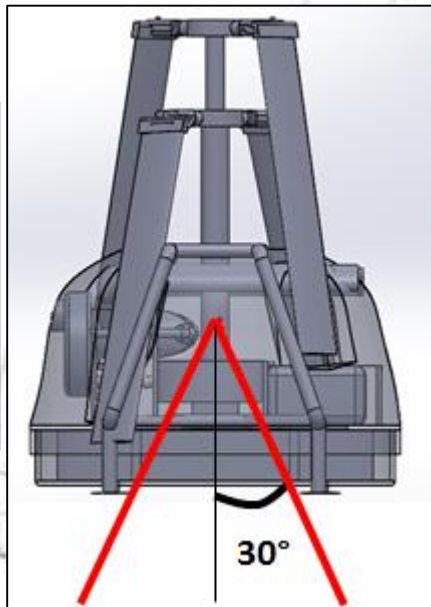


Pod Landing and Storage Stability

30° Stability Cone While On Side and Landing

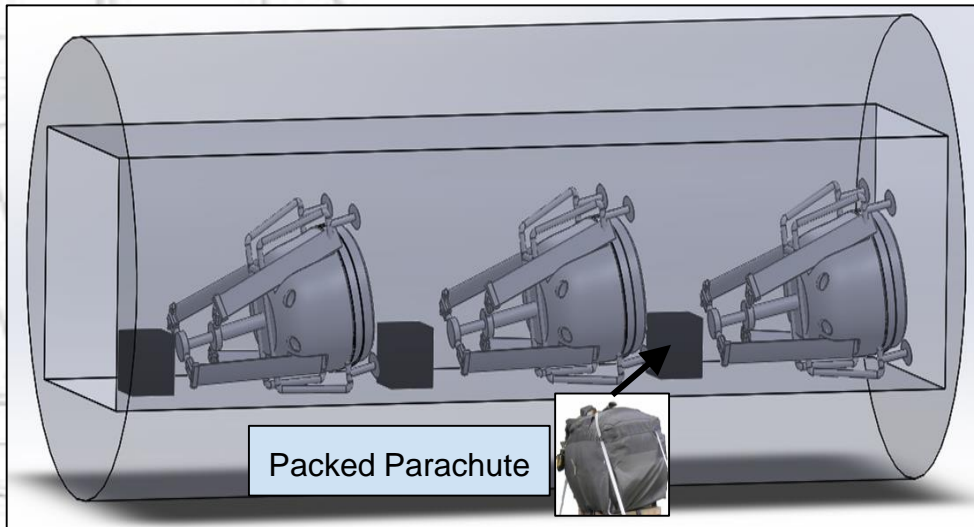


On Side



Landing

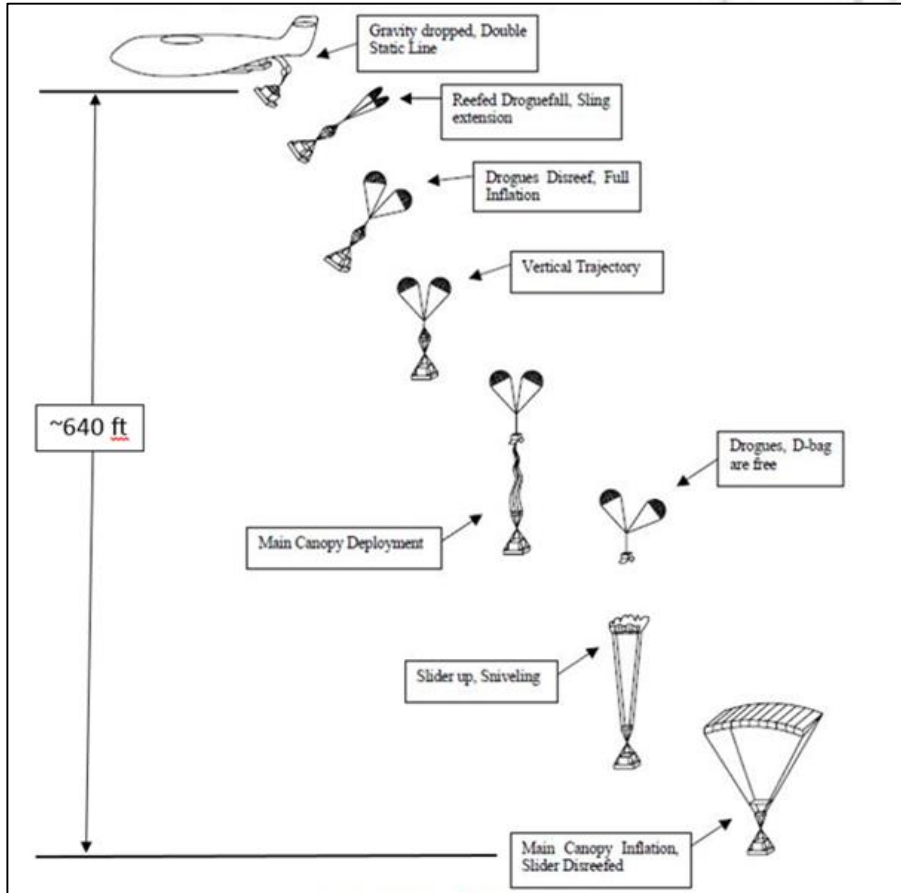
- Room for 3 Droplets and Parachutes in C-130 J cargo bay
- Manual deployment of each pod for three different disaster sites
- Each Droplet carries 500 lbs; 1500 lbs for each C-130 J Mission



Packed Parachute

Deployment Systems - Parafoil

Unguided Airborne Systems 1TFF (One Time FireFly)



Specifications	1TFF® System	
Payload capacity		
Minimum	750 lb	340 kg
Maximum	2,200 lb	998 kg
Weights		
Canopy	72 lb	32.7 kg
AGU	27 lb	12.2 kg
Opening shock (max)	4.5 g's	
Altitudes		
Maximum Release (ASML)	17,500 ft	5334 m
Minimum Release (AGL)	5,000 ft	1524 m
Operational Use	5,000 ft AGL	1524 m
Training Use	3,500 ft AGL	1524 m
Max Glide	3.25 : 1	
L/D, No Wind		

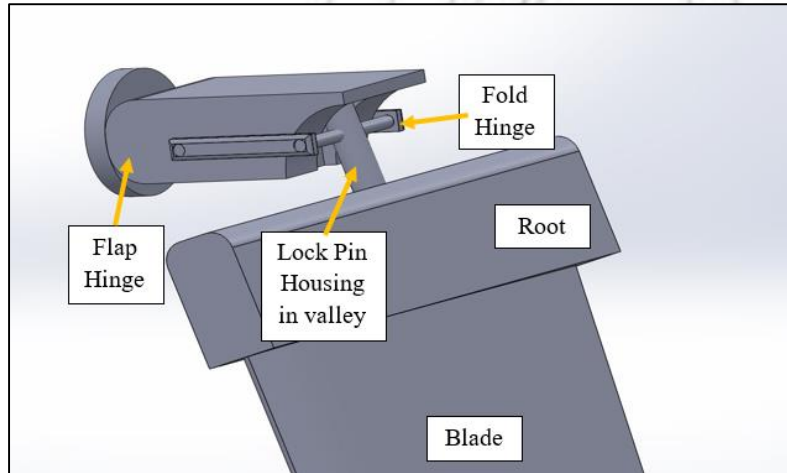
Deployment Segments



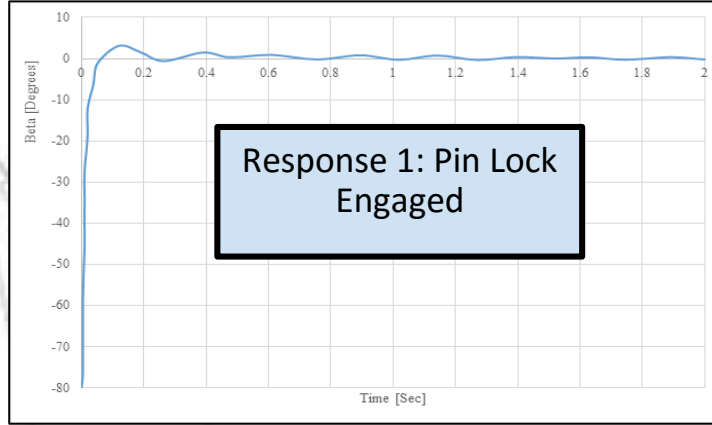
Type of Descent	Deployment Phase	Time [Sec]	Vertical Distance Covered [Feet]	Above Ground Level [Feet]	Altitude [Feet]
--	Start	--	0	5000	15000
Free Fall	Fall to fully open parachute	7	640	4400	14400
Parachute Glide (Descent rate at 18 feet/sec)	Start Engine	10	180	4200	14200
	Engine at ground Idle and ready to engage	120	2200	2000	12000
	Blades Pop up and lock (No Rotation)	5	90	1900	11900
	Rotor Brake Released and engine increased to full RPM	15	270	1700	11700
Release Parafoil		----			
Controlled Flight (Descent Rate 10 feet/sec)	Allowable time to enter Autonomous Flight	70	700	1000	11000
Controlled Flight (Descent Rate 5 feet/sec)	Controlled Descent to Hover	190	950	50	10050
Total Time [Sec]		410			
Total Time [Min]		7			

Blade Pop up System and Dynamic Analysis

- Blades start folded at hinge connection
- Blade latches are released and pin lock engaged when blades get into rotor plane [Response 1]
- Blade flapping transient response occurs with 100 foot-lbs/rad torsional spring [Response 2]
 - Rotor reaches full RPM and parachute released

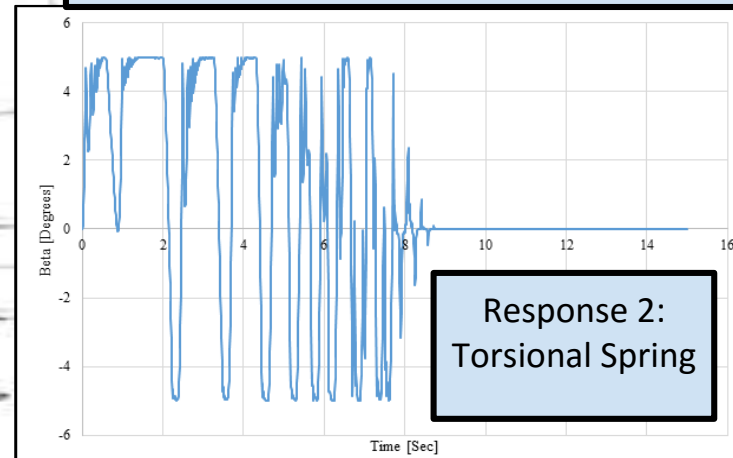


No Rotation: Rotor Brake Engaged



Response 1: Pin Lock Engaged

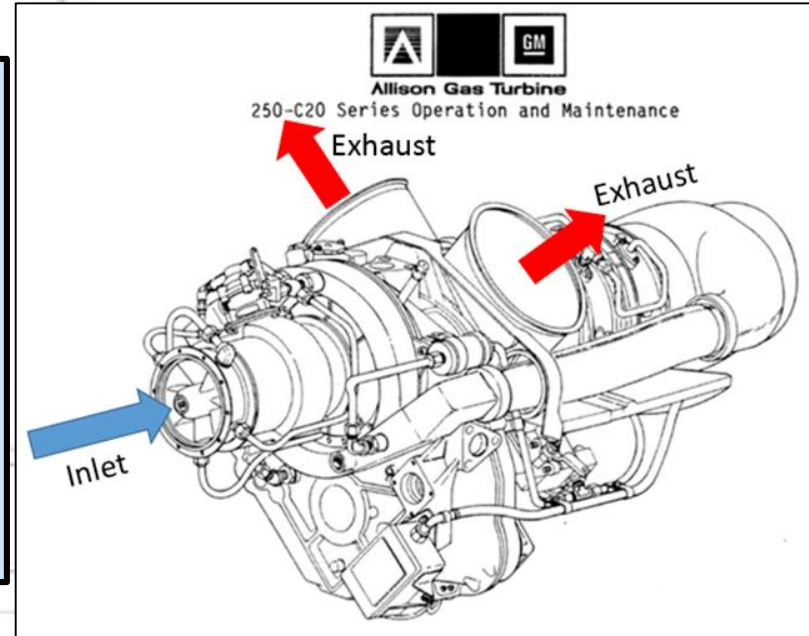
Rotation: Rotor Brake Released



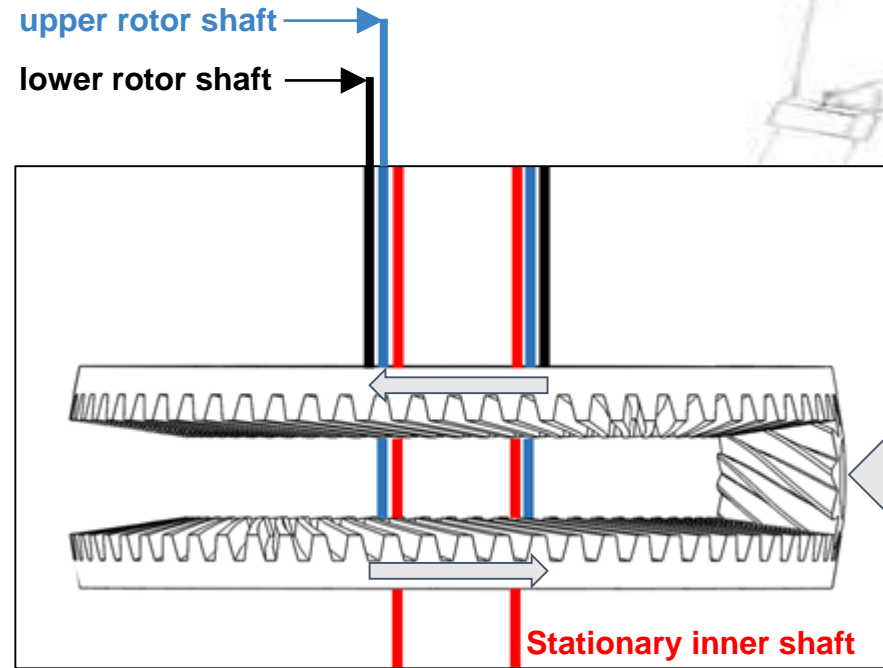
Response 2: Torsional Spring

Propulsion System - Overhauled RR M250-C20B

- 420 SHP maximum power
- 6016 RPM maximum output shaft speed
- Over 30,000 engines manufactured
- \$60,000 - \$330,000 (depending upon engine condition)
- Used on Bell 206, Ka-226, and many others



Transmission System - 90 deg. Bevel Gearing



Transmission Ratio = 5.9

Input Speed = 6016 RPM

Max. Power = 420 SHP

Output Speed = 1022 RPM

Engine Output Shaft

Bevel Gear Material: ASTM A322 Steel Alloy

Pinion Material: AISI 6150 Steel Alloy

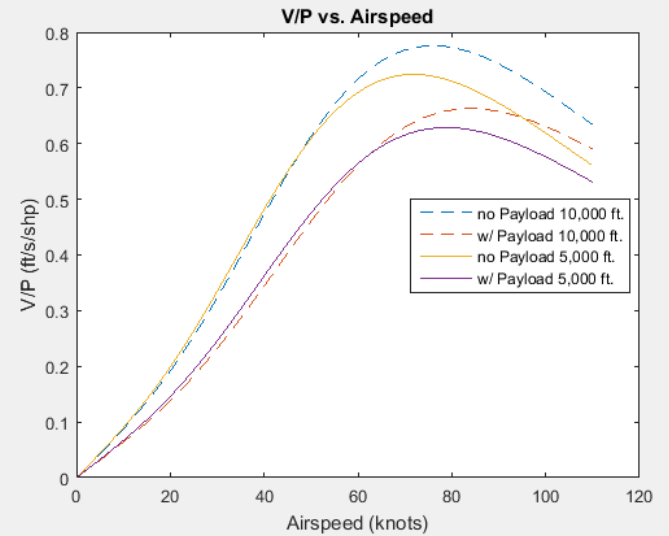
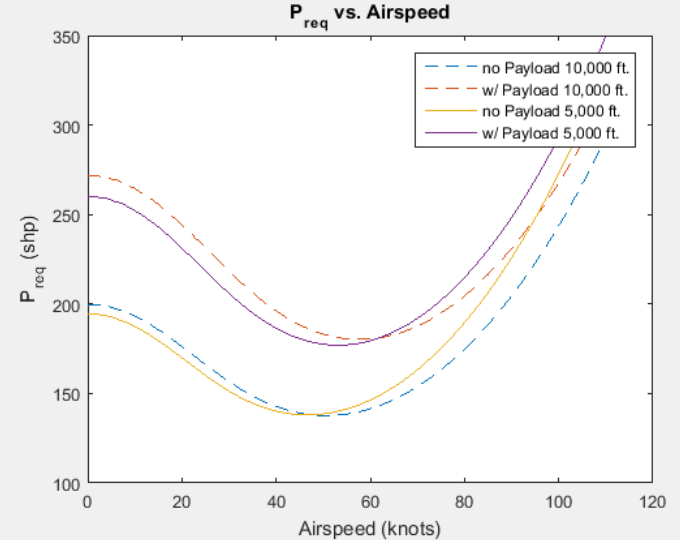
Bevel Gear Diameter = 23.47 in

Total Weight of Gearing = 204 lb

Performance Analysis

At 10,000 feet altitude

	W/ Payload	No Payload
Weight (lbs)	2200	1700
C_T/σ	0.080	0.062
Hover power (shp)	273	199
V max range (knots)	84	76
Drag at cruise velocity (lb)	172	141
P max range (shp)	214	182
Max vertical climb (fps)	18.6	71.9
Max vertical load factor (g's)	1.51	1.95

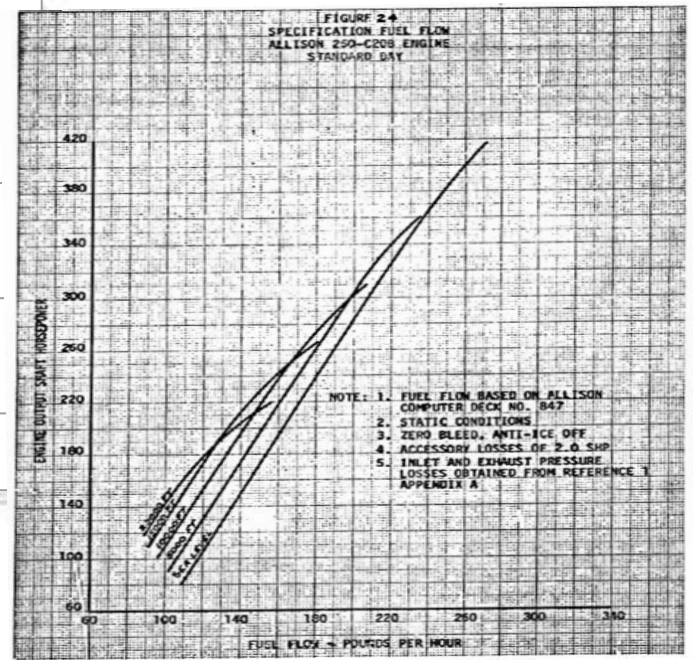


Fuel Calculation



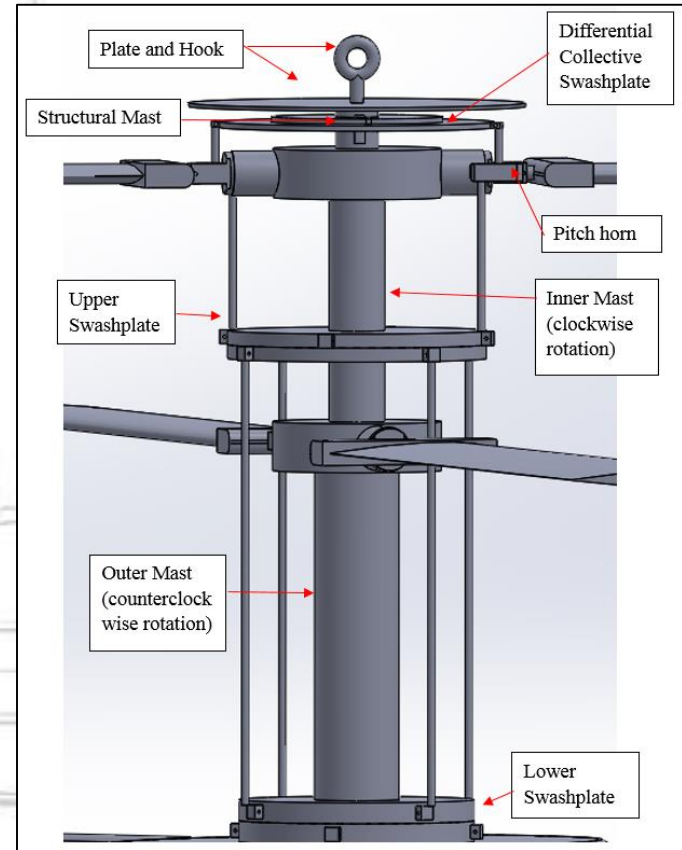
Mission Phase	Altitude (ft)	Power (shp)	Cruise Velocity (knots)	Fuel Flow (lb/hr)	Time (min)	Fuel Weight Used (lb)
Start-up	15,000-11,000	0-214*	0	145	3.00	7.3
Loaded Cruise	11,000*	214	84	145	2.75	6.7
Loaded Hover	10,000	273	0	185	1.00	3.1
Unloaded Cruise	10,000-4,000	165	72	130	40.0	86.7
Unloaded Hover	4,000*	191	0	150	1.00	2.5
Reserve	5,000	165	72	130	20.0	43.5

* denotes the use of higher fuel flow curve

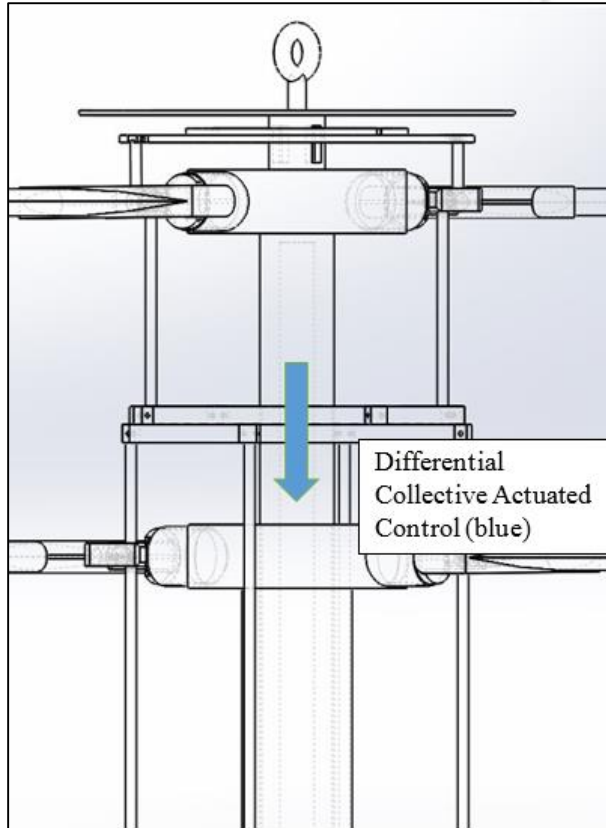


Flight Control and Response

- Main Actuation System
 - 3 Main Linear Electric Servos positioned 120° around the base of shaft
 - 2 Cyclic for longitudinal and lateral control
 - 1 Collective Control applied through lower swash plate



Flight Control and Response



- Differential Collective
 - Fourth actuator to control yaw
 - Control rod supported by stationary inner mast
 - Extends from below transmission through shaft
 - Applies control down/up on upper rotors

Autonomous Flight - Avionics & Electrical

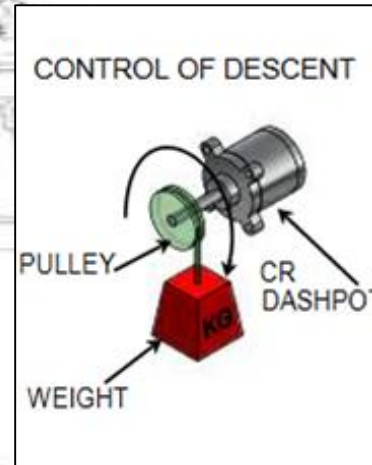


- Flight Control Computer
 - Interprets and sends out sensor data
 - Controls flight mechanics and control through actuators
- Sensor Channels
 - GPS
 - ADAHRS
 - VHF system
 - Servo sensors

- Battery
 - Provides 24 VDC at 19AH
 - Supply power to avionics and starter prior to engine start up
- Generator
 - Supplied by Allison M250 accessory gearbox
 - Supplies power to avionics and electrical actuators during flight
 - Also source of power to recharge battery unit

Lowering Mechanism

- Mechanism:
 - Model LE 5 Vane Dashpot
 - Angular velocity of rotation: 2.8 rad/sec
 - Dashpot Damper: 4300 lb-in/(rad/sec)
 - Water Bottle Final Speed: 1 feet/sec
 - Time to Drop: 50 seconds
- Cable for Drop
 - Galvanized Steel Cable
 - 3/16 inch. diameter
 - Cable Length: 55ft
 - Maximum Load 800 lbs.



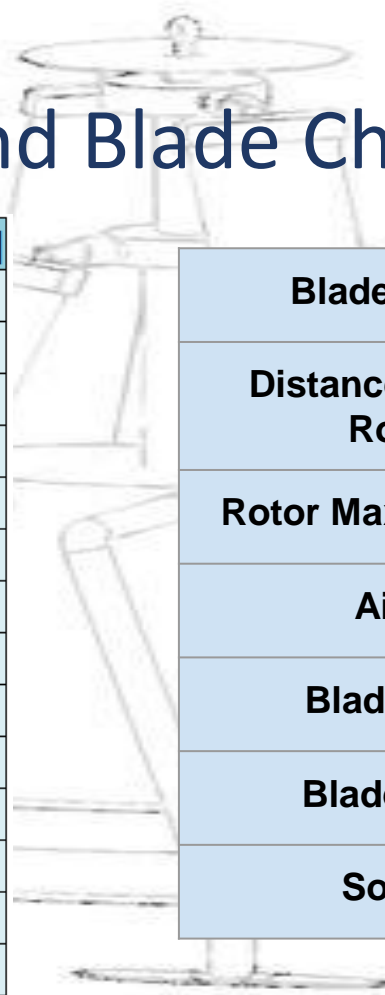
Model LE 5 Vane Dashpot



Droplet Weight and Blade Characteristics

Weight	Value [Lbs.]
Engine Installation	160
Main rotor blades	150
Main rotor Hub/Hinge	240
Body	200
Landing Gear/Structure	120
Fuel System	10
Transmission	420
Electrical	42
Avionics	5
Payload	510
Hoist	40
Fuel	150
Variation	50
Total Weight [lbs]	2100

Blade Radius	7 ft
Distance Between Rotors	1.5 ft
Rotor Maximum RPM	1022
Airfoil	NACA 0012
Blade Twist	-6 degrees
Blade Taper	1/3
Solidity	0.0909



Renderings

