An Airship Platform
vs
A Tethered Balloon Platform
for Science Applications

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Advantages of a Tethered Balloon Platform

A high altitude balloon platform that is tethered to the ground doesn't have some of the mass associated with an airship's power and recovery systems.

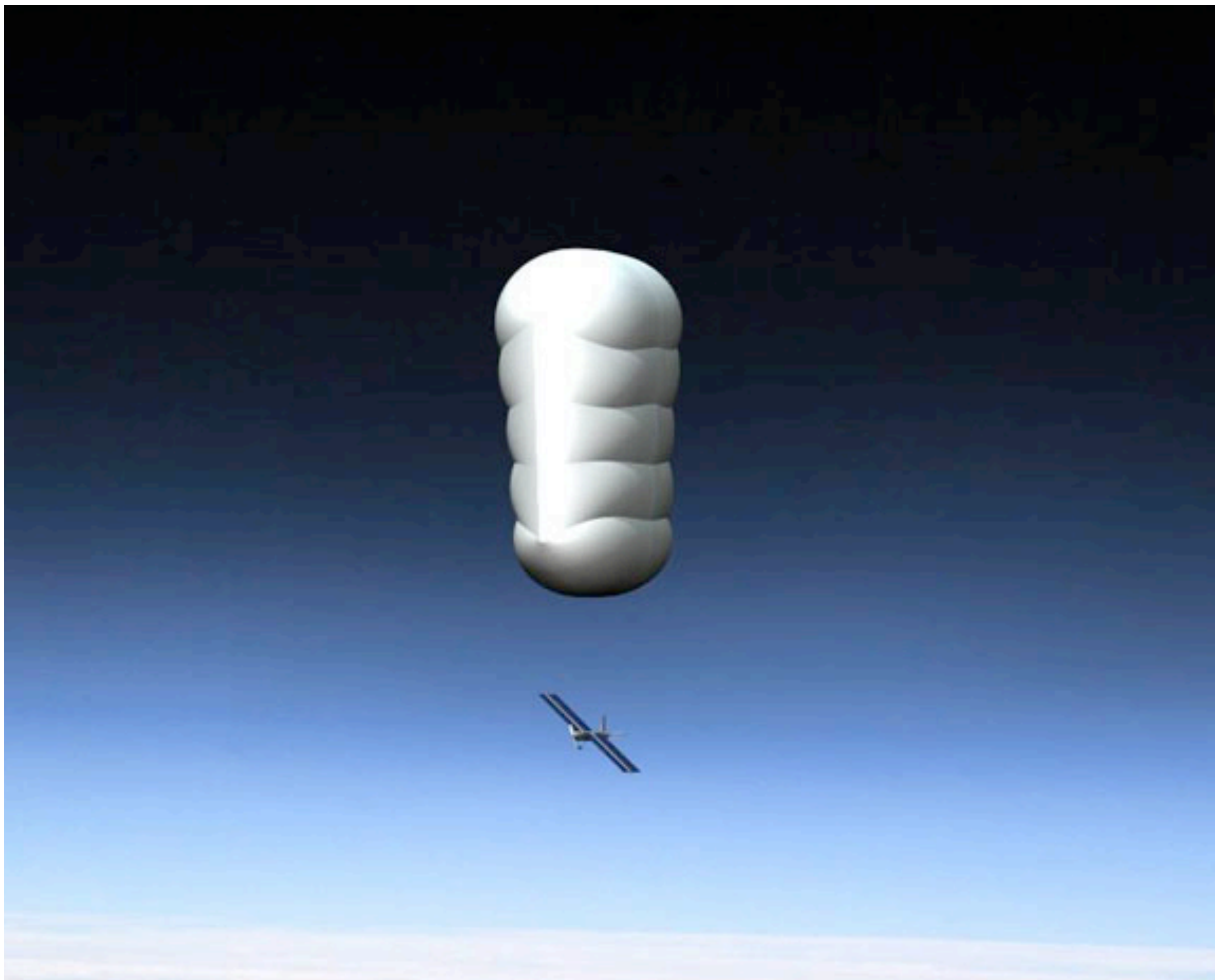
- no propulsion motors
- no propellers
- no large solar panels to power the motors
- no batteries needed to power propulsion at nighttime

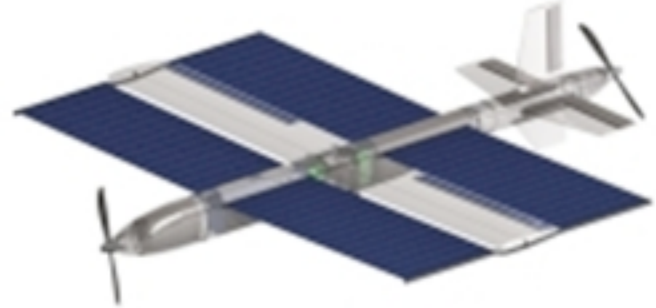
- maybe no parachute (?)
- maybe no balonet and associated mechanisms (?)

A Comparison of High Altitude Platforms for Science Applications

Item	Airship	Tethered Balloon
Altitude Range	< 75 kft	65 kft +
Payload mass	~ 40 kg (Hale-D, HiSentinel80)	> 100 kg ?
StationKeeping	only if winds < 10 m/s	its tethered
Cost	$35M for HALE-D	unknown, probably less
Duration	days to weeks?	days to weeks ?

A hybrid tether idea is the "StarLight" high altitude platform under development by Global Near Space Systems Inc (GNSS). It consists of a slightly aerodynamic balloon which is attached to a solar powered propulsion unit hung below.





Starlight with narrow-wing, high-speed configuration…

and with wide-chord, light-gathering configuration

This arrangement solves several problems associated with the multi-balloon tethered to the ground approach.

- No winch needed
- No aviation hazard issues associated with a grounded tether line
- Avoids most issues regarding stormy weather
- Tether wind loading is modest since tether altitudes > 65 kft
- Simpler deployment process with fewer elements

Separating the propulsion unit & PV panels from the balloon:

- propulsion propellers located in denser air and in lower winds
- propulsion unit could act like an "anchor" to the balloon
- PV panels competely unblocked by the balloon

I've run some calculations and in the next slides I show the results.

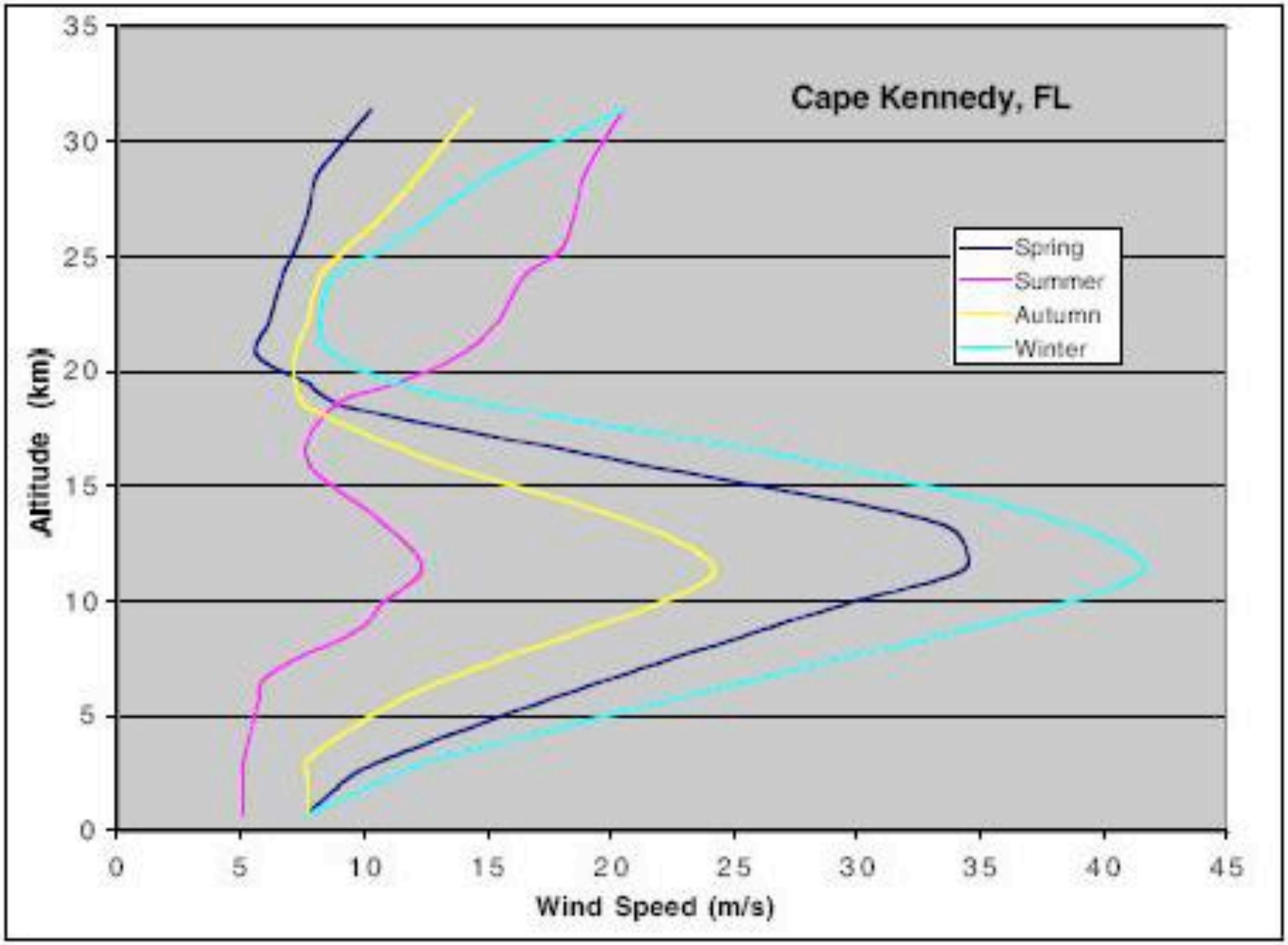
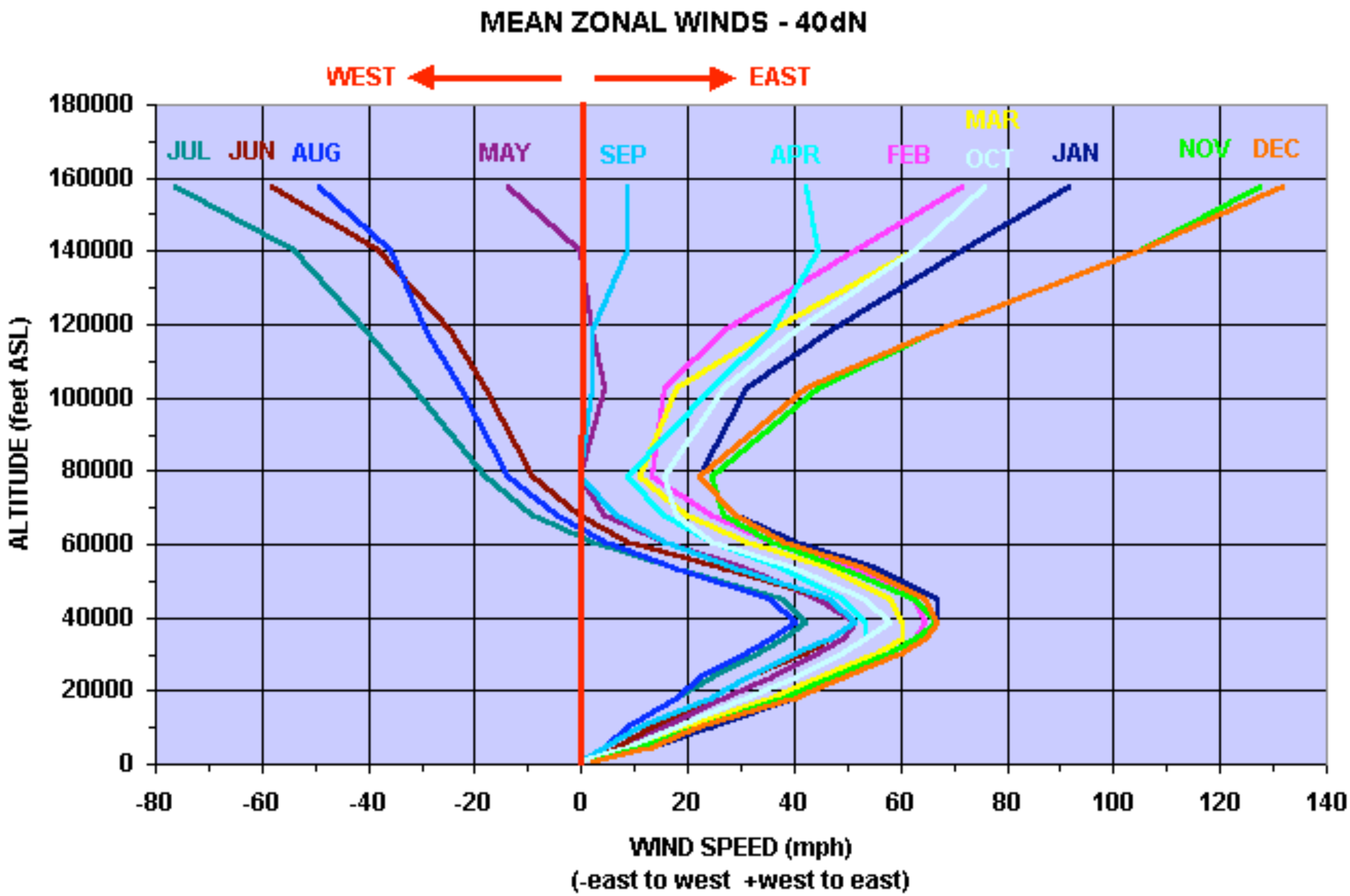
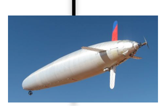


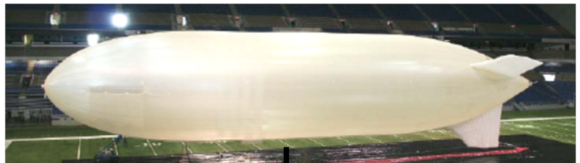
Figure 15 Mean Winds for Cape Kennedy, FL, Throughout the Year [21]


MEAN ZONAL WINDS - 40dN
WEST
EAST
JUL
JUN
AUG
MAY
SEP
APR
FEB
MAR
OCT
JAN
NOV
DEC
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
ALTITUDE (feet ASL)
-80
-60
-40
-20
0
20
40
60
80
100
120
140
WIND SPEED (mph)
(-east to west +west to east)

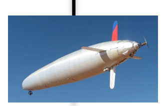
65,000 ft: Spherical Balloon

				Drag Force @		
				5 km/s	10 km/s	20 m/s
66 kft	54 millibars 0.086 kg/m^3		C_D = 0.50 D = 20 m Disp:115 kg	170 N	680N	2700 N
65 kft	56 millibars 0.091kg/m^3	Mission payload	C_D = 0.5 D = 1.0 m L = 1.0 m	1 N	3.6 N	14 N
		3 kft (1 km) 3 mm tether 6.8 kg wt MBS = 1500 kg	C_D = 0.5 L = 1 km	2 N	6 N	26 N
64 kft	59 millibars 0.095 kg/m^3	 Propulsion vehicle	C_D = 0.10 D = 0.5 m L = 2.5 m	0.1 N	0.4 N	1.5 N

65,000 ft: Aerodynamic Balloon



Mission payload

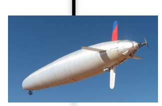


Propulsion vehicle

3 kft (1 km)
1.4 mm tether
1.1 kg wt
MBS = 200 kg

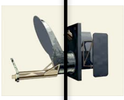
Altitude	Pressure / density	Component	Parameters	Drag Force @ 5 km/s	10 km/s	20 m/s
66 kft	54 millibars, 0.086 kg/m^3	Aerodynamic balloon	C_D = 0.10, D = 7 m, L = 30 m, Disp: 100 kg	4 N	17 N	66 N
65 kft	56 millibars, 0.091kg/m^3	Mission payload	C_D = 0.5, D = 1.0 m, L = 1.0 m	1 N	3.6 N	14 N
		Tether	C_D = 0.5, L = 1 km	1 N	3 N	13 N
64 kft	59 millibars, 0.095 kg/m^3	Propulsion vehicle	C_D = 0.10, D = 0.5 m, L = 2.5 m	0.1 N	0.4 N	1.5 N

65,000 ft: Best Aerodynamic Shapes

Altitude	Atmosphere	Element	Parameters	Drag Force @ 5 km/s	10 km/s	20 m/s
66 kft	54 millibars 0.086 kg/m^3		C_D = 0.05 D = 7 m L = 30 m Disp: 100 kg	2 N	9 N	33 N
65 kft	56 millibars 0.091kg/m^3	 Mission payload	C_D = 0.35 D = 1.0 m L = 1.0 m	0.8 N	3 N	9N
		3 kft (1 km) 1.4 mm tether 1.1 kg wt MBS = 200 kg	C_D = 0.5 L = 1 km	1 N	3 N	13 N
64 kft	59 millibars 0.095 kg/m^3	 Propulsion vehicle	C_D = 0.05 D = 0.5 m L = 2.5 m	0.05 N	0.2 N	0.8 N

90,000 ft: Spherical Balloon

91 kft	17 millibars, 0.027 kg/m^3
90 kft	18 millibars, 0.028 kg/m^3
65 kft	56 millibars, 0.091 kg/m^3



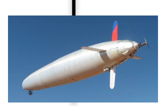
Mission payload

25 kft (7.5 km)
1.7 mm tether
13 kg wt
MBS = 300 kg

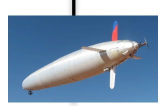
Propulsion vehicle

Parameters	Drag Force @ 5 km/s	10 km/s	20 m/s
C_D = 0.50, D = 40 m, Disp:285 kg	210 N	850 N	3400 N
C_D = 0.5, D = 2 m, L = 5 m	0.5 N	2.0 N	8 N
C_D = 0.5, L = 10 km	4 N	16 N	64N
	@ 0.05 kg/m^3		
C_D = 0.10, D = 0.5 m, L = 2.5 m	0.1 N	0.4 N	1.5 N

90,000 ft: Aerodynamic Balloon

Altitude	Pressure / density	Element	Parameters	Drag Force @ 5 km/s	10 km/s	20 m/s
91 kft	17 millibars 0.027 kg/m^3		C_D = 0.10 D = 15 m L = 60 m Disp:285 kg	6 N	24 N	95 N
90 kft	18 millibars 0.028 kg/m^3	 Mission payload	C_D = 0.5 D = 2 m L = 5 m	0.5 N	2 N	8 N
		25 kft (7.5 km) 1.7 mm tether 13 kg wt MBS = 300 kg	C_D = 0.5 L = 7.5 km	4 N	16 N @ 0.05 kg/m^3	64 N
65 kft	56 millibars 0.091 kg/m^3	 Propulsion vehicle	C_D = 0.10 D = 0.5 m L = 2.5 m	0.1 N	0.4 N	1.5 N

90,000 ft: Best Aerodynamic Shapes

Altitude	Atmosphere	Component	Parameters	Drag Force @ 5 km/s	10 km/s	20 m/s
91 kft	17 millibars 0.027 kg/m^3		C_D = 0.05 D = 15 m L = 60 m Disp:285 kg	3 N	12 N	50 N
90 kft	18 millibars 0.028 kg/m^3	 Mission payload	C_D = 0.35 D = 2 m L = 5 m	0.2 N	0.8 N	1.6 N
		25 kft (7.5 km) 1.7 mm tether 13 kg wt MBS = 300 kg	C_D = 0.5 L = 7.5 km	4 N	16 N	64 N
				@ 0.05 kg/m^3		
65 kft	56 millibars 0.091 kg/m^3	 Propulsion vehicle	C_D = 0.05 D = 0.5 m L = 2.5 m	005 N	0.2 N	0.8 N

Airship

The top balloon might have a size like HiSentinel80 but without the propulsion motor, parachute, and heavy battery packs.

HISentinel80: 60 m long, 15 m wide
Payload mass 40 kg
Solid mass = 500 kg
Helium mass = 100 kg
Drop Ballast ~ 20 kg