

Lox/Paraffin Hybrid Motor

Propellant Mass:

$I_{sp} := 220s$	Specific impulse of LOX/Paraffin
$I_{total} := 100000N \cdot s$	Total desired impulse of hybrid motor
$OF_{ratio} := 2.5$	Oxidizer to Fuel ratio
$T_{burn} := 15s$	Burn Time

$$Thrust_{average} := \frac{I_{total}}{T_{burn}}$$

$$Thrust_{average} = 1498.7 \text{ lbf}$$

$$Mass_{propellant} := \frac{I_{total}}{I_{sp} \cdot g}$$

$$Mass_{propellant} = 46.351 \text{ kg}$$

$$Weight_{propellant} := Mass_{propellant} \cdot g$$

$$Weight_{propellant} = 102.186 \text{ lbf}$$

$$Mass_{paraffin} := \frac{Mass_{propellant}}{OF_{ratio} + 1}$$

$$Mass_{paraffin} = 13.243 \text{ kg}$$

$$Weight_{paraffin} := Mass_{paraffin} \cdot g$$

$$Weight_{paraffin} = 29.2 \text{ lbf}$$

$$Density_{paraffin} := .000895 \frac{\text{kg}}{\text{cm}^3}$$

$$Volume_{paraffin} := \frac{Mass_{paraffin}}{Density_{paraffin}}$$

$$Volume_{paraffin} = 0.015 \text{ m}^3$$

$$Volume_{paraffin} = 0.523 \text{ ft}^3$$

$$Mass_{lox} := Mass_{propellant} - Mass_{paraffin}$$

$$Mass_{lox} = 33.108 \text{ kg}$$

$$Weight_{lox} := Mass_{lox} \cdot g$$

$$Weight_{lox} = 72.99 \text{ lbf}$$

$$Density_{lox} := .00141 \frac{\text{kg}}{\text{cm}^3}$$

$$Volume_{lox} := \frac{Mass_{lox}}{Density_{lox}}$$

$$Volume_{lox} = 23.481 \text{ liter}$$

$$Volume_{lox} = 6.203 \text{ gal}$$

Vehicle Mass

$$\text{Fuel}_{\text{ratio}} := 0.6$$

$$\text{StageMass}_{\text{total}} := \text{Mass}_{\text{propellant}} \cdot \frac{1}{\text{Fuel}_{\text{ratio}}}$$

$$\text{StageMass}_{\text{total}} = 77.251 \text{ kg}$$

$$\text{StageWeight}_{\text{total}} := \text{StageMass}_{\text{total}} \cdot g$$

$$\text{StageWeight}_{\text{total}} = 170.31 \text{ lbf}$$

$$\text{StageMass}_{\text{empty}} := \text{StageMass}_{\text{total}} - \text{Mass}_{\text{propellant}}$$

$$\text{StageMass}_{\text{empty}} = 30.9 \text{ kg}$$

$$\text{StageWeight}_{\text{empty}} := \text{StageMass}_{\text{empty}} \cdot g$$

$$\text{StageWeight}_{\text{empty}} = 68.124 \text{ lbf}$$

Motor Component Weights (rough guesses):

$$\text{Tank}_{\text{helium}} := 3 \text{ lbf} \quad 72 \text{ cubic inch } 3000 \text{ psi paintball tank}$$

$$\text{Tank}_{\text{lox}} := 10 \text{ lbf} \quad 20 \text{ liter (aluminum)}$$

$$\text{Regulator}_{\text{helium}} := 2 \text{ lbf} \quad \text{MarottaRV89}$$

$$\text{Rupturedisk} := 1 \text{ lbf} \quad \text{includes holder}$$

$$\text{CombustionChamber} := 8 \text{ lbf} \quad \text{chamber, liner, injector, nozzle, etc}$$

$$\text{Plumbing}_{\text{misc}} := 7 \text{ lbf} \quad \text{cryo lines, transducers, fill, vent and safety ports}$$

$$\text{Gimbal} := 5 \text{ lbf} \quad \text{electric linear actuators and battery (optimistic)}$$

$$\text{Structure} := 5 \text{ lbf} \quad \text{Majority of propulsion module (minus fins)}$$

$$\text{Weight}_{\text{motor}} := \text{Tank}_{\text{helium}} + \text{Tank}_{\text{lox}} + \text{Regulator}_{\text{helium}} + \text{Rupturedisk} + \text{CombustionC} \\ + \text{Plumbing misc} + \text{Gimbal} + \text{Structure}$$

$$\text{Weight}_{\text{motor}} = 41 \text{ lbf}$$

$$\text{Mass}_{\text{motor}} := \frac{\text{Weight}_{\text{motor}}}{g}$$

$$\text{Mass}_{\text{motor}} = 18.597 \text{ kg}$$

$$\text{LV3Mass}_{\text{remaining}} := \text{StageMass}_{\text{empty}} - \text{Mass}_{\text{motor}}$$

$$\text{LV3Mass}_{\text{remaining}} = 12.303 \text{ kg}$$

$$\text{LV3Weight}_{\text{remaining}} := \text{LV3Mass}_{\text{remaining}} \cdot g$$

$$\text{LV3Weight}_{\text{remaining}} = 27.124 \text{ lbf}$$

A more probable Scenario

Fuel_{ratio} := 0.55 reduce the fuel ratio

$$\text{StageMass}_{\text{total}} := \text{Mass}_{\text{propellant}} \cdot \frac{1}{\text{Fuel}_{\text{ratio}}}$$

$$\text{StageMass}_{\text{total}} = 84.274 \text{ kg}$$

$$\text{StageWeight}_{\text{total}} := \text{StageMass}_{\text{total}} \cdot g$$

$$\text{StageWeight}_{\text{total}} = 185.793 \text{ lbf}$$

$$\text{StageMass}_{\text{empty}} := \text{StageMass}_{\text{total}} - \text{Mass}_{\text{propellant}}$$

$$\text{StageMass}_{\text{empty}} = 37.923 \text{ kg}$$

$$\text{StageWeight}_{\text{empty}} := \text{StageMass}_{\text{empty}} \cdot g$$

$$\text{StageWeight}_{\text{empty}} = 83.607 \text{ lbf}$$

Weight_{motor} := 35lbf be clever and reduce the weight of the pressure fed design

$$\text{Weight}_{\text{motor}} = 35 \text{ lbf}$$

$$\text{Mass}_{\text{motor}} := \frac{\text{Weight}_{\text{motor}}}{g}$$

$$\text{Mass}_{\text{motor}} = 15.876 \text{ kg}$$

$$\text{LV3Mass}_{\text{remaining}} := \text{StageMass}_{\text{empty}} - \text{Mass}_{\text{motor}}$$

$$\text{LV3Mass}_{\text{remaining}} = 22.048 \text{ kg}$$

$$\text{LV3Weight}_{\text{remaining}} := \text{LV3Mass}_{\text{remaining}} \cdot g$$

$$\text{LV3Weight}_{\text{remaining}} = 48.607$$

This gives us approximately 50 lbs for the remainder of the airframe, fin canister, recovery system and avionics.