plete this burn. The effective specific impulse, I_{sp}, of the STAR 27E motor is given as 287.4 s. The required propellant mass is 248 kg leaving 204 kg injected into this orbit. The STAR 27E is recommended by Orbital Sciences Inc. for use with the Pegasus XL for acceleration to GTO and is the smallest STAR motor that will accommodate the amount of fuel required. If we allow 25 kg for the motor casing and 15 kg for the mounting and release mechanism we have 165 kg remaining.

Again using orbital mechanics the required change in velocity to raise perigee from a radius of 6578 km (200 km altitude) to 9020 km (~1.4 R_E) is 280 m/s applied at apogee. Using the Kaiser-Marquardt model 20 hydrazine motor, the specific impulse, I_{sp}, is 235 s. Again using the rocket equation we find that we need 20 kg of propellant to complete this burn.

The final burn requires a raise of apogee from a radius of 5 R_E to 25 R_E while releasing satellites. Using the same method outlined above, the change in velocity at perigee is determined to be 846.2 m/s. Using the conservative assumption that all of the satellites would be accelerated to 25 R_E apogee, 45 kg of propellant would be required. In fact, release of the satellites during orbit raise would require somewhat less fuel due to the constantly decreasing mass to be accelerated.

In order to accommodate the required hydrazine, we have selected tank #80364-1 from Pressure Systems Inc. The capacity of this tank is 68 kg which easily accommodates the 64 kg of hydrazine required for both burns. Also under consideration is the Kaiser-Marquardt model 20 hydrazine motor which has a mass of 1.6 kg and a nominal thrust of 455 N. This would allow the first burn at apogee to occur in less than two minutes and be effectively instantaneous. The perigee burn would require about five minutes corresponding to about one release every six seconds for 48 satellites. Due to motion of the bus this burn would occur over ±1500 km at perigee. This range is small enough that the orbital calculations assuming the burn occurred at perigee should be sufficiently accurate for the present estimates.

After subtracting all of the separation systems, motors and tanks we are left with 93 kg for the bus and satellites. If we allow approximately 45 kg for the bus, then we can accommodate 48 satellites at 1 kg each. If it is found that the bus or satellite mass can be further reduced, additional satellites could be flown. This mass breakdown is shown in Figure 4.

5.2 Packaging and Release System

Preliminary design concepts for the packaging of the satellites and their release from the bus have been developed. One promising approach follows. The satellites will be carried in the bus in six stacks of eight satellites each as shown in Figure 5. These stacks will extend radially outward from a hexagonal center core. Allowing a 3 cm height plus a 1cm gap between satellites, the length of a spoke of 16 satellites plus the center core will be 99 cm, leaving an adequate margin within the 116.8cm internal diameter at the base of the Pegasus XL payload compartment. With 20cm diameter satellites this stack would require less than 30cm space along the bus axis. The other components carried on the bus that might require significant length in the payload are the thruster (40 cm), hydrazine fuel tank (20 cm) and STAR kick motor (90 cm). Taking these measurements into account, there should be no problem fitting into the payload compartment that is 214 cm long. The individual satellites will be released from the outside of the stack and the inner satellites will be delivered mechanically to the outside release position.

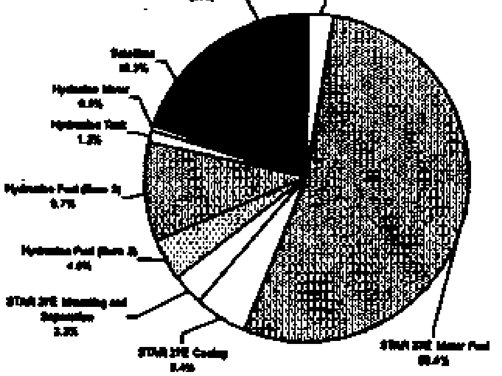

Figure 4. The launch mass budget. The fraction of the ma that is launched into a 200km circular orbit that is applied each stage of the deployment process. Based on a Pegasu XL launch which places 465 kg into the low Earth orbit.

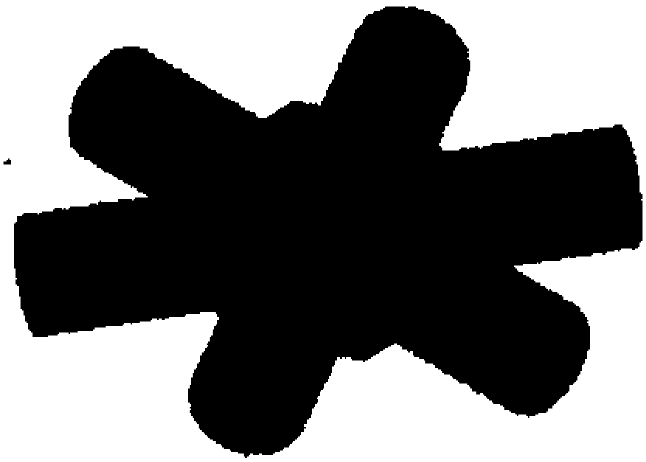

Figure 5. Satellite packaging arramgement in Pegasus X payload compartment. Satellites will be moved mechanicall to the outside position prior to release.

One of the constraints on the release system is that while the b likely to be spin stabilized around its velocity vector, the satellite spin about an axis which is roughly perpendicular to the plane o orbit. This requirement must only be met to ±30° since both the cells and the RF transmission depend only on the cosine of the a The above satellite storage arrangement was chosen so that the side satellite in the stack can be released at the proper bus orientat when the satellite axis is perpendicular to the orbit. As each satell released it will be given a separation velocity and a spin.

The satellite spin immediately after release will be complica consisting of a combination of the bus rotation rate and the rota added on release. We plan to include a damping mechanism on satellite so that its final rotation will be only around a single axis, cylindrical axis of the satellite that will be designed to have the lar moment of inertia. In order to have the final spin axis close to perp dicular to the orbit plane, the release spin rate must be several ti larger than the bus spin rate.

Specific mechanisms for holding the satellites, ratcheting them ward, providing the release velocity and spin have not yet been de mined. Various combinations of springs, motors, gas jets and mi ture explosive bolts are under consideration.

6. Ground station requirements