LEGO NEARSPACE JUMP – BEST DESIGN

InterSpace System (a small 3 person team) designed a capsule and electronics to attempt the world's highest Legoman jump! The objective of this launch was to determine if we could successfully trigger an event at a specific altitude. Our design was inspired by the Red Bull Stratos high altitude near space jump. We envisioned recreating the Red Bull Stratos (Figure 1) using Legoman and triggering a servo to have him jump outside the capsule at 50,000ft (Figure 2). Embracing the recent record breaking events performed by Red Bull Stratos, and the thought that all individuals should have access to nearspace, all models were created from scratch using 3D modeling software (Inventor, Alibre & Solidworks), and additive manufacturing (3D printing). A solid model capsule similar to the red bull capsule was modeled by Seth Hahn and 2 parts were 3D printed using the Solidoodle Gen 3 and Makergear MK2 (Thanks to B3Dprintjobs & InterSpace Systems).

Figure 1: Red Bull Stratos Capsule

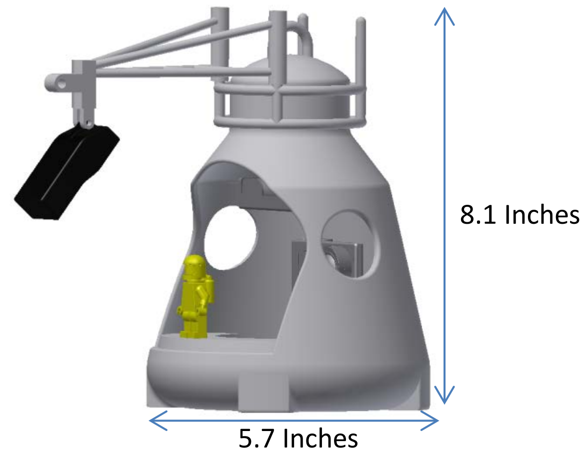


Figure 2: Legoman Capsule (CAD model)

The capsule was then fitted with one lego Felix and a small servo motor (Figure 3). Inside the capsule was an Arduino Uno coded with a 10 Degree of Freedom (10DOF) inertia measuring unit (IMU) and an SD card shield for datalogging. The Arduino would capture the motion, acceleration, heading and altitude of the capsule during the duration of the flight. A MUVI camera with a boom was also attached to the capsule so footage of the jump could be recorded.

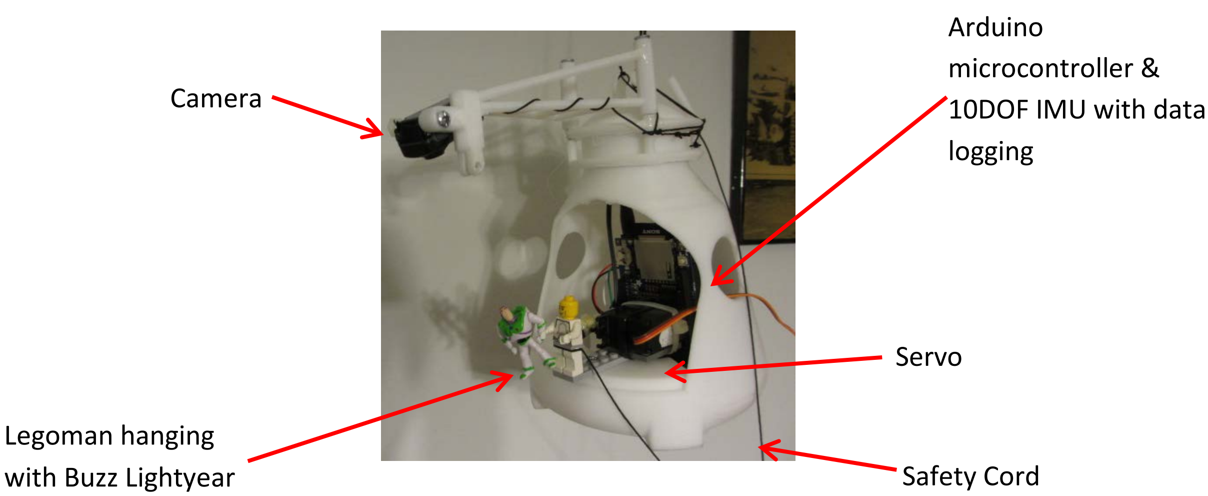


Figure 3: 3D Printed Capsule with boom (10% infill, 0.31mm layer height)

An additional controller box was created by Peter Himmerich to capture flight data, photographs, video, and trigger the capsule servo motor (Figure 4). This electronic box was created using a Parallax Propeller DX40 microcontroller & protoboard, an MS5607 altitude sensor, BMP085 pressure sensor, SD card shield, and GPS shield (Figure 5). A Cannon point and shoot camera was inside the control box to take pictures every 15 seconds after a 30 minute waiting period using the Cannon Development Hack Kit Intervalometer script.

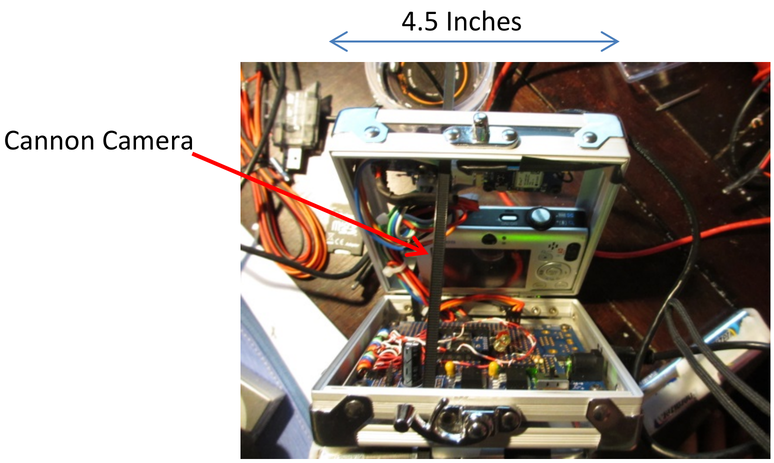


Figure 4: Control Box with Camera

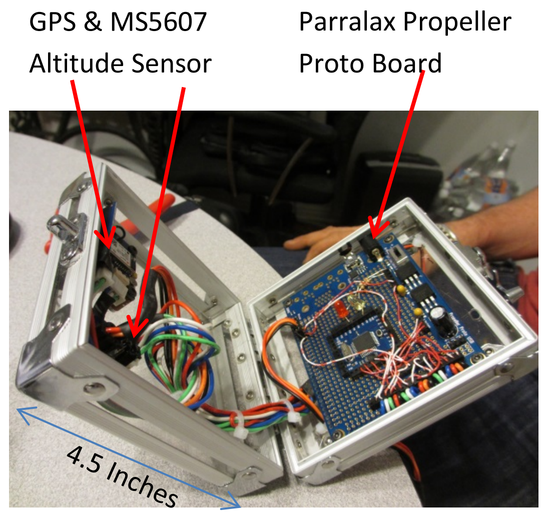


Figure 5: Internal Electronics and sensors

On the exterior of the control box, video footage would be captured using a HackHD camera connected to a 6Ah battery (Figure 6). Additionally on the exterior, a MUVI camera mounted on a boom was attached.

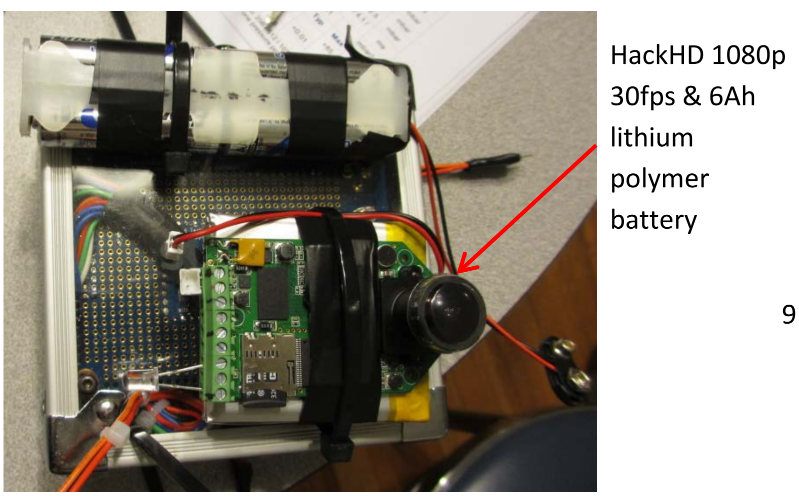


Figure 6: Exterior Electronics

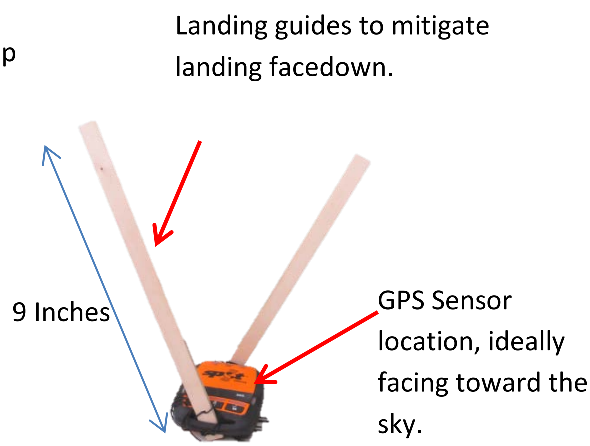


Figure 7: SPOT GPS with Landing Guides

A SPOT GPS with impact guides was also connected above the control box. These guides were attached to the SPOT GPS at 45 degrees from vertical to displace the center of gravity of the assembly and increase the probability of the GPS sensor to land face up. The guides also stop the unit from facing downward and decrease the possible loss of a satellite link. Finally a Rocketman 5ft parachute was connected to the SPOT GPS (Figure 7). Our lifting body was a Kaymont 800 gram balloon filled with hydrogen. All team members have hydrogen safety training. Our complete payload train can be seen in Figure 8.

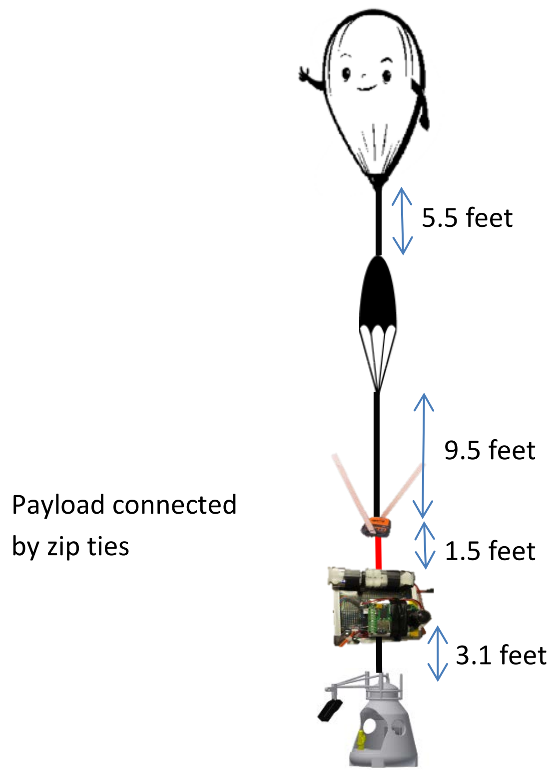


Figure 8: Payload Train Schematic

Our complete payload train consisting of the following had a total weight of 1499 grams! This weight and use of specific 25lb maximum cord line allowed us to remain unregulated per FAR 101.1.

Table 1: Payload Training Inventory & Weights

Rocketman 5ft Parachute	169 grams
Spot GPS	135 grams
Control Box Parallax Propeller DX 40 protoboard MS5607 altimeter sensor BMP085 Pressure sensor GPS sensor 4 AA lithium batteries Cannon sd980is MUVI 480 video camera Hack HD 1080p Video camera 6Ah lithium battery	751 grams
Legoman Capsule Arduino Uno 10DOF IMU SD card Shield 4 AA lithium batteries MUVI 480 video camera Servo Legoman	444 grams
Total Weight	**1499 grams**

LAUNCH LOCATION

Approximate time of launch was 10:19 am on 05/03/14. We decided to launch near Mojave to allow for a relatively flat landing location (35.13053 latitude, -118.14618 longitude). Previous launches ended in non-ideal landing locations. Our long duration, launched on April 19th, landed on top of a 7300 ft mountain which took 7.5 hours to retrieve and our April 21st launch landed in inaccessible brush on the other side of the most polluted river in North America (the New River in El Centro), which we swam through to recover our payload.

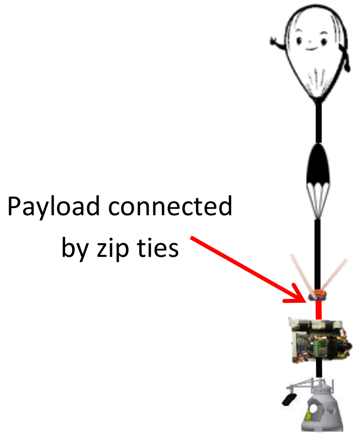
OUTCOME OF FLIGHT

We lost signal coverage of the SPOT GPS faster than estimated (~33 minutes into the flight). This indicates an altitude higher than 60,000ft (commercial GPS limitation). We still tracked and monitored the SPOT GPS during descent but once we located the GPS we found that the control box and capsule were nowhere in sight. The 2 cord attachment loops were intact but there was no sign of the zip ties previously attached to this area. Unfortunately, flight data, photos and video have not been recovered. Yet. ☺

Figure 9: Recovery point (35.23561 Lat. -117.51288)

PRESUMED FLIGHT ANOMALY

We assumed that 2 zip ties failed during the ascent portion of the flight and detached the control box & capsule from the GPS and parachute. Specific non-freezing line was used to attach the balloon to the parachute, the parachute to the SPOT GPS, and the control box to the capsule but it was overlooked that zip ties were used to secure the control box and attach the control box to the SPOT GPS. One black zip tie and a secondary (redundant) zip tie secured the control box to the SPOT GPS (Figure 10).



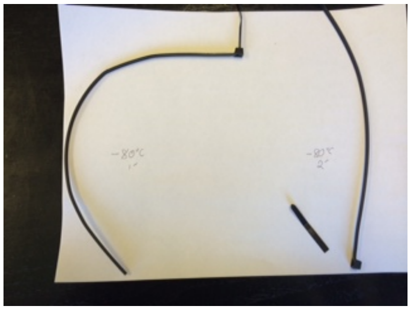


Table 2: Zip tie break test

Temperature	Duration	1lb force break (Yes/No)
0 C	12 hours	Yes
~ -20 C	15 minutes	No
~-80 C	15 minutes	Yes
~-80 C	2 minutes	Yes
~-80 C	1 minute	Yes

Figures 10 &11: Payload Train Schematic (left) showing zip tie connection and break test (right)

This failure was likely due to extreme cold. Testing of zip ties at freezing temperatures showed that they do embrittle and break with less than 1lb of force (Figure 11 & Table 2).

If the control box and capsule, which had a mass of 751 grams, was severed from the payload train then the amount of free lift would increase by 25% and the payload mass would decrease by ~50%, thus sending the parachute and SPOT GPS racing up in altitude. This would explain the loss of signal (assuming a 60,000 ft or higher altitude) 17 minutes earlier than expected. The regain of the GPS signal at a further than predicted distance and extended decent duration also lead us to this conclusion.

POSSIBLE RETRIEVAL (FURTHER EFFORTS)

The quick loss of signal leads us to believe that the payload was severed during the ascent phase of flight. We have approximately 12 data points showing the presumed ascent phase of flight (Figure 12). This spans approximately 9.82 miles (~51850 ft). Assuming the control box and capsule followed the same wind trajectory and detached from SPOT GPS, it may be within this 9.82 mile area. Further calculations are in progress to narrow down the search area.

Figure 12: GPS SPOT DATA

SUMMARY

Although the jump data wasn't recovered yet, this particular design allowed our small team of 3 to enhance our skills in solid modeling, additive manufacturing (3D printing), open source electronic programming (Processing & Parralax language), relay triggering and data collection. We used commercial products and open source programming as much as possible to promote participation by everyone from students at all levels to everyday citizens. We believe this design should be recognized as one of a kind for its high level of creativity, complexity, small weight, and employment of multiple fields of engineering (manufacturing, modeling and programming.

Figure 13: Legoman with Buzz Lightyear awaiting launch!