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Wireless Digital Repeater (WiDR) network's packaging/ Initial deployment review

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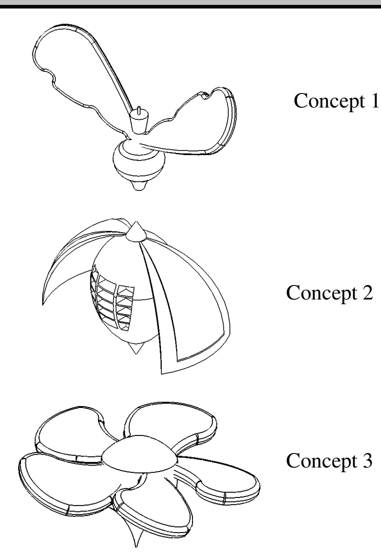
Overview

The WiDR Network's packaging element of the project aims to develop a survival/storage unit for the inner components of the network nodes. There are many factors that go into building a successful embodiment or housing for the electronic features of the system. The orientation or course direction that the unit will take, the survivability or ability to adapt to multiple environments, the landing capabilities and the ability to collect solar energy and recharge are all important characteristics that go into building a successful system. Along with the main factors for the network's packaging, several parts such as the antenna, the solar fins and compartments for the rf electronics are important aspects that went into the design of the project.

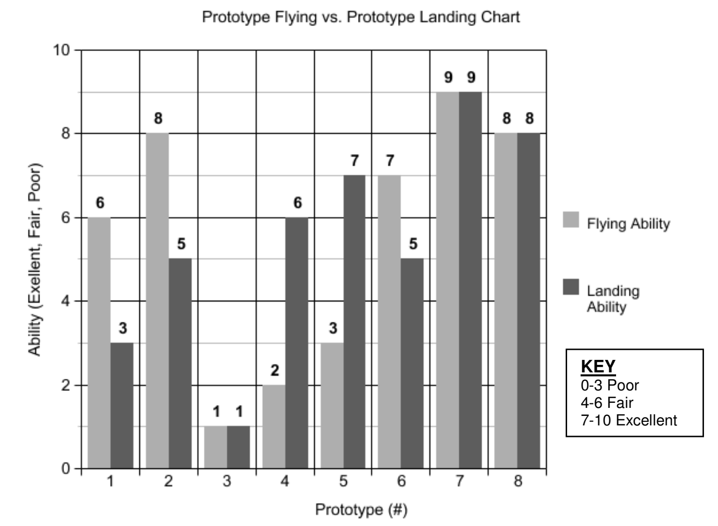
Initial development of concepts stemmed from a wide range of areas. Concepts were developed based on elements in nature (plants, leaves, and insects) and existing mechanical devices such as propellers, planes and other flying objects. Thus, after extensive research, 10 – 15 hand drawings of completely different shapes and sizes were produced. The next stage was to concentrate on three designs and formulate questions and other concerns on those ideas. Consequently, 3D CAD drawings, form studies and dimensioning of the concepts were formulated. See Figure 1 for three of the explored concepts.

Figure 1: *Three Initial Concepts*



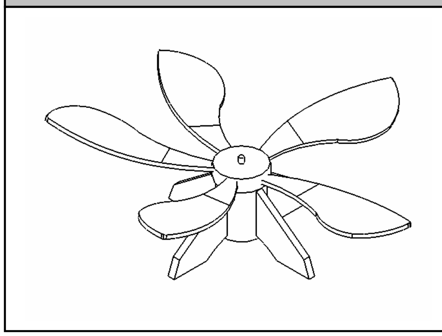
The next phase of development consisted of making basic prototypes. These prototypes were built to explore certain characteristics of the structure such as flying ability (or spin) and landing ability. By simply modifying the size and/or different parts of the model, a better understanding of the shape and volume of the system could be discovered.
Accordingly, eight simple prototypes were made and judged on certain criteria. Then, by performing several tests on each model, two designs stood out. See Figure 2 for a look at the prototype rating chart that was used to narrow down the field of possible structural choices.

Figure 2: *Prototype Flying and Landing Rating Chart*



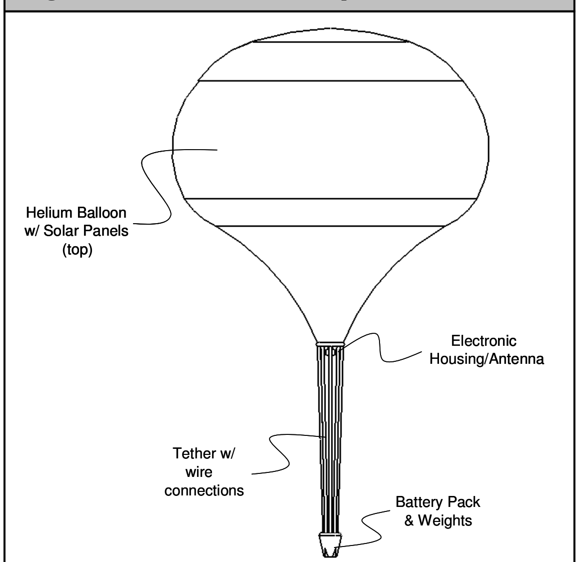
From these tests, prototype number seven appeared to be the superior design. As shown in Figure 2, prototype seven had the overall best flying and landing ability. Also, this design was unique because it had five tilted fins that aided in supplying a nice spinning motion. Furthermore, the base of the design provided an upright landing and a very smooth fall. A 3D drawing of prototype seven is shown in Figure 3. Next, the process of making higher quality prototypes began.

Figure 3: *Prototype #7*



As newer and stronger prototypes were built, more deployment and landing issues came into play. With the new materials used to build Prototype #7 (Figure 3), the larger and denser structure created a harder landing. This model turned out not to be a sufficient design because of the possible dangers that landing the device presented. Although it was unique and compact, the model posed a threat of injury for any unsuspecting patrons below. Thus, this design soon became eliminated from the whole scheme of the project. The next task was to gain a better grasp of the type of design that should be obtained. With the help of several professionals the direction in which the packaging design should go towards became more apparent.

Figure 4: *Helium Balloon Concept*



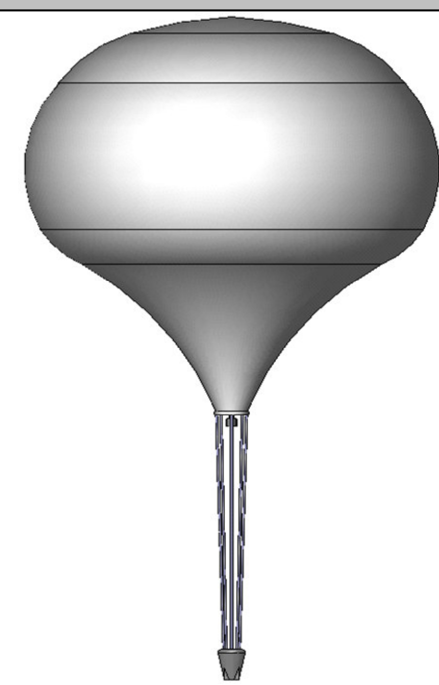
Through these meetings, another design was formulated that had a strong correlation with the structure and basic concept of a hot air balloon. This idea would allow a smooth/controlled landing of the network. In other words, the network would be attached at the base of the helium filled balloon and have solar collecting panels at the top of the balloon. See Figure 4 for more details.

Experimentation started out with several fixed features and a single variable or adjustable feature of the model that would alter the flight maneuverability and landing of the device. Features such as the tether or connection between the balloons and the weight became a fixed size on the model. The additional slack in the tether allowed the electronics which sat directly below the balloons not to hit the ground. This was an important discovery in the experimentation, because the nodes, antenna and other electronics would be protected from certain elements in nature. The next key variables in the testing included varying the number of balloons, varying the weight and varying the height of the drop to obtain substantial data. By varying each of these features, the speed of system was calculated. Hence, using a simple distance/time equation helped develop credible velocity data from the balloon trials. See Appendix A for the results.

The next balloon test, focused on having a constant number of balloons, a constant tether, a constant drop distance and varied amounts of weights. Then, by using five gram weight increments, a suitable weight was acquired for the speed of the device to travel. This information helped define a specific weight limit for the electronics below the balloons and the weights at the end of the tether. Then, with this new data, multiple tests were run and an average drop time and speed were obtained. See appendix B for the results. Thus, through experimenting with different size Mylar balloons and weighted bodies on the model to test the battery/node weight limits, the exact dimensions were tabulated.

The next stages went into specific balloon research. This research focused on the different factors that go into designing a lightweight balloon that will survive severe environmental changes during flight. Accordingly, the structure of the system, the specific material used, the flight maneuverability and certain inflatable drag devices became the sole targets for the research.

Figure 5: *Recommended Packaging Solution*



In brief, the best solution for the packaging of the Wireless Digital Repeater (WiDR) System is the helium balloon design shown in Figure 5. See Appendix B for the final/best measurements. These measurements provide the smoothest deployment and landing. This light weight, mechanism-free system offers control and protection for electronic nodes. The design also provides a larger surface area for the rechargeable solar cells that will be perched atop the balloon. Moreover, with the addition of a self inflatable balloon, the system's mass lowers, there is increased flexibility in the design and there is a softer deployment. All of these features go hand in hand to produce a less expensive, strong, controllable and efficient device.

Appendix A

MYLAR BALLOON DROP TEST

# of Balloons TYPE: Mylar SIZE: .304 m	Drop Distance (Meters)	Weight Nickels (#)	Time Seconds	Speed meters/sec
5	Distance: 3.429 (First Floor)	1	-	-
		2	-	-
		3	9.00	0.381
		4	4.97	0.689
		5	4.29	0.799
		6	-	-
		7	-	-
		8	-	-
5	Distance: 6.172 (Second Floor)	1	-	-
		2	-	-
		3	12.47	0.494
		4	8.59	0.718
		5	7.06	0.874
		6	-	-
		7	-	-
		8	-	-
6	Distance: 3.429 (First Floor)	1	-	-
		2	-	-
		3	-	-
		4	8.18	0.419
		5	6.10	0.562
		6	5.44	0.633
		7	-	-
		8	-	-
6	Distance: 6.172 (Second Floor)	1	-	-
		2	-	-
		3	-	-
		4	-	-
		5	-	-
		6	10.12	0.609
		7	6.85	0.901
		8	7.06	0.874
7	Distance: 3.429 (First Floor)	1	-	-
		2	-	-
		3	-	-
		4	-	-
		5	10.41	0.329
		6	8.12	0.422
		7	7.03	0.487
		8	6.72	0.510
7	Distance: 6.172 (Second Floor)	1	-	-
		2	-	-
		3	-	-
		4	-	-
		5	27.75	0.222
		6	12.81	0.481
		7	9.15	0.674
		8	6.43	0.959

Distance (from balloon to weight): 1.498 meters

Weight Charts

(# of Nickels vs. Weight in grams)

		Weight (g)
Nickels	1	5
	2	10
	3	15
	4	20
	5	25
	6	30
	7	35
	8	40

Electronic Weight	9.9
Weight Holder	6.3

(# of Nickels vs. Nickel Weight + Weight Holder)

		Weight (g) (w/ Weight Holder)
Nickels	1	11.3
	2	16.3
	3	21.3
	4	26.3
	5	31.3
	6	36.3
	7	41.3
	8	46.3

Appendix B

MYLAR BALLOON DROP TEST 2

TEST RESULTS:

Table 1: Time Trials of Seven Helium-filled Mylar Balloons

# of Trials (#)	Time to Drop Seconds	Speed Meters/Seconds	Description of Flight (Smooth/Interference/Drift)
1	8.38	1.06	Slight Interference
2	8.03	1.11	Slight Interference
3	7.50	1.18	Smooth
4	7.94	1.12	Drift to left
5	7.81	1.14	Smooth
6	8.41	1.06	Drift forward
7	8.15	1.09	Smooth
AVERAGE:	8.03	1.11	

CONTROL MEASUREMENTS:

Table 2: Fixed Measurements for the Timed Trials

Feature	Fixed Measurement
Height of Tether:	1.498 meters
Height of Drop:	8.915 meters
Volume of Balloons:	24.5 Liters (3.5 Liters x 7 Balloons)
Weight of Electronics:	24.9 grams
Weight of Holder & Added Weight:	61.3 grams

FACTORS TO CONSIDER:

Table 3: Flight Considerations/Errors

#	CONSIDERATIONS
1	Landing: Wind drift that effects flight
2	Human error: Obtaining the exact height of the drop distance
3	Using the proper materials for each part of the system