Research & Development Competition

for NARAM-50

GPS RECOVERY TECHNIQUE FOR ROCKETRY

by Michael Konshak NAR 896 L3

OBJECTIVE

To find a reliable method of locating and retrieving a downed rocket who track has disappeared or has fallen out of the line-of-sight of the rocketeer. As rocketeers become older and possibly infirm, it becomes more difficult to wander over long distances over rough or hilly terrain searching for a missing rocket. Conventional radio tracking systems, which require Ham radio licenses, become inoperable when the transmitter is not within the line-of-sight of the receiver or the range is too far for reception. Weather could cause delays in recovery and batteries within the rocket powering the radio transmitter could be drained before the errant rocket is located.

APPROACH

To obtain Commercial Off-The-Shelf Products (COTS) and modify to fit within the airframes, avionics bay, or payload sections including nose cones, of high powered rockets. In particular, a system is desired that does not require any special requirements from the FCC such as the user needing a Ham radio license. The systems would need to store sufficient data at the time of flight such as the last known position, that the rocket can be located and recovered, even if the search continues beyond the first day or perhaps several days.

In particular, certain Garmin GPS products designed for outdoor activities for the use by hunters, hikers and hunting dogs were selected to be evaluated for their compatibility in rocketry applications. These units are able to transmit data to one another to help locate others in the party (Garmin Rhino Series) or to track hunting dogs in search of quarry (the Astro 220 and DC20). The concentration of this report will be on the later, since voice communication is not required for rocketry recovery purposes.

PREVIOUS REPORTS

The author has published the techniques used within this report, in part, in *Extreme Rocketry Magazine*, March 2008 edition, with a follow-up article to be published in the future.

PREVIOUS WORK

There are several rocketry manufacturers (Adept, Rocket Hunter, Walston and Beeline) that have produced radio tracking transmitters that use small handheld ham radio receivers to receive an AM or CW tone or coded signal being broadcast on certain frequencies. The receivers utilize a directional antenna, that when pointed at the transmitter, will produce the loudest audio volume from the receiver. If by chance the rocket has climbed out of sight of the viewer and the direction of drift cannot be determined, the user must search a 360 degree area in an attempt to capture the loudest signal, or any signal at all. By the time the user may have tried various directions, the rocket may have fallen outside the range of the transmitter or out of line-of-sight of the receiver, behind a hill or some other obstruction. If the transmitter or battery is damaged upon landing, there there may be no signal being broadcast at all.

Other transmitter systems (Beeline) that transmit GPS locations to the receiver require the use of a laptop computer, special antenna, computer port cable adapters, proprietary software and in some cases a data packet convertor. Once the data is downloaded the coordinates must be entered into a separate handheld GPS which is then used for searching for the rocket.

Adept Rocketry (Pictures courtesy of adeptco.com and adeptrocketry.com)

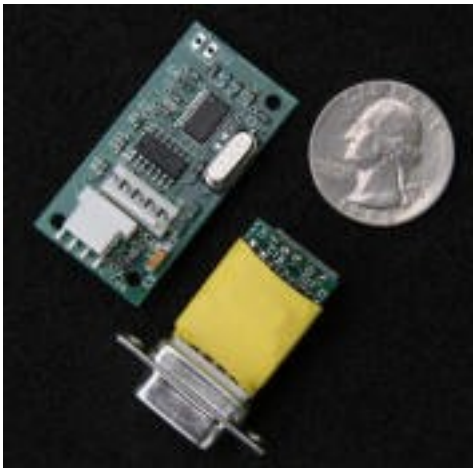
T400, T400AM or T400CW Transmitter which requires a separate receiver with a directional antenna.

The T400AM transmits AM burst tone signals. The T400CW transmits keyed on and off CW signals.

- T400AM and T400CW - Transmit Frequency: 433.9 MHz. Battery Life: 2 days typical.
- Measures .55" wide by .67" thick by 2.7" long.
- Weight: 8 grams. Weight with battery installed is 14 grams (1/2 ounce).
- Fits inside a tube with a minimum ID of .68 inch (17.3 mm), a loose fit in an Estes BT-20 model rocket body tube.
- Accessory required: one 12-volt alkaline lighter battery (included).

The Adept T400AM and T400CW transmitters transmit on 433.9 MHz, and because of the modes used, and because the signals are of the repeating type, and due to the power level, they do not fall under the Part 15 rules of the Federal Communications Commission, FCC. The transmit frequency used falls within the 440 MHz. Amateur Radio (ham) band. An Amateur Radio License is required.

Bee Line - Radio Directional Finding Transmitters (Pictures courtesy of bigredbee.com)
website: http://www.bigredbee.com/index.htm



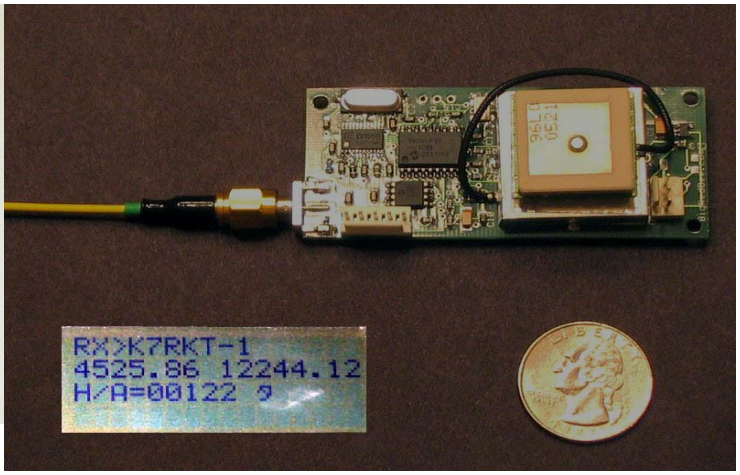
Uses FM scanner or hand-held ham radio and an build your own Yagi antenna .Coupled with a lithium-poly battery lasting more than 48 hours, the entire unit weighs 30 grams (1 oz). and fits inside a 29mm coupler tube (id= 1.14"). Requires a specialized charger to charge li-ion batteries. When assembled, the battery fits behind the transmitter, and the entire board is wrapped in protective heat shrink. The 1/4 wave whip antenna is 6.25" long.

Key Features:

- FM Modulation (CW available by special request)
- Frequency optimized for the 70cm amateur radio band
- Frequency range user programmable in 250Hz steps from 420-450 Mhz
- 1/4 wavelength whip antenna
- Optional SMA antenna connector
- Output power user selectable from -20 to +12 dBm
- Small size: less then 1"x2", fits inside a 29mm body tube and weighs less than 1/2 ounce!
- PC programmable call sign, frequency, and tone parameters (requires optional serial port adapter)
- On board voltage regulator for 4-12 volt input (see documentation for restrictions)
- Low voltage battery protection
- Range: Tested on the ground to over 5 miles, and over 180 *miles* in the air!

Bee Line - 2 Meter (144-148Mhz) High Power BeeLine GPS

website: http://www.bigredbee.com/index.htm

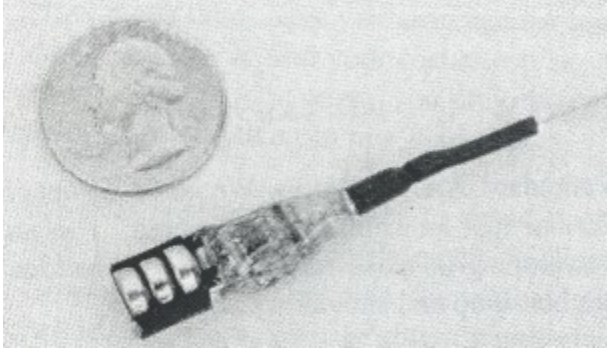


Key Features:

- Frequency selectable operation throughout the 2 meter band (144.000 to 148.000 Mhz)
- Power output more than 1 watt with 4-volt supply, more than 4+ watts with 8-volt supply
- Your choice of High sensitivity SirfSTAR III, or high altitude Trimble Lassen IQ GPS chipset -- both with integrated patch antenna
- Smart Beaconing(TM) or periodic operation
- TimeSlotting allows multiple transmitters to share same frequency based on GPS time
- Compatible with 144.390 APRS network
- Battery operating range: 4.0 to 9.6 Volts
- Integrated Power Regulator for direction operation from 12V-24V automotive power
- Size: Approximately 33mm x 90mm
- These boards do NOT have an integrated G-switch or any additional user inputs like the later version of the 70cm transmitter.
- Pricing: $279 for the board as shown above. The following are NOT included but available for additional charge: batteries, battery charger, and the serial adapter required to change the transmit parameters.
- *Special antenna required, 1/4 wave whip is not sufficient. Please see this topic for more information.*

Walston Retrieval Systems (pictures courtesy of walstonretrieval.com)
website: http://www.walstonretrieval.com/main.htm

This system uses a proprietary receiver, of which there are three models to choose from, and three models of transmitters.



Range 3+ miles ground. (30 miles line-of-sight(LOS). Weighs 7 grams with batteries. Changeable 19" braided flexible SS wire antenna. Battery life 150 hours. Other models with longer range (9+ miles) and extended battery life.

Features

Transmitters have:

- 20 to 90 mile air range
- 2 to 9-plus mile ground range
- light weight. Planes:(2 1/2 to 6 grams) Rockets: (7 to 28 grams)
- crash proof, waterproof circuit

Receivers:

- are sensitive
- have spare channels for future growth
- use standard AAA batteries
- have nylon carrying case

Directional antennas:

- plug into receiver
- have nylon carrying case
- provides maximum signal when you're pointing at the model

Garmin GPS Systems with Data Transmission Capabilities

There are several Two-way GMRS Radio “walkie-talkie” type systems that Garmin sells in their “On the Trail” series that are a combination GPS navigation receiver as well as a communication device. Aside from voice transmission, weather receiver and GPS mapping, these waterproof units allow one person (A) holding onto a handheld GPS to 'poll' another person (B) with a compatible handheld which initiates th transmission of the GPS coordinates back to first person (A). Due to federal regulations, the responses from polled radios can only occur once every 30 seconds, but that is fine for most outdoor activitioes. Hunting parties and families can thus keep track of each others location, even if person (B) is incapable of responding with a voice transmission. This features opens up possibilities for uses in amateur rocketry as well.

These two-way radio systems, the Rhino series, have several models of varying capabilities and include the Rino 110, Rino 120, Rino 130, Rino 520HCx and Rino 530HCx.

Rino 110 combines two-way radio and GPS features to help you communicate with your partners and find them easily. Using Rino’s unique Position Reporting feature, you can send your exact location to other Rino users in your group, so they can see your precise location on the map page.

As you can imagine, this feature can be a real lifesaver in an emergency, but it’s also handy anytime you need to round up family and friends at an amusement park or other outdoor activity. And, because Rino is a standard FRS/GMRS radio, you can use it to communicate with any other conventional FRS/GMRS radio around.

The FCC has granted Garmin a waiver that allows the Rino products to send position data on GMRS channels. In addition, Industry Canada has established a license-free GMRS service. Canadian Rinos now allow users to access and transmit their position on Canadian GMRS channels.

Rino Comparisons

	Rino® 130 $ 374.99 USD remove from list	Rino® 110 $ 194.27 USD remove from list	Rino® 120 $ 267.84 USD - $ 642.84 USD remove from list	Rino® 520HCx $ 482.13 USD remove from list	Rino® 530HCx $ 535.70 USD remove from list
Unit dimensions, WxHxD:	2.3" x 4.5" x 1.6", 7" high with antenna (5.8 x 11.4 x 1.6 cm, 17.8 cm with antenna)	2.3" x 4.5" x 1.6", 7" high with antenna (5.8 x 11.4 x 1.6 cm, 17.8 cm with antenna)	2.3" x 4.5" x 1.6", 7" high with antenna (5.8 x 11.4 x 1.6 cm, 17.8 cm with antenna)	2.3" x 5.1" x 1.8", 7.5" high with antenna (5.8 x 13.0 x 4.6 cm, 19 cm with antenna)	2.3" x 5.1" x 1.8", 7.5" high with antenna (5.8 x 13.0 x 4.6 cm, 19 cm with antenna)
Display size, WxH:	1.4" x 1.4" (3.6 x 3.6 cm)	1.4" x 1.4" (3.6 x 3.6 cm)	1.4" x 1.4" (3.6 x 3.6 cm)	1.3" x 1.7" (3.3 x 4.3 cm)	1.3" x 1.7" (3.3 x 4.3 cm)
Display resolution, WxH:	160 x 160 pixels	160 x 160 pixels	160 x 160 pixels	176 x 220 pixels	176 x 220 pixels
Display type:	4-level grayscale LCD	4-level grayscale LCD	4-level grayscale LCD	256 level color TFT	256 level color TFT
Weight:	7.6 oz (236 g) with batteries	7.6 oz (236 g) with batteries	7.6 oz (236 g) with batteries	10.3 oz (292 g) with battery pack	10.3 oz (292 g) with battery pack
Battery:	3 AA batteries (not included)	3 AA batteries (not included)	3 AA batteries (not included)	removable, rechargeable lithium-ion battery pack	removable, rechargeable lithium-ion battery pack
Battery life:	14 hours	15 hours	15 hours	14 hours	14 hours
Waterproof:	yes (IPX7)	yes (IPX7)	yes (IPX7)	yes (IPX7)	yes (IPX7)
High-sensitivity receiver:	no	no	no	yes	yes
PC interface:	serial	serial	serial	USB	USB
RoHS version available:	no	no	no	no	no
Basemap:	yes	no	yes	yes	yes
Ability to add maps:	yes	accepts points of interest data	yes	yes	yes
Built-in memory:	24 MB	1 MB	8 MB	none (expandable memory only)	none (expandable memory only)
Accepts data cards:	no	no	no	microSD™ card (not included)	microSD™ card (not included)

Rino Comparisons Continued...

	Astro® $ 535.70 USD - $ 642.84 USD
Unit dimensions, WxHxD:	2.3" x 6.3" x 1.3" (5.7 x 15.9 x 3.2 cm) (Astro 220)
Display size, WxH:	1.5" x 2.2" (3.8 x 5.6 cm)
Display resolution, WxH:	160 x 240 pixels
Display type:	256-color TFT
Weight:	6.5 oz (185 g) without batteries
Battery:	2 AA batteries (not included)
Battery life:	24 hours
Waterproof:	yes (IPX7)
High-sensitivity receiver:	yes
PC interface:	USB
RoHS version available:	no
Basemap:	yes
Ability to add maps:	yes
Built-in memory:	none
Accepts data cards:	microSD™ card (not included)
Waypoints/favorites/locations:	1,000
Routes:	50
Track log:	10,000 points; 20 saved tracks
Automatic routing (turn by turn routing on roads):	yes
Electronic compass:	yes
Barometric altimeter:	yes
Hunt/fish calendar:	yes
Sun and moon information:	yes
Area calculation:	yes
Geocaching mode:	yes
Frequency band:	MURS
Channels:	NA
Squelch codes:	NA
Transmit power:	NA
Range:	5 miles (line of sight)
VOX (voice activation):	NA
Location reporting (send and receive GPS positions):	NA
Voice scrambler:	NA
Vibration alert:	NA
NOAA weather radio:	NA
External temperature recording:	NA
ID codes:	50
Additional:	Tracks up to 10 dogs simultaneously

Garmin DC 20

The DC20, which is normally attached to a hunting dog's collar, contains a GPS which determines its physical location data from up to five WAAS satellites, then transmits over the MURS band to the Astro 220 handheld. The handheld is also a self contained GPS and will track its location as well as up to 10 dogs (or rockets in this case). Each DC20 GPS/TX sends out data once every 5, 10 or 30 seconds (programmable at the handheld), that can be monitored on the handheld, giving each rockets horizontal track, speed, location, the satellites its receiving, and the battery life remaining The data burst is about 500 milliseconds long transmitted using 2 watts of power over the MURS frequencies of 151.82 MHz, 151.88 MHz, 151.94 MHz, 154.57 MHz, and 154.60 MHz

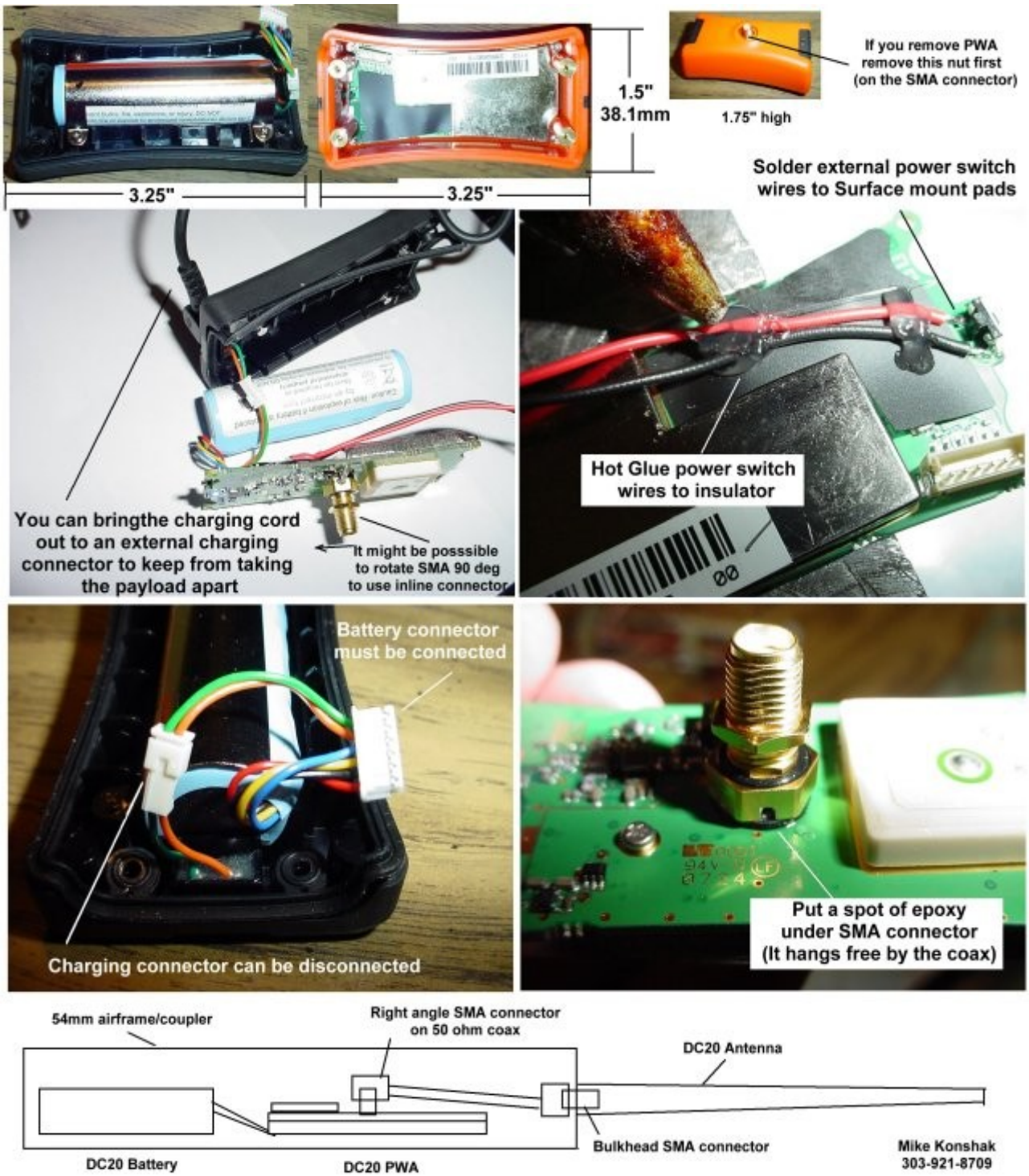
The DC20, as shipped by Garmin weighs 6 ounces (170 grams) and the body is 1.75” high x 3.25” long x 1.5” wide. The replaceable rubber ducky antenna is mounted in the center of the body and can be relocated to other parts of the rockets using a scratch built extender cable. Garmin offers a low profile antenna with less range, but I haven't seen the need to try it.

After a day of launchings you can easily re-charge the DC20 battery. The DC20 comes with both an AC charger as well as a 12V car charger. A very convenient accessory when you are at a launch site for a couple of days. My recommendation is to cut the leads on the two chargers, adding interconnects so you can semi-permanently attach the charging connector to the DC20 for charging without taking the avbay or nose cone all the way apart. You then have a set of cables for powering from AC at home or away or from your DC accessory outlet in your rocket-mobile.

The handheld can be used as a regular GPS, with stored color maps, and has fittings for mounting to a car's dashboard, so the investment is a good one. It will help you get directions to those events in other states, and for my fetching and tolerant wife, the closest Starbucks.

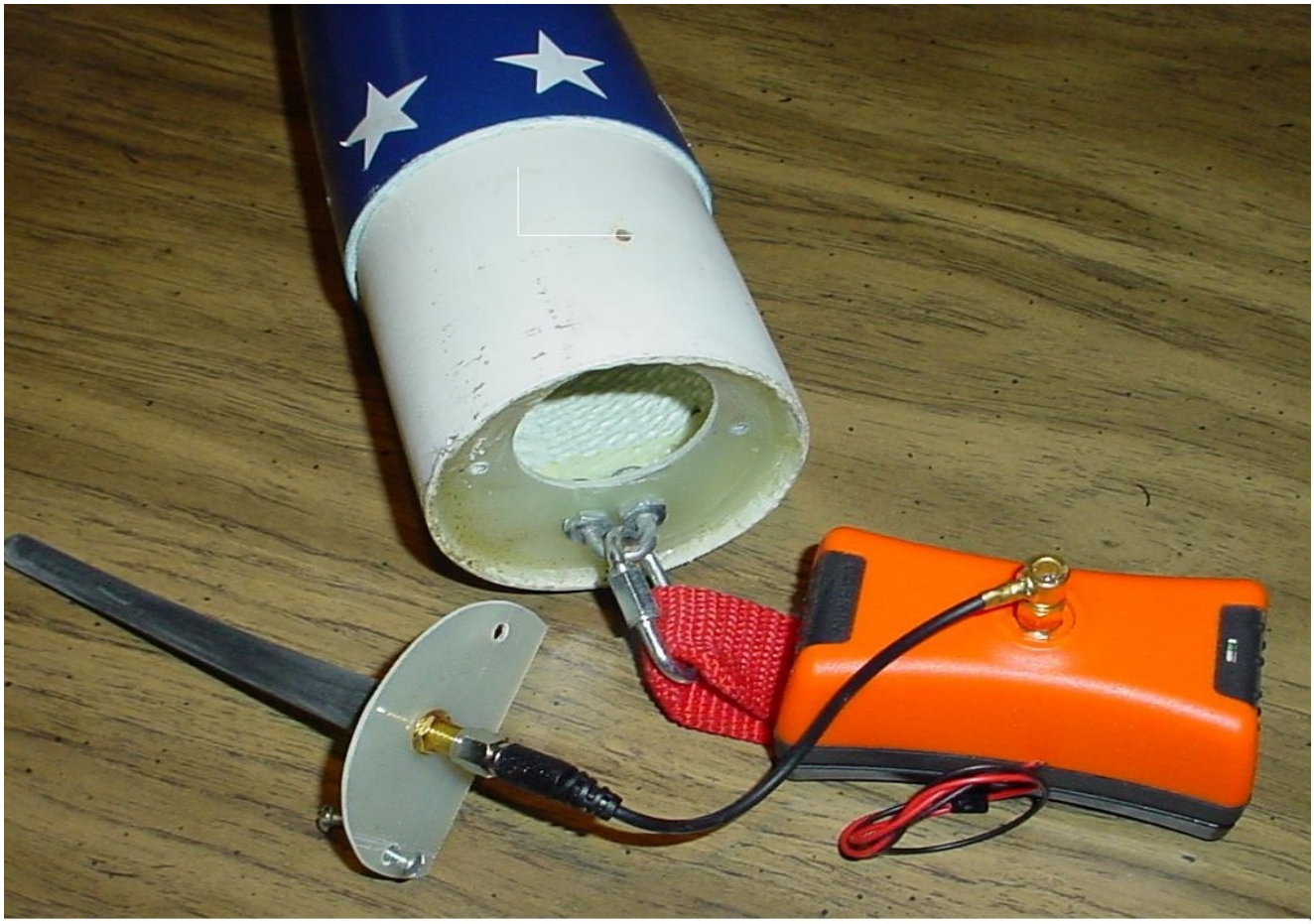
Applications:

During the spring of 2008, I experimented with various packaging and antenna options of mounting the Astro DC-20 in rockets, varying from 54 mm in diameter up to 5 inches in diameter. Obviously, because of it size and shape, larger airframe rockets, such as found in mid to high power rocketry makes the task easier. However, I have been able to fit the internal components within a 54mm airframe. Here's what the internal components look like and some tricks to some easy modifications.

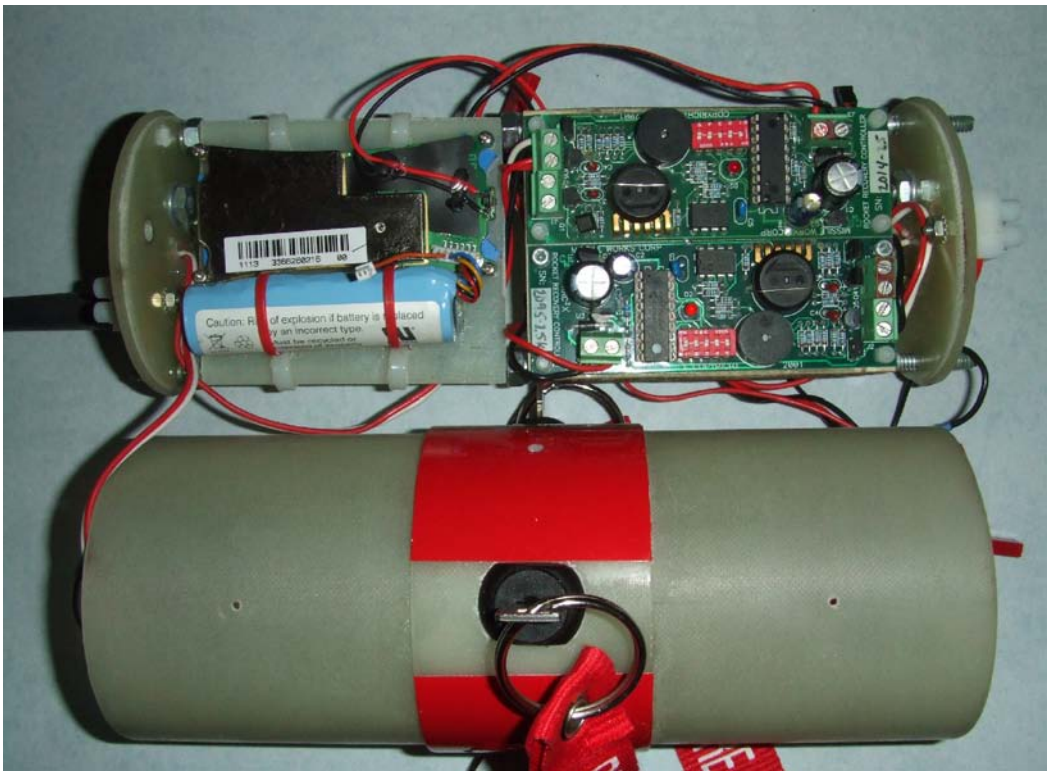


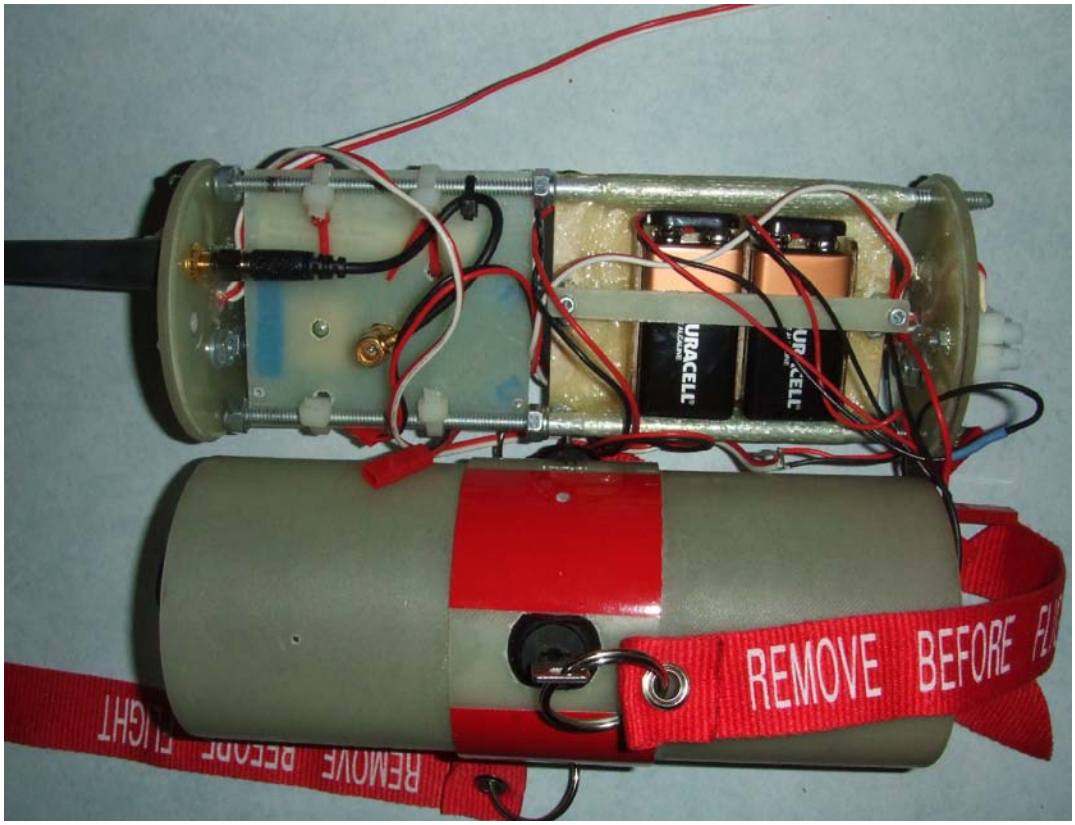
To get the GPS to fit into 2.1 inch diameter and smaller airframes, you'll have to split the orange and black case apart and come up with a different mounting scheme. The Lithium-Ion battery is connected to the main PWA with a short cable, but it allows you to rotate the battery in-line with the PWA. With a right angle SMA connector this will fit fine in a 54mm diameter coupler and airframe, and you may not have to take it further apart. However, I found that if you attache the coax wire center conductor directly to the DC20 SMA female connector (without the housing) and solder the shield to a star washer that is under the SMA cinch nut, the unit will slide into a 2.1 inch diameter airframe without taking apart the DC20. You have to wrap electrical tape around it to hold it together,

In a 3 inch airframe, the Dc20 can be attached by a 1 inch Nylon strap, using the clamp for the dog collar attachment. A short coaxial cable needs to be made up with a right angle connector. In the following application the antenna is mounted in the nose cone which is attached to a separate payload bay.

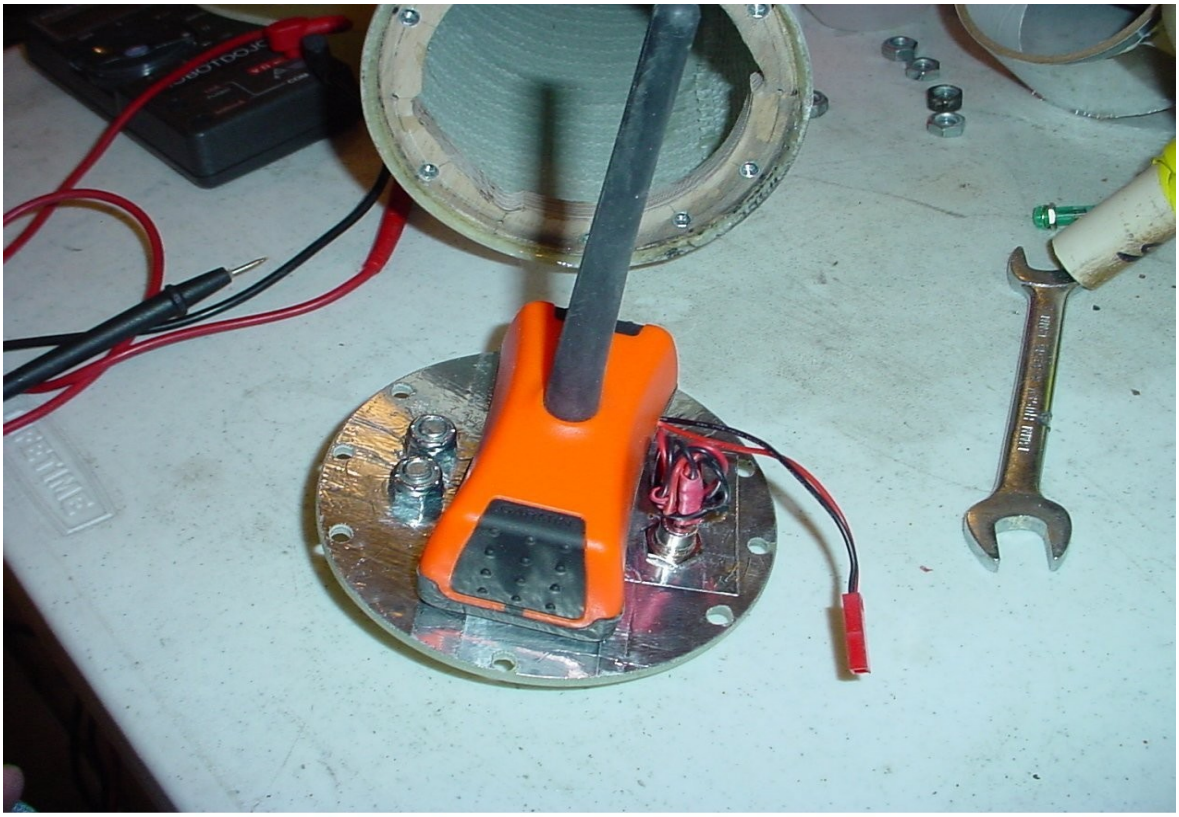


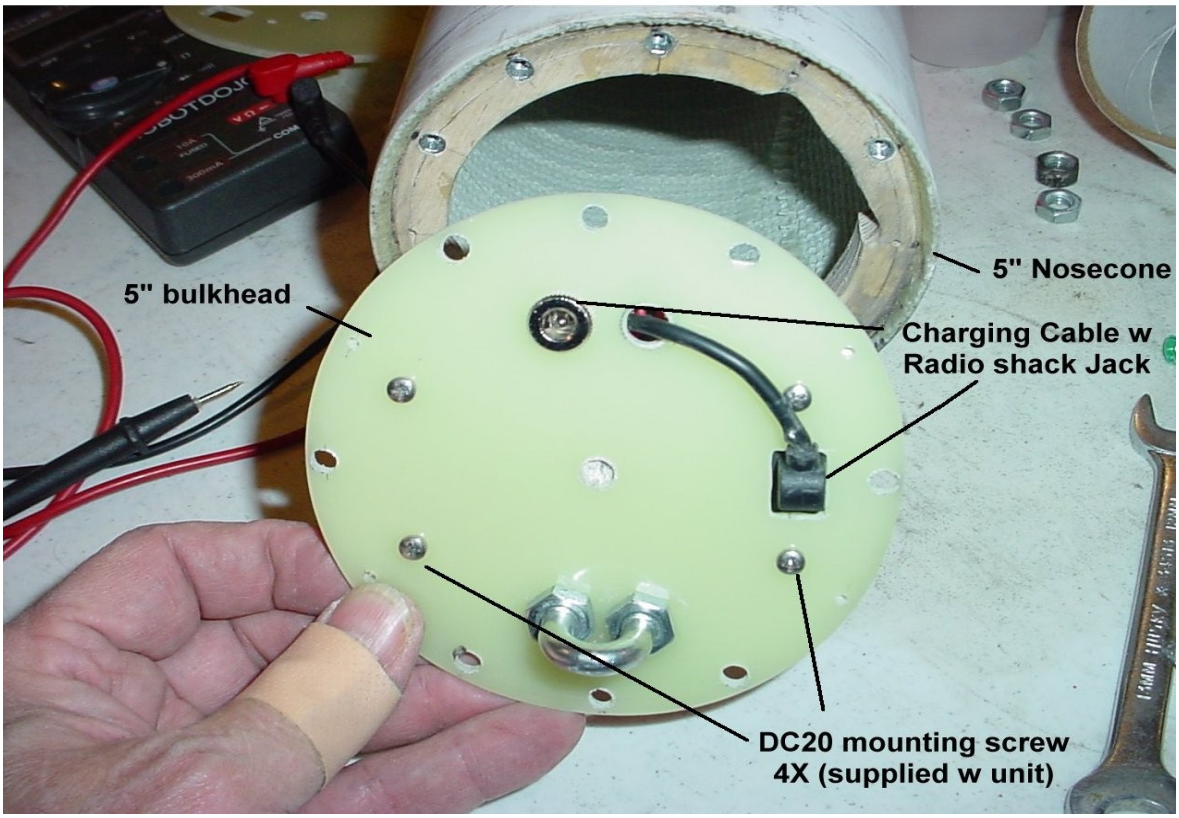
The first manifestation of the unit was to take the DC20 apart and install it in a 3 inch diameter avbay with redundanant dual deploy rocket controllers. This was a good application and did not present any problems as it was compatible with the Missileworks RRC2-X barometric altimeters. This will be discussed further along in the report. In these pictures the rubber duck antenna is mounted on the avbay bulhead.





In a 4” airframe and above, the DC20 can be mounted directly to a bulkhead plate with its rubber-duck antenna attached like normal. The screw mounts used are the same as what attaches the supplied collar bracket. In the picture you will see that the charging cable has been modified to go to a connector on the bulkhead plate to allow the rocketeer to charge the units battery without taking the nose cone off.

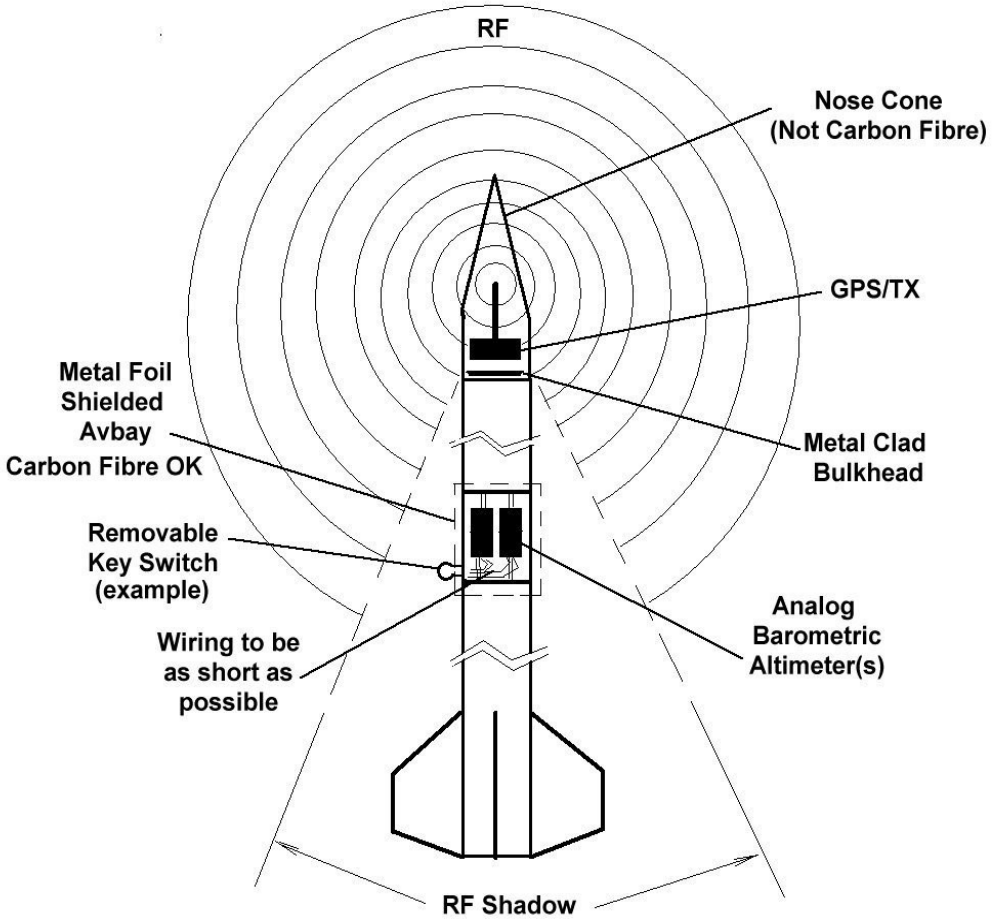




RF Interference Problem

The first installs of these units were placed within HP rocket avionics bay in close proximity to the dual deploy barometric altimeters. The very first of these was in a 3 inch diameter avbay and the flights in this rocket were continuously successful and reliable. In another larger rocket with different models of barometric altimeters on board, premature separation and deployment of the drogue chute charges while the rocket was resting on the launch pad was encountered. This happened twice. As it turned out, the GPS transmitter was inducing current in the avbay's internal wiring, which happened to be the correct length to become an antenna. The induced current raised the voltage level at the altimeter's input amplifier to the Analog to Digital converter, to a voltage level above the threshold equivalent of 300 feet, fooling the altimeter into believing that a launch had occurred. The altimeter then determined that since the rocket was not moving, it must be at apogee, and being less than than 1000 feet AGL (the set point for the main recovery) the main charge was fired and the main parachute was deployed.

After many proximity tests of various manufacturer's barometric altimeters it was determined that as



long as DC20 was greater than 6 inches from the avbay (24 inches preferred) then there would be no interference with the operation of the avionics. Additionally, if the interior of the avionics bay was laminated with conductive aluminum tape, then the altimeters were totally protected. The following graphic shows a recommended fail-safe installation. Of course, rockets using motor deployment charges are unaffected by nearby RF emissions. Altimeters that incorporate ground planes in their

electronics designs are more robust at blocking external radiated emissions.

I sent out requests to various barometric altimeter manufactures to get a representation of their products to do further testing. Besides the Garmin DC-20, another test was done on some units using a Garmin Rhino 110, a GPS/2-way radio using the FRMS and GMRS bands. These are the results of those follow-on tests:

Adept Rocketry ALTS25K (60K option): False launch within 5 inches. (no ground plane)
(Tommy Billings of Adept Rocketry says all his altimeters use the same circuit design)
Missile Works RRC2-X : No failures (has a ground plane)
Missile Works RRC2-mini: False launch within 6 inches. (no ground plane)
Missile Works PET2 Timer: No failures. (digital non-barometric)
PerfectFlite Alt15K/WD: No failures.
PerfectFlite mini-Alt/WD: No failures with DC-20, False launch using Rhino 110 . (ground plane)

Additionally a few other new models, that are not in production were tested as well. In all cases, separation and shielding prevented false launch triggers, so all can be counted on for safe and reliable operation, assuming rocketeers follow these guidelines.

If you, the rocket designer, wants to minimize the potential that the wires may become antennas, or if you want to design an antenna, the relationship between a radio signal's frequency and its wavelength (lamda) can be found by the industry-accepted formula where wavelength (in meters) equals 300 divided by the frequency in megahertz.

The MURS frequencies used by the Astro system is 151.82 MHZ, 151.88 MHZ, 151.94 MHZ, 154.57 MHZ and 154.60 MHZ, all very close to the Ham two meter band. This calculation will produce a wavelength around 1976mm or 77.795 inches. Any even division of this wave length, 1/2, 1/4, 1/8 etc, becomes a tuned antenna for this frequency and should be avoided.

However, in one of my experiments I designed a folding dipole antenna antenna that fit within a 3” airframe. I used the lower of the 5 frequencies to determine the longest antenna length, which could be easily cut down to tune the antenna better, and divided it again by 2 to get a half wave dipole of .988 meters or 988 mm or 38.883 inches. Each side of the dipole is 1/4 the wavelength which is equivalent to 494 mm or 19.4415 inches. Theoretically this would give maximum range over the rubber-duck antenna supplied with the DC. However, the stock antenna is fine for most ranges with waivers that keep you within a couple miles of the launch pad. Solid signals have been read over 7 miles away.

Knowing that the 2 watt transmitter in the DC20 could create a false launch signal in a barometric altimeter used to deploy recovery systems, I then wondered if it could affect the actual altitude, for drogue deployment and main deployment. This would be very important if you were trying to set an altitude record.

I built a vacuum chamber out of a 2-1/2 gallon "Montana Jar" that you can buy at Target. I drilled a hole in the lid and through the seal, then placed a brass fitting with a threaded tube in the hole. An automotive dash board altimeter was placed inside the jar and zeroed out. A small shop vac was connected to the fitting on top of the jar and when powered up was able to lower the pressure inside to an equivalent altitude of 3300 feet. My home in Colorado is at 5500 feet, so higher AGL readings could be obtained at lower elevations where the air is more dense.

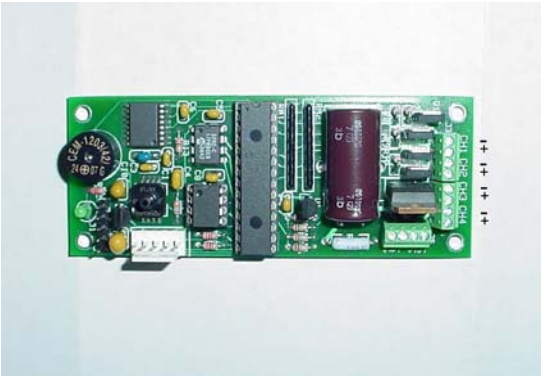
With the DC20 in close proximity (within the jar) I could never get the altimeters to alter their recorded altitude over repeated tests. Part of that is the fact that the DC20 only transmits once every 5, 10 or 30 seconds for about a 500 millisecond duration. That means that at the 5 second interval it is off 90% of the time and it is almost impossible synchronize the moment that apogee id detected with the transmission pulse. If you set the DC20 at 30 second transmission intervals, the unit is off 98.3% of the

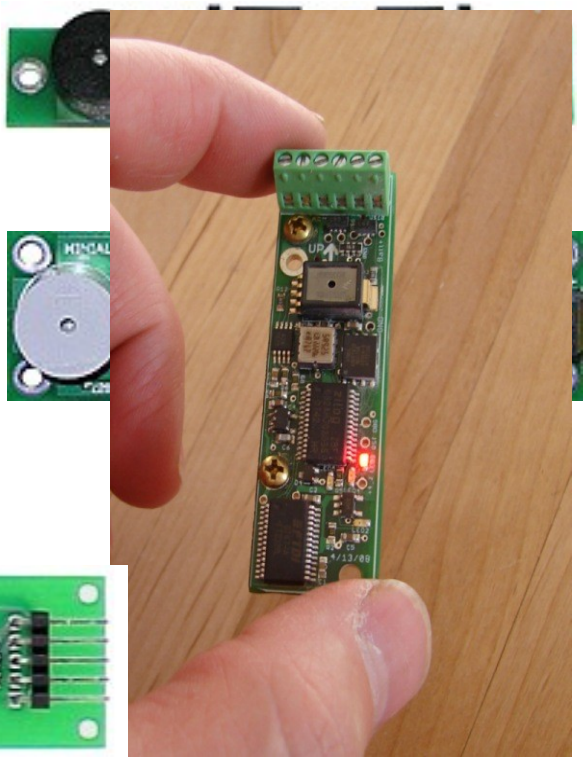
time. This would actually be the safest setting to use, but a rocket can drift fairly far in a half-a-minute.

The conclusion of this test was that the DC20 could not affect the apogee readings or harm the normal operation of a dual deploy system.

However, one side result of this test was the discovery of how far off the apogee readings from various altimeter models from the different manufactures were to each other. I was seeing deltas of up to 500 feet between units. Each unit was repeatable within its own right, but were not consistent among models. Because I was not concerned as much about individual model accuracy at this time as I was functionality, I did not pursue any comparison tests.

I would have to conclude, though, that as the NAR allows altimeters (hopefully) to be used in contesting and record attempts, especially for E motors and above, a standard must be established to make the readings fair and useful across the board. A simple vacuum chamber like I have just described may be used to qualify any given altimeter to a known base unit, and a delta, plus or minus, used to offset the recorded readings. This may be my next R&D project.





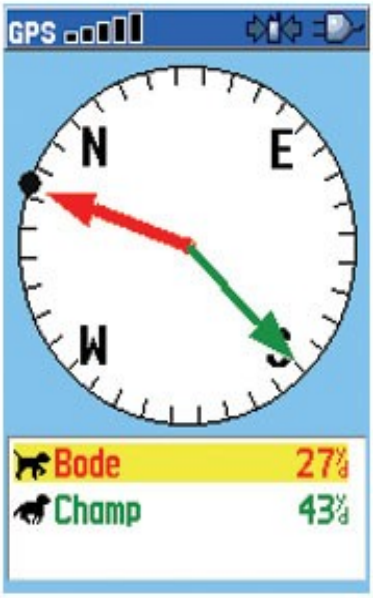
Operation:

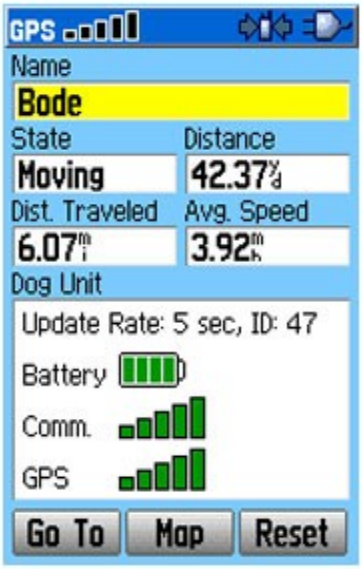
The data is stored in the handheld as long as you want to keep it. If you lose communication with the rocket, you still retain the last known position, which I found handy, as you can continue to launch rockets before you head out to retrieve them, all at the same time. The batteries in the DC20 last up to 17 hours, but since you know where it is supposed to be, you can go back the next day, week or month later. The data can be downloaded to your PC later on.

Here's the beauty of the system for individuals and clubs. Although the initial cost is about $500 (on eBay), you only need to buy additional DC20s for each rocket for about $180 each. The Astro handheld can track up to 10 rockets (dogs) at once, so only one member of your club needs to have the full system.

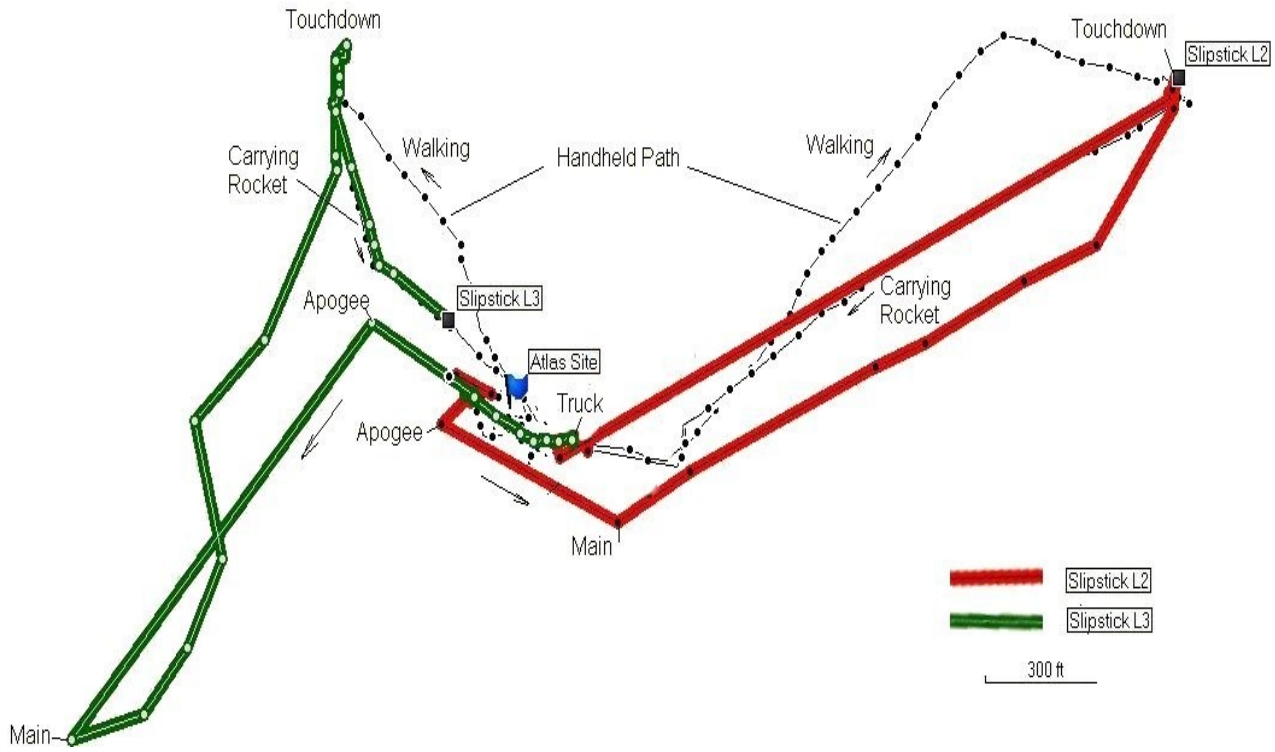
The battery in the DC20 can transmit for up to 17 hours leaving plenty of time to track down all the rockets or making multiple flights between charges. Another feature, is if you lose the rocket behind a hill, the last known position will be tracked by the Astro. On most radio tracking systems you may lose the signal once the rocket has made contact with the ground and is out of line-of-sight. The tracker then has to wander around in the general direction until he (hopefully) gets a beacon. On the Astro, you just move the cursor over the respective track to its end and mark the spot. The rocket should be fairly close as it will be under that position. You can mark multiple rocket locations if you want to wait to retrieve several missiles on one excursion. For additional redundancy, or for boosters that separate from sustainers (a two-stage rocket), two or more DC20's can be installed in one rocket. Each section will be tracked and located separately.

On the compass page of the Astro 220, you'll see a little dog in the lower left hand corner. If the DC20 is mounted in the av-bay like it would be when attached to a dog, the dog icon would indicate 'moving' or 'on point during the rocket's descent. When the rocket is laying on the ground the dog will indicate 'sitting' or 'treeing'. You can mark the location of a found rocket for later analysis by reporting it as a covey; only enter the number of 'birds' as just 1. This location could be good starting point and general direction of drift for searching for other errant rockets flying that day.



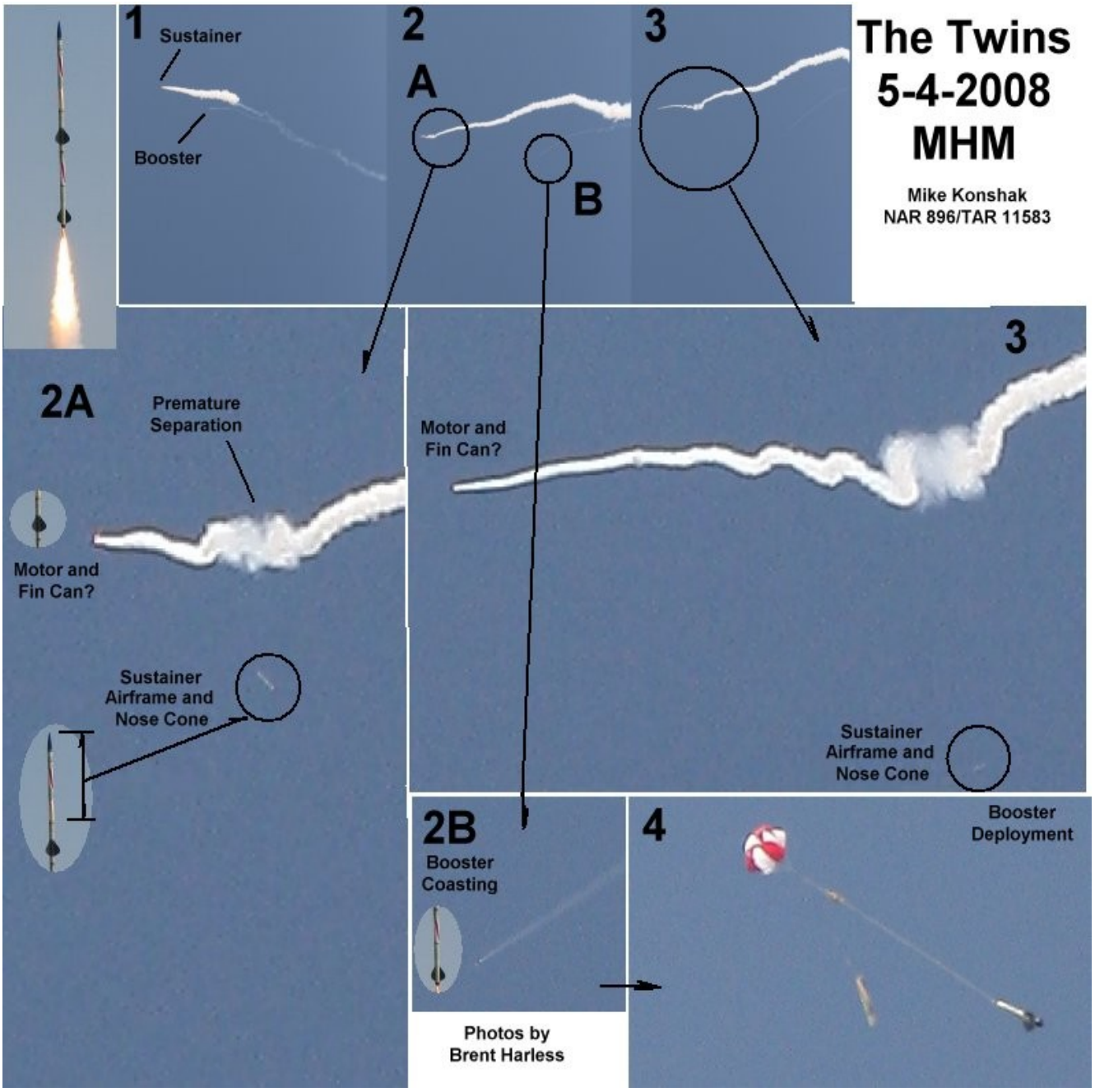


The map screen can be used to find public roads that might get you close to your lost rocket (be sure to politely ask permission from the landowners before trespassing). You'll have to buy a MicroSD card for additional memory if you want to load topographical or extended street map software on the handheld. The next graphic is the data uploaded from the Astro 220 to a laptop and shows the tracks of two rocket as well as the track of the rocketeer. This image is displayed on the handheld but with more detail on the computer.



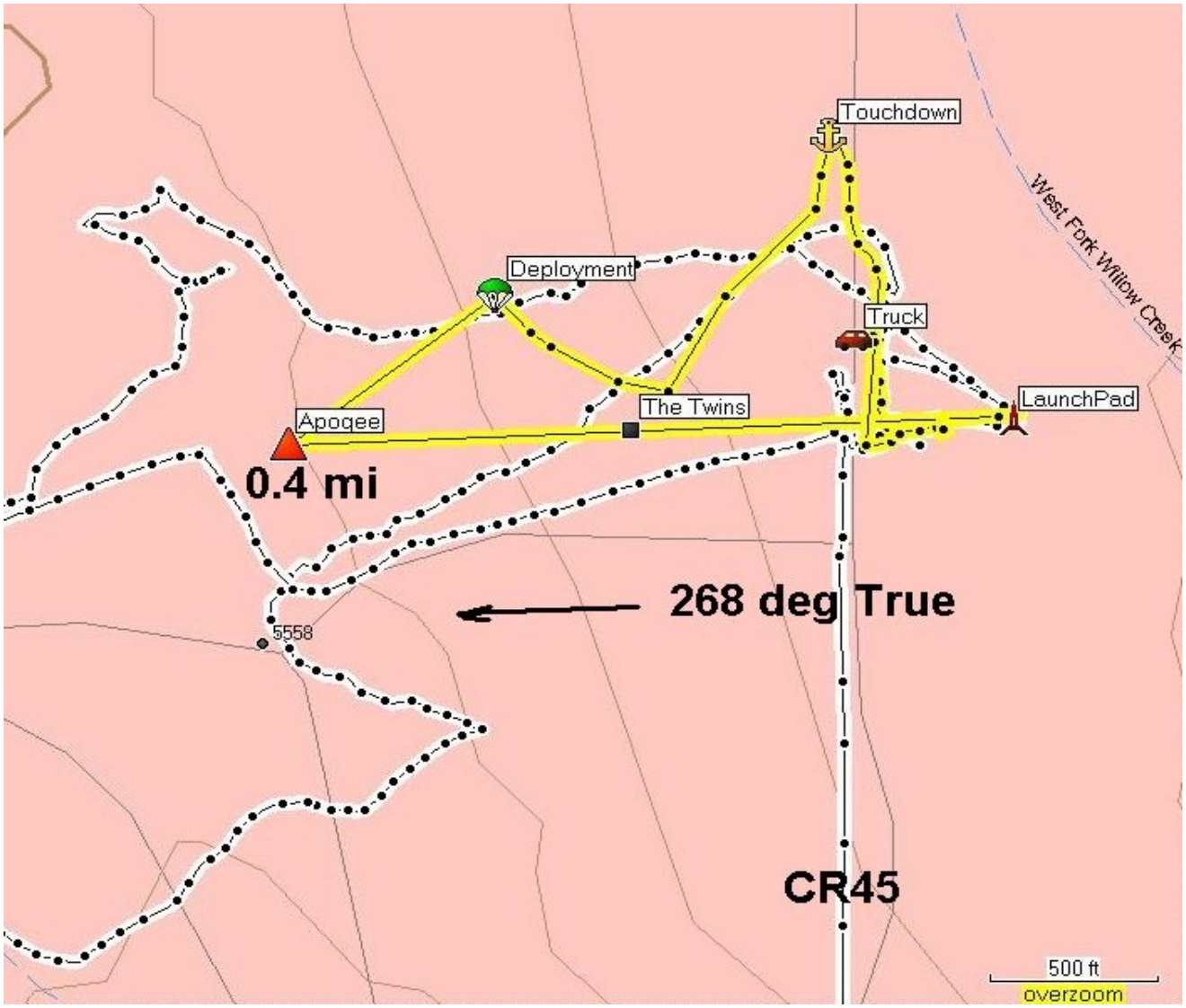
A Case Study

In one launch of a two-stage HP rocket, the Mach delay was not set correctly in the sustainer (upper stage) and the altimeter detected apogee while the rocket was passing through the speed of sound. The drogue was deployed and the fin can was violently separated from the rest of the rocket. The fin can continued in a ballistic arc as the rest of the sustainer descended and popped the main out at the pre-programmed 1000 foot AGL with a safe recovery. See the next picture which is a composite of the flight.

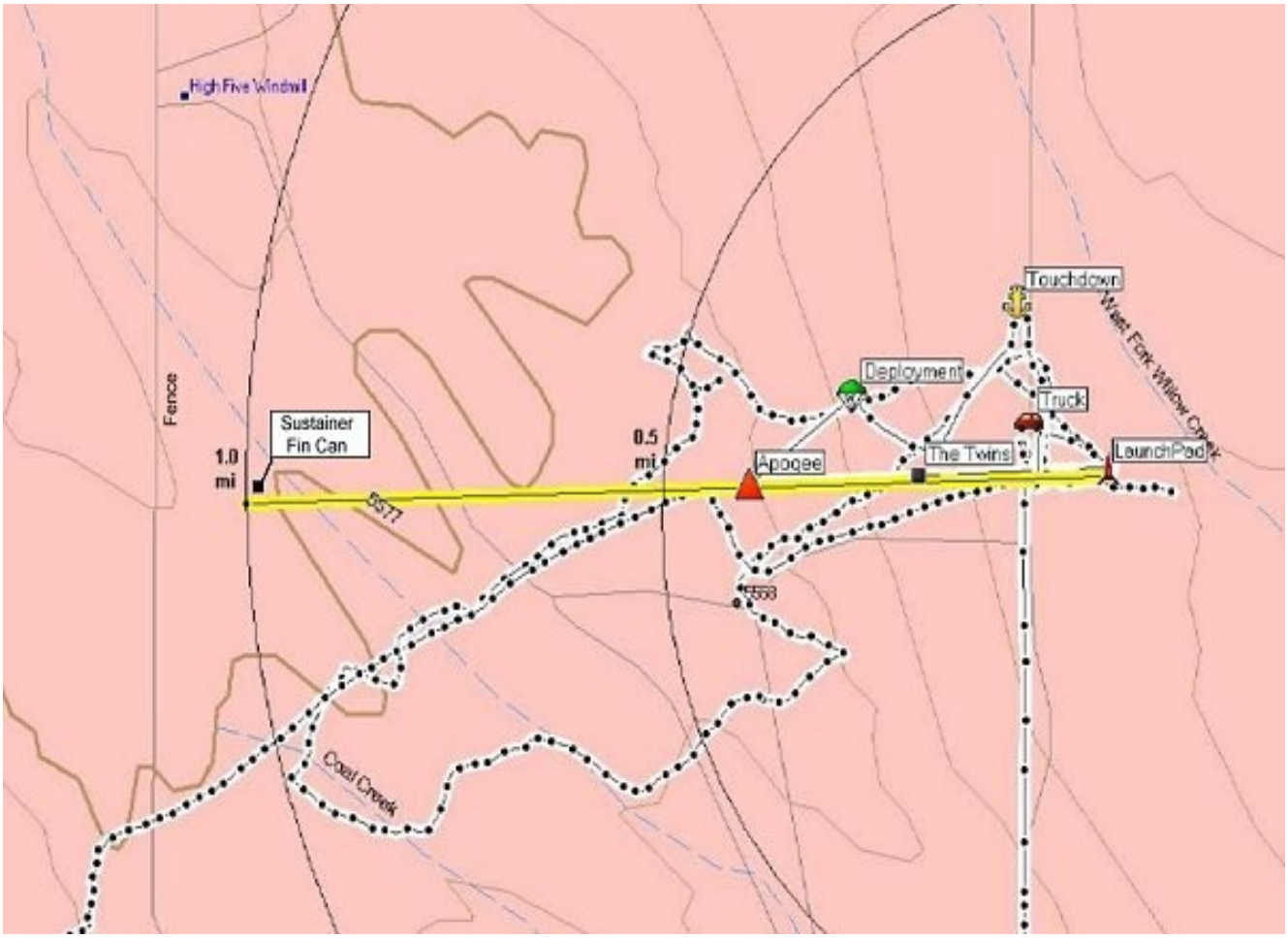


Attempts that day to find the fin can, with the expensive K700 motor hardware ($200 worth) was in vain, and follow-up searches by others turned up “no joy” as well.

When I looked at the track reported by the DC20 (see next graphic) which was located in the surviving payload section by the nose cone, I figured that if the apogee was at the furthest location away from the launch pad, and was at the top of the arc, then the fin can must have continued in the same direction and have descended in an arc mirroring the ascent arc. The rocket had weather cocked into the wind and the other pieces had drifted back, close to the launch site on their chutes.



I drew a line on the computer using the Garmin software, to extend the flight path to twice the distance of what was recorded from the launch pad to apogee, then saved that added track back onto the handheld unit.



A month later I went back to the launch site and using the Astro 220, was able to walk right up to where I predicted the fin can to be. It was 50 feet away from the end of the drawn track. I used the Astro 220 to mark the location as a way point for future reference.

Unfortunately the fin can had hit first on the avbay and the fin/motor section broke apart and settled six feet away from the divot. The motor ignition avbay, including the battery, timer, and coupler were shattered, but the motor hardware and carbon-fiber reinforced fins were intact and reusable. This recovery was another great feature of using this system.

Above: The errant fin can from the sustainer off the two-stage rocket “The Twins” found on the Pawnee National Grasslands with another casualty of the Western prairie.

Numerous flights using motors from F to M, has shown that the DC20 can withstand the G forces of a rocket launch, and the fact that it is watertight, will allow itself to survive until it can be found. A very robust design (unless you hack into it).

COST of Project

The equipment used in developing this application for my R&D project began in November of 2007 as part of a series of rocket projects that would incorporate and utilize this system. One Astro 220 and DC-20 system was purchased for less than $600 on eBay followed by the purchase of a second DC20 for less than $180. One DC20 was kept intact for the most part, except for adding an external power switch. The other was taken apart and modified to see how small an airframe that it could be adapted to.

In one experiment, the changes were so radical that eventually the DC20 printed wiring board was damaged to the point that it would not receive a GPS signal anymore, and had to be sent back to Garmin for replacement. I had tried to sand down the corners of the printed wiring card to get more clearance in a 38mm airframe, and I believe that the sanding damaged the layers of the photo-etching which changed the impedance of the assembly or shorted the layers together. I know know not to cut into the PWA.

When i called the Garmin support center, I informed them, that although my damaged DC20 was still under the warranty timeframe, I had purposefully sabotaged the unit for a special application. They allowed a complete replacement for $52, which included shipping.

The rockets themselves, with motors, cost between $100 to $1500 to build and fly and were used as part of a 5 month path in getting my L1, L2 and L3 NAR high-power certification. Several rockets were flown multiple times with different motor sizes. Because the DC20 is can be adapted to fit within various rocket sizes it is a very portable unit. A unit tethered to a 3 inch nose cone has been used as a loaner to other club members. The risk of loss is very low, since it is easy to find the DC20, if not your friend's entire rocket.

All the tests were flown at Northern Colorado Rocketry's (NAR section #565) North and Atlas sites in the Pawnee National Grasslands near the Colorado and Wyoming border. this is a 200 mile round trip, to get to this location from my home in Louisville, CO, near Boulder, but the launch sites are great and waivers can be obtained for up to 35,000 feet.

At this time there are now 8 DC20's being used by separate NCR members as my efforts in developing this R&D report have popularized it use.

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