Synopsis:
The Melbourne Amateur Radio And Technology Group fly two high altitude balloons as part of the annual Global Space Balloon Challenge. Using amateur radio digital modes they get some good pictures of near space, but for the group the story does not stop there.

Amateur radio group has its head in the clouds

The Melbourne Amateur Radio and Technology Group

In April this year the Melbourne Amateur Radio and Technology Group (MARTG) took part with 291 other teams in 47 countries in the Global Space Balloon Challenge (GSBC) – an event where "People around the world can simultaneously fly high altitude balloons celebrating an age where anyone can reach the edge of space." The purpose of the event is to promote community, education and innovation in a way "where everyone can learn from each other and build on each other's accomplishments." To the members of the MARTG it all sounded simple enough. Why not give it a try, they thought? What could go possibly wrong?

So how does one "fly" a high altitude balloon, you may ask? Well the process is relatively straightforward on paper: An electronics package (called a payload) is attached to large balloon which is filled with helium. The balloon floats up into the sky and the payload transmits measurements (called telemetry) back to ground receiving stations (called trackers). Of course eventually the balloon bursts because up there in the rarefied atmosphere it gets too big to hold all that helium inside. Then what? Well as you know what goes up must come down: So it falls back to earth, its decent rate being slowed to safe limits by a small parachute. The ground receiving stations are supposed to keep a track of the balloon's position and altitude at all times and relay this information to servers on the Internet so that everyone will know exactly where it lands. In theory at least.

The next obvious question for the MARTG was "Why just launch one balloon when we can launch two?" Exactly! So to maximize the objectives of the challenge they decided to enter two quite different balloon payloads. Each one was developed independently, doubling the effort of course, so that the experience, challenges and results could be shared, analysed, compared and appreciated all the more. The idea was to launch the two balloons from the same location, track them and see where they both landed. To enable the possibility of payload recovery (and finishing the BBQ lunch and getting back home in time for dinner) all agreed that a quick 2-hour flight time was in order.

Now modern high altitude ballooning is not just a hit and miss activity. No, everything can be simulated on-line using computers. With this sort of technology it is a wonder why anyone actually launches anything. Again the process is simple: Get on-line, choose a balloon type and size, enter the payload mass, select a desired ascent rate and the exact balloon burst altitude is displayed. Of course that just works for going up. For coming down you'll need the parachute simulator: Choose a parachute size and shape, enter the payload mass, again, and out comes the predicted decent rate. Then there's the flight predictor: It knows all about the prevailing winds at different altitudes. Just enter the launch location and all the information above, again, and it will tell you the street address of the landing site. You can play around with these numbers all you like until you get the flight time you want. Perfect. So now the MARTG had their flight profile locked in: No problems so far.

Ah, that is all except maybe the problem of getting the Airservices Australia's approval to launch the high altitude balloons in accordance with CASA regulations. It seems the application had in fact been filled out, sent in and received and everything was actually in order. It was just that the approval part hadn't arrived. Suffice to say that when the "Notice To Airmen" advising the launch of two high altitude balloons was finally issued, the MARTG collectively breathed a very large sigh of relief.

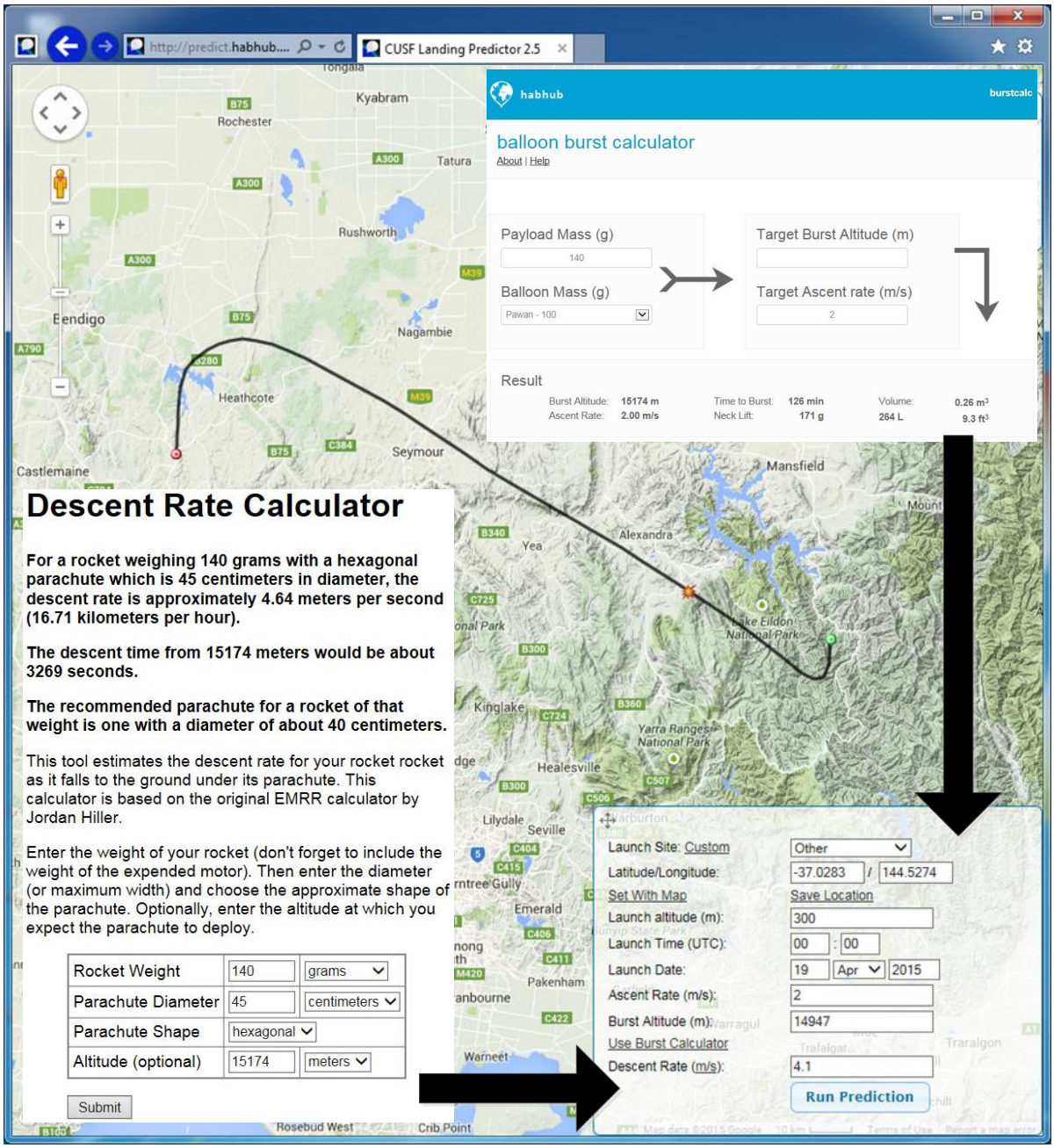

Figure 1 – Balloon Burst, Decent and Flight Simulations

While all this was going on the two payloads were being developed; one completely from scratch as it happened. This part was quite technical, apparently, as per the "T" in MARTG: The first balloon, designated MTG003, would carry aloft a colour camera payload capable of sending both images and telemetry back to earth using BPSK1000F and BPSK63F on 70cm FM. The second, MTG004, would send telemetry only, but it would use alternating JT65 and JT9 on 30m USB. All the fancy digital modes selected use forward error correction coding for high reliability. It proved to be a critical factor in the end.

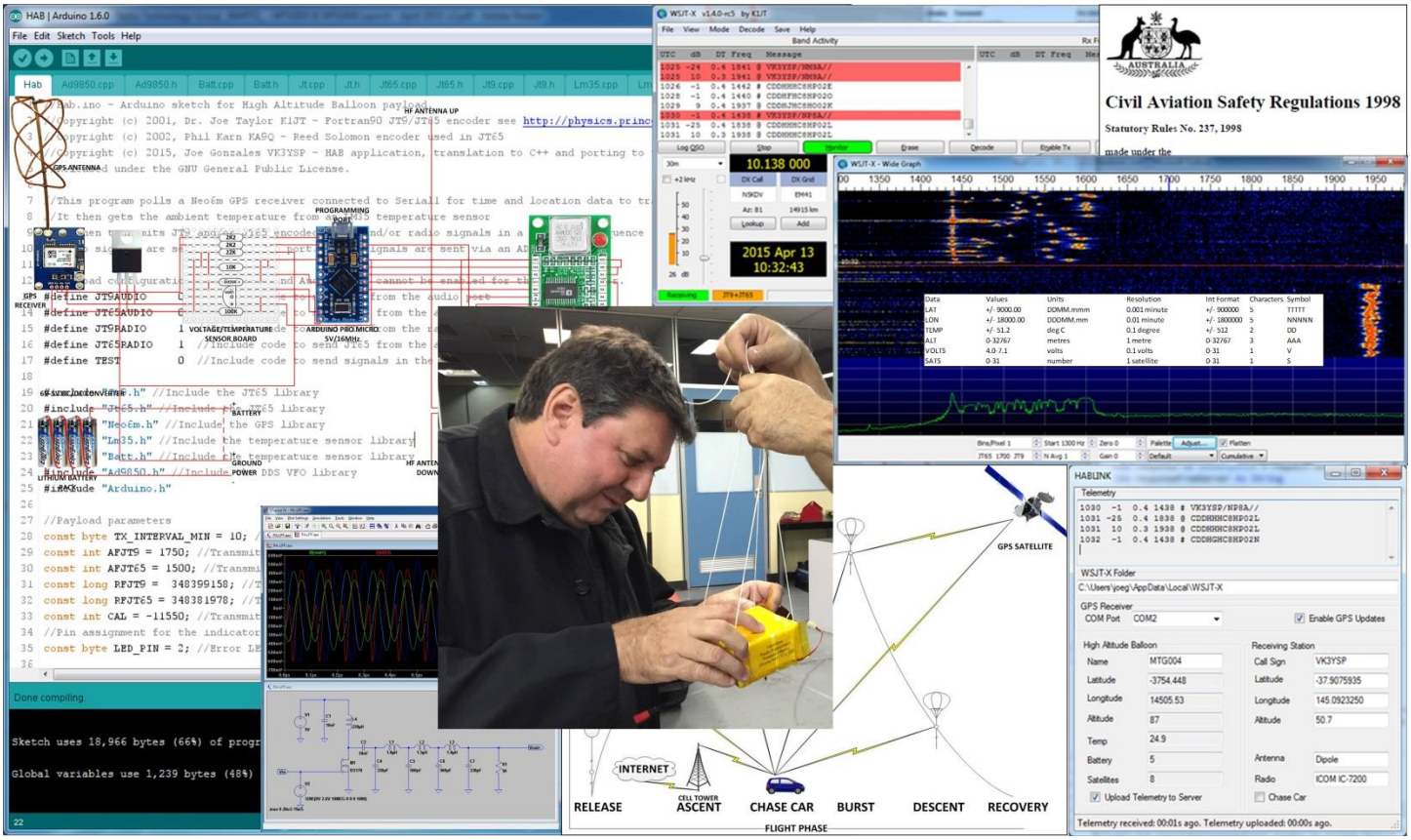

Figure 2 - Technical stuff going on at MARTG

Now, the payloads need to know where they are so they can relay this information to the trackers on the ground (who don't actually track anything, they just listen). Consequently, each payload has to have its own GPS module. And you have to get special GPS modules that work to 50km for high altitude ballooning. And you have to remember to turn on this extended-altitude feature or it won't work a jot above 12km. That's obvious, really.

Next, the payloads need to have a little on-board computer to make everything work. Both use tiny Arduino™ compatible modules – different types, of course. The computers read the GPS data, internal temperature and the battery voltage. They encode this information and send it to a transmitter module at regular intervals. MTG003 uses a 25mW UHF FM module and MTG004 uses a 50mW HF SSB module. All this payload electronics is powered by lithium batteries, which are chosen for their performance in the sub-zero temperatures encountered at high altitudes. The latter also being the reason why the payloads are housed in polystyrene foam blocks: One square and one round.

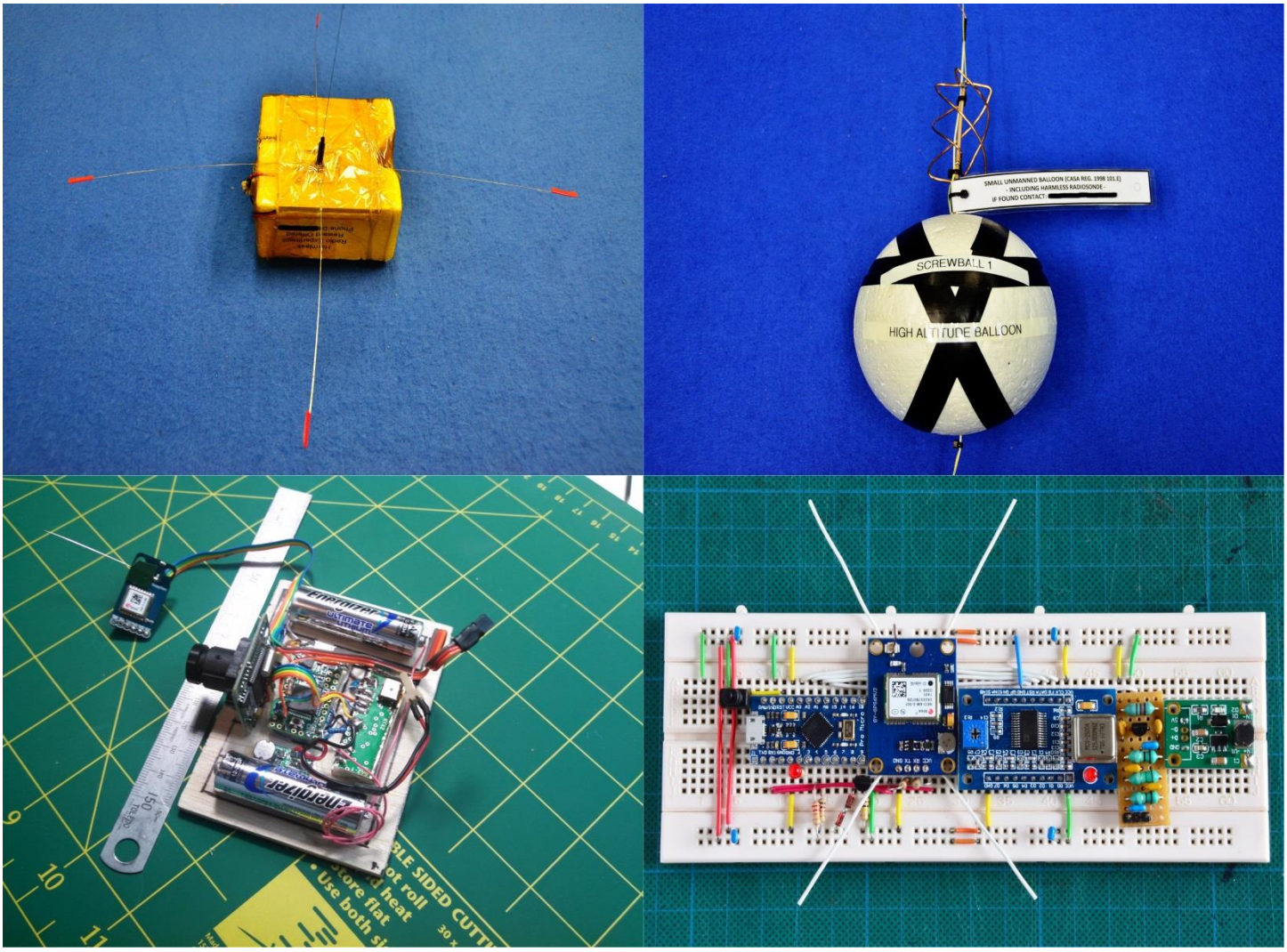

Figure 3 – MTG003 and MTG004 Payloads

You would expect the ground receiving stations to be straightforward, but here again it gets a bit technical and every setup was a little bit different, introducing its own set of problems. Each listener has to receive the weak telemetry signals from the balloons. They have to decode it and send it to a server on the Internet. That means mobile antennas, receivers, GPS again, computers, software and a mobile broadband Internet connection. Two different programs, DL-FLDIGI and WSJT-X, are used for decoding and uploading. Then one server, called HABITAT, accepts the telemetry data and sends it to another server, called HABHUB, which displays the location of the balloons and the listeners together on a world map. It conveniently shows the balloon's existing and predicted flight paths. Both servers are kindly operated by the UKHAS group.

Now the servers have to be configured for each balloon prior to the launch. You have to lodge a Payload Configuration Document and a Flight Document and then you have to get the Flight Document approved by UKHAS. And you wouldn't want to forget that last step would you?

Launch day finally arrived. The MARTG launch crew was up early driving to a remote location near Bendigo, Victoria, chosen specially for its… flatness. Balloons don't always go straight up apparently and it is not good if they crash into or get shielded by nearby mountains. The weather was freezing and windy… 35km/h winds predicted. But that wouldn't affect the launch, would it? Meanwhile MARTG Mission Control, back in Melbourne, was oblivious to the weather conditions and was coordinating a dozen or so participating stations on 40m over a hot mug of coffee.

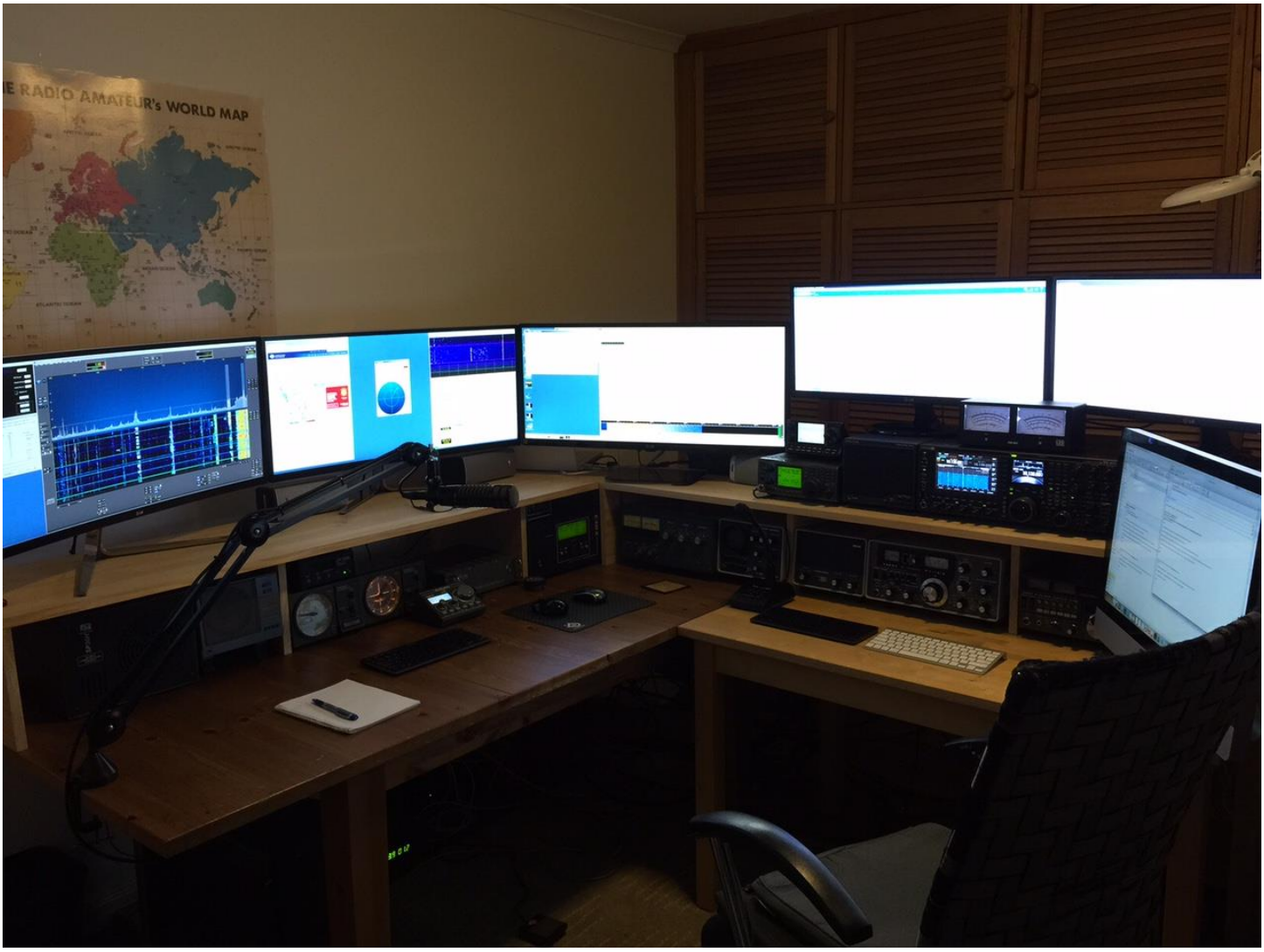

Figure 4 - MARTG Mission Control

On site, over a protective ground mat and with latex gloves on, the launch team carefully filled the two 1.6m latex balloons with gas. Precise and critical lift calibration measurements, involving suspending an equivalent payload mass from the neck of the inflated balloon and observing its gentle lift characteristics, were summarily abandoned due to the gale-force winds - A small hiccup, only, nothing to worry about. At the same time another group was chasing a payload tumbling down the paddock after the wind had caught its parachute - It could happen to anyone. In fact it wasn't really official until the MARTG safety officer remarked: "Gee it's windy today."

Figure 5 – The MARTG Launch Team and The Launch

So then it was time for the actual launch. It is interesting to note at this point how the phrase "let go" can be misinterpreted under these tense conditions. But, never-the-less, both balloons lifted gracefully into the sky "in exactly the same way as a brick doesn't." Back on the ground and not quite sure what to do next, the MARTG launch team settled into adjusting antennas, radios, computers and seriously tracking two separate balloons. It was a good time to install and configure windows applications for the first time, restart locked up computers and ask questions like "what does this button do?" But soon, all reported favourably: "They're going up." Although this was just confirmation of what everyone already knew; it was important that the technology knew it too. Everything had worked out perfectly and nothing had gone wrong…

But, not for long. At exactly 12km altitude, MTG004 when silent. No signal. Not a peep. What was wrong? Was it too cold? Not likely, with all that polystyrene, the electronics had reached an alarming 53°C on the ground before launch. The last temperature data indicated a balmy 37°C. Was it the battery voltage? No that was OK too. It was simply a mystery and bitterly disappointing. It must have crashed near the last reported position. An MARTG chase car was dispatched to investigate; maybe the signal could be picked up closer to the crash site, if it even survived that is.

Then, the disappointment suddenly turned to joy: Everyone cheered as MTG003 hit an altitude of 20km: A new record for the MARTG. That's more than 65,000 feet. "Now it's coming down." Someone said. "Yes, it's burst." Said another. Again, an MARTG recovery team headed off for the predicted landing site. But that was hours away now by car. Did someone miss a step? And it was so important to get close to the landing site and

get the very last GPS fix or the payload might be lost forever. Nothing could be done. The MARTG trackers all watched as MTG003 descended. It had just dropped down below 12km, when a miracle occurred.

The MTG004 recovery team was now driving around its last reported position. There was no signal, as before. They started driving further east along the predicted flight path. But the roads didn't line up and they were going all over the place. Then, as clear as anything, a strong JT65 transmission, bang on frequency… Now it takes a minute for a JT65 signal to be decoded. The suspense was unbearable. When it was finally decoded as an MTG004 telemetry frame, everyone saw it on the map. "It's alive!" It had just descended below 12km. Immediately, both recovery teams were on the road headed for Lake Eildon, the predicted landing site for both payloads.

Knowing that neither recovery team would make it there in time for the landing, was simply devastating. It was a major error in planning; not heading off sooner. The payloads could crash and they'd never find them. But then: A mobile phone call from an amateur radio buddy. It was his wedding anniversary. "Congratulations." He's gone away for the weekend. "That's nice." He's staying near Eildon! "You're kidding me?" And he's got his 817 with him. "Brilliant!" Half an hour later he calls back: "I can hear a strong signal on 434.650. And there is some JT65 on 10.139." Both payloads have survived the landing! When the recovery teams arrive they can decode the landing coordinates. That is if the batteries held out until they got there. It was only then they noticed that the wind had died down and it was quite warm. The MTG004 electronics would be now be critically overheating in the afternoon sun.

But luck was with them: 10km away from Eildon the JT65 signal from MTG004 was strong enough to decode. Its precise landing site was now on the map. It had landed only 500m from the lake, on a spur with treacherous slopes on either side. There was a dirt track along the spur – that was convenient. In fact when they found it, it was just sitting there in the middle of the track. Fully operational. There was no damage what so ever... A piece of cake.

MTG003 on the other hand was down by the river on private property. How to approach this one, they wondered? "Ah hello, Mr. Farmer, yes a high altitude balloon payload of ours has crashed landed on your property. It's transmitting these pictures of your back yard, err, and we'd like to get it back, please." While they were still wondering what to say, the property owner drove up. "Yeah sure." He said. "Do you guys need a lift down there?" MTG003 had landed softly on some grass and was transmitting pleasant pictures of trees, grass, and cowpats. Fully recovered. No damage… A piece of cake.

Figure 6 - Recovery of MTG003 and MTG004

It was interesting how both balloons had followed the same path and landed only 7.5km from each other. It was amazing that MTG003 had gone to 20km altitude. Maybe MTG004 had got there too, but they'll never know. The burst prediction was a bit out because the balloon lift couldn't be accurately set in the strong wind. It was within limits for the reported ascent rate, though. But the flight prediction was pretty good. They had both landed, conveniently, 20km short of the originally predicted site which was located in totally inaccessible bush land.

The MARTG team headed triumphantly back to Melbourne. It was an amazing, rollercoaster day of emotions, successes and failures. So many things could have gone horribly wrong: The launch could have been called off due to bad weather. The lack of server flight document approval did not affect the tracking. The telemetry failure of MTG004 did not affect its recovery. And so many things just worked: Mission Control coordinated the day's events smoothly. There was just enough helium to launch both balloons. Getting some unexpected help in the right place at the right time to recover the payloads was incredible. The pictures returned by MTG003 were simply perfect. There were so many good ones without even a single error!

Figure 7 - The view from MTG003

So who or what is the MARTG? It's not a club, it's a select group of amateurs with common interests. It doesn't have a president or a constitution. Its members meet each week to decide what the group will do next. They bring along their own projects to demonstrate new technologies and inspire new ideas. Some bring food and drinks. Everyone has a story or a joke to tell. Their backgrounds and collective skills are impressive: Some can design, some can build, some can code, some can organize. There's the guy who provides the meeting room, workshop, equipment, tools and utilities for free. The guy who can fix anything and rework SMDs. One who does web design, photography and videos. Another who knew someone who donated the helium. The list goes on. High altitude ballooning and the GSBC is just one example of this multifaceted group's activities. Reaching 20km altitude is pretty impressive, but the group wants to go higher still and to be able to talk to the balloon - who knows why exactly? And what after that? Well, the MARTG is already working on its own CubeSat™: It's a complete micro satellite launch package, donated by a member of the team, with the aim of putting the group and amateur radio into a low earth orbit! It seems like the sky is no longer the limit for the MARTG.

Figure 8 - Who or what is the MARTG?