SECTION IV: LAUNCH PROCEDURES

Figure 1: Launch procedure flow chart
Launch overview: The BOREALIS launch procedure is illustrated schematically in Figure 10. The basic strategy is that a single Flight Director (“Flight”) maintains overall control of the launch while the subsystem leads (“Balloon”, “Launch”, “Power”, and “Comm”) are responsible for executing their system checklists (Appendix E) and readying their systems for flight. If scientific payloads are carried, a fifth subsystem lead (“Science”) will work in parallel with the other four.

Balloon inflation: The balloon inflation team starts by finding a safe place to lay out the inflation tarpaulin, gas bottles, and necessary supplies including duct tape and 100 pound test line. The ideal location for inflation is a clean area leeward of any ground winds. The balloon itself is laid out, inspected, and connected via the connection nozzle (Figures 9 and 20) to the gas bottles, then inflation may begin.

The balloon is inflated to the point where its lift exceeds the payload weight by approximately two pounds. Lift is determined by means of a digital fish scale (Figures 20 and 21), relative to the payload mass, which is typically measured before departing for the launch site.

Figure 2: (Left) Measuring the lift of the balloon. An inverted digital fish scale is connected to the loop attached to the inflation nozzle. (Right) Inverted digital fish.

When the desired lift is achieved, the balloon inflation team seals the balloon and prepares the balloon for connection to the payloads. The balloon team leader gives a “GO” to Flight, and awaits the order to connect.
Launch tower operations: It is the responsibility of the “Launch” team lead to set up the launch tower and secure the command and payload capsules to the tower. This allows the other teams to safely carry out their checklists prior to flight. Once the tower and capsules are prepared, and while the other teams set up their systems, Launch connects the parachute to the payloads and carefully lays out the lines by which the balloon will be connected to the parachute. Launch also sets up the lanyard lines for the four lanyard operators to hold the stack vertical immediately prior to release.

Communications and IBIS: During the pre-launch preparations, everything can get rather hectic, so every subsystem has developed their own checklists. For BOREALIS, the communications and power subsystems have a single checklist, since so much of the systems are interlinked. This checklist is included in Appendix A. The basic overview of the pre-launch procedure for power/communications is this: First, the GPS antenna needs to be connected to the GPS unit before power-up. As soon as power is connected to the GPS unit, it begins to look for GPS satellites, so the antenna needs to be connected. After power-up of the GPS unit, radio, and camera, everything else can be connected. The GPS unit needs to be plugged into the radio, and the radio needs to be set to receive GPS coordinates from the unit. For the TH-D7 and Garmin to work together, the TH-D7 needs to be set for the GPS to read in NMEA format. It is important to make sure that the flight antenna is connected to the radio before transmission begins, or the transceiver could burn out due to lack of resistance. Once the radio is receiving coordinates correctly, it needs to be set to send these coordinates in a “beacon mode” setting. This setting allows the radio to automatically send an APRS packet at a chosen interval, which we usually choose to set to the radio minimum of 12 seconds. Once we have successfully received APRS packets with the correct coordinates (verify using a separate GPS unit), we then turn off the auto-shut-off option on the radio, as well as lock out the keypad, so that no buttons can be pushed accidentally during the sometimes bumpy flight. Once this is completed, the connections between pieces of equipment are secured, and the payload box is sealed. From this point until launch, it is the job of Comm to monitor the packets and ensure that the system is working properly. If everything is working correctly when the system is ready for launch, communications gives the last GO, and the pre-launch sequence is finished.

Launching the balloon: After the balloon has been connected to the payloads, and the final GO/NO GO check has been performed by Flight (with particular emphasis on communications with the balloon), Launch takes over the operation.

There are several different techniques that can be used to launch the stack, depending on surface wind conditions. Ideally, surface winds will be low, and a Vertical Launch may be attempted. This provides the most control over what is happening, and the least danger of losing the balloon or damaging the payload.

During low-wind conditions the balloon may be let up a certain distance, enough to pull the payload cords straight below the balloon. This is called a Vertical (low wind) Launch. The goal is to let the balloon rise smoothly so as to not risk breaking the payload suspension cord attaching the balloon to the parachute. The BOREALIS system uses a small plastic piece with four holes in it. The holes are positioned such that two are in a vertical line with each other, the other two are in a horizontal line with each other making a + shape with one hole at both ends of each line. The vertical holes are used to attach the balloon to the parachute, and the horizontal
holes are used for control of the height of the balloon. This is achieved by using two kite string spools with Dacron cord wrapped on each. By letting enough length out the loose end of cord is threaded through one of the horizontal holes and a person is given the loose end to hold. The other spool is set up similarly on the other side. The person holding the spool then may control the height of the balloon by letting cord out or spooling it in.

During high wind conditions the Vertical Launch will not work; the balloon will become like a sail and be very difficult to control. It is easy for high winds, pushing on the balloon, to create a force exceeding the 50 pound breaking strength of the payload suspension line.

In such conditions, if a launch is desired (the best choice may be to wait for another day), it is possible to overcome this problem by not letting go of the balloon until the entire stack is in position to be lifted by the balloon. To do this the payload, parachute, and balloon are arranged in a horizontal line along the ground with a person cradling each item in their arms (NOT holding them, but merely providing support underneath). On command from the Flight Director the balloon is let go and the payload is simply cradled such that the balloon picks them up as it rises. This is called a **Horizontal (high wind) Launch** (often referred to as a “Hail Mary” launch). It is important that the line of components is pulled upward smoothly when the balloon is let go so as to avoid the possibility of breaking the connecting cords. The line of components should be stretched out such that the connecting lines are taut, and everyone supporting the components of the stack must be careful to not hold on as the string quickly rises and is snapped from their arms.

![Figure 21: Launching the balloon. (Left) the balloon has just been attached to the top of the parachute, and the stack is being raised to vertical by the lanyard operators. (Right) the stack has been released.](image-url)