SmartTether^{TM} Version 8.0 Operating Manual

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Anasphere SmartTether Version 8.0 Manual

Hardware Version 8.0

Manual Revision E

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1.0 Introduction

SmartTether™ is a tethersonde system developed for boundary-layer profiling and near-surface meteorological measurements. One or more flight modules are deployed on the tether of a blimp, kite, or similar platform. A free PC-based program (Windows XP or newer) operates the system, saves data in a file, and can display data in real time. A single ground station is connected to a PC to communicate with the modules. Any number of modules may be operated through a single ground station. Data may be collected at up to a 1 Hz rate for up to eight modules; using higher numbers of modules will lead to gradual reductions in maximum data rate.

SmartTether has been specifically designed to be a flexible, multipurpose atmospheric profiling system suitable for a wide range of applications. Therefore, it uses a comparatively higher-powered telemetry system which enables ranges of up to six kilometers. This extended range comes at the expense of shorter battery lifetimes (12-24 hours depending on battery type) as compared to some of our smaller tethersondes.

Users requiring longer battery lifetime, or seeking a simpler tethersonde solution, will find a solution in our LiteTether™ line of tethersondes. The tradeoffs are that LiteTether only accommodates the collection of data from one module at a time and has a shorter telemetry range. LiteTether does not require a ground station, and uses an Android-based device such as a tablet computer to operate the system and collect data.

SmartTether has been designed to offer the flexibility of incorporating additional sensors with minimal effort. Analog-to-digital converters, serial ports, and counters can be added to SmartTether by the inclusion of a suitably configured daughterboard. These are not standard options, but are available upon request.

2.0 System Setup

2.1 Flight Platform

SmartTether is designed to attach to the tethers of small airborne platforms such as blimps, balloons, and kites.

2.2 Ground Station

A ground station is required to receive the data from the SmartTether module(s). This ground station is powered by 12 volts DC, and comes with a power cable that can plug into a standard car jack (cigarette lighter plug).

The ground station connects to a PC via a DB-9 serial cable. At the PC end, a USB-to-serial converter is required (not supplied).

Please note that the data from the ground station is not in plain serial format, but rather a format proprietary to the radio manufacturer. Therefore, it is not possible to directly receive serial data from the ground station into a third-party program. The Anasphere SmartTether program must be running to receive data.

If it is desired to pass the tethersonde data to a third-party program, a data pipe is provided by the SmartTether software which allows third-party programs real-time access to the incoming data.

2.3 PC

The SmartTether software runs on a Windows PC running Windows XP, Vista, 7, or 8.

Please be sure to run the correct software version which matches your hardware version. SmartTether 8.0 modules will work with any SmartTether version 8.0 software. Sub-variants (8.0.x) refer to which radio is installed in the flight modules: 8.0.0 works with 900 MHz radios, and 8.0.1 works with 2.4 GHz radios. 8.0.2 and later will work with all radio variants.

2.4 Flight Module

The following diagram illustrates key components of the SmartTether flight module in its pitot anemometer configuration (one of two anemometer types available).
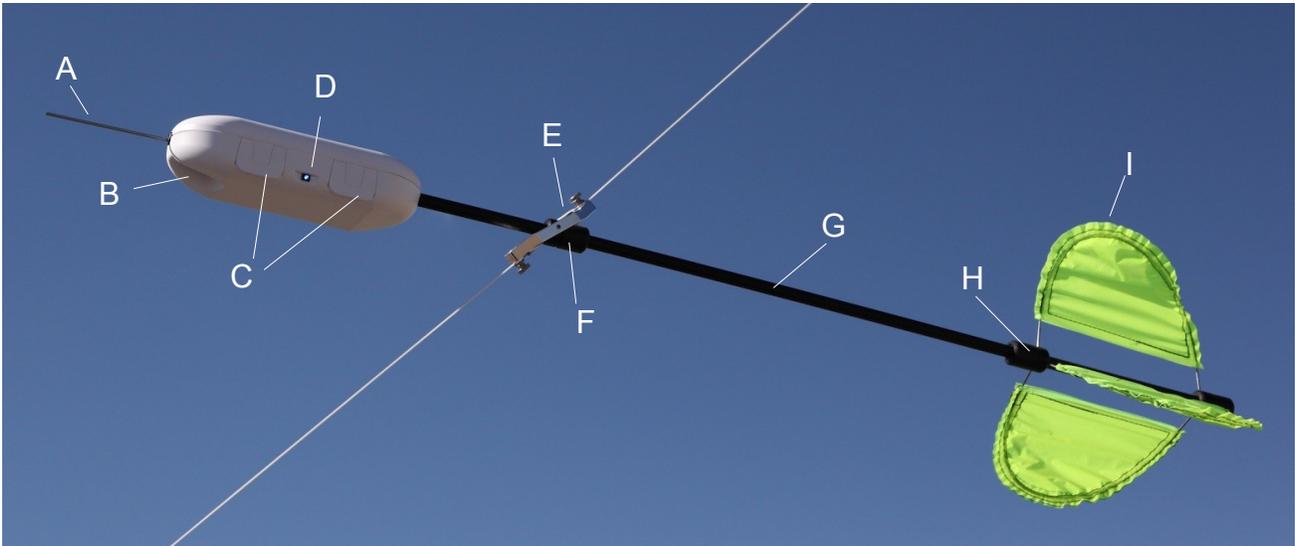
System Components

A: Pitot probe for wind speed measurement (see next page for cup option).

B: Protective recess for temperature and humidity sensors.

C: Housing latches.

D: Power switch (push on / push off) and indicator LED. LED turns on when system starts, toggles state to indicate each time a command is received or a measurement is taken, and provides feedback during calibration.

E: Metal line attachment block with thumbscrews and washers to secure the line.

F: Hub which can be loosened or tightened by twisting the two ends of the hub. Holes spaced at 180 degrees are provided for set screws to secure the hub within the line attachment block. Slide this hub along the boom to balance the module.

G: Fiberglass boom.

H: Fin hubs (identical to the line attachment hub, item F). Holes spaced at 120 degrees are provided for mounting the fins.

I: Fins (ripstop nylon with steel wire supports).

2.5 Anemometer Options

Pitot Anemometer. An anemometer based on a pitot-static system is the first anemometer option. A variety of maximum wind speed options are available, the most common choices being 0-14 or 0-28 m/s under standard conditions at sea level. The 0-14 m/s range is supplied by default unless another configuration is requested by the user. The module corrects the measured speed to true air speed prior to reporting the measurement.

For best performance, the pitot anemometer should be re-zeroed before each use of the module. This option is available in the software during the module acquisition step.

Cup Anemometer. A cup anemometer option is available for users who require a traceable anemometer. This option involves the addition of a front boom to support the cup anemometer, both of which add significantly (approximately 150 grams total) to the module weight. The cup option is pictured below:

3.0 Preflight Operations

3.1 System Setup

Turn on the ground station and connect it to the PC. Open the SmartTether version 8.0 software and acquire the ground station by selecting the appropriate COM port. Once this is done, the software is ready to begin the module acquisition process using either the "Acquire Modules" option (for systems which have already been configured) or the "Configure and Acquire Modules" option (for systems which need to be calibrated or configured).

Open each flight module housing by lifting the two latches on the side of the module. Confirm that the tail boom and pitot probe (or nose boom, in the case of the cup anemometer version) mounts are secure. Install two AA batteries, and close the housing.

Turn each module on by pressing the pushbutton power switch which protrudes between the latches. Operation will be indicated by the illumination of the bright LED in the power switch. Allow each module to be acquired before turning on the next module.

SmartTether modules pair with their corresponding ground stations. This enables multiple SmartTethers to be operated adjacent to each other without mutual interference. If switching a module between ground stations, or pairing a newly acquired module with an existing ground station, this pairing must be changed. To associate a flight module with a new ground station, first ensure that all other modules used by that ground station are turned off. Then, with the ground station software in acquisition mode, turn on the module to be paired and wait for approximately one minute. A successful pairing with the new ground station will result in the module being acquired. If this does not happen within two minutes, repeat the procedure.

If the module's compass has not been calibrated, or if the module is being used in a new location, follow the prompts on the screen to calibrate the compass module. Repeat these steps for additional modules as necessary to calibrate all of the compasses. See section 3.3 for details of this procedure.

3.2 Indoor Operation

Sample timing in SmartTether 8.0 is ordinarily controlled by the on-board GPS receiver. However, operation indoors will likely preclude reception of an adequate GPS signal to enable normal operation. Selection of the indoor mode, done in the SmartTether software, establishes a fixed and fast (between 1 and 2 seconds) sampling period which is not user adjustable but will work indoors.

3.3 Compass Calibration

The tilt-compensated electronic compass must be calibrated prior to use, and any time it is moved to a new geographic location. This procedure requires user participation, and takes a little more than two minutes. The SmartTether module should be in the general area where it will be used. In the software, select the "Magnetic Calibration" command. After a several second pause (allowing the user to leave the computer and pick up the SmartTether module), the process begins. Progress is indicated by a progress bar on the screen.

During these two minutes, the user must manipulate the SmartTether module so that it can sample its local magnetic environment and develop tilt correction coefficients. The objective of this procedure is to let the SmartTether module sample all directions in its local environment while varying its pitch and roll angles. This can be achieved by rotating the module several times while pitching and tilting it to varying degrees. For those who desire a more specific procedure, the following procedure may be used.

Hold the module with one hand just behind the line attachment block and hold the rear of the tail boom (by the fins) with the other hand. When the LED illuminates, use the rear hand to spin the module about the boom axis while using the forward hand to point the module in as many different directions as possible. This includes straight up and down, right and left, forward and backward, and as many intermediate angles as can be achieved during the calibration period. Be careful to not drop the module while doing this!

At the conclusion of the process, the software will inform the user whether or not the calibration was successful. If not, repeat the above steps.

Compass calibration can be repeated at any time, as long as the user has access to the module and can manipulate it through the range of orientations needed for calibration. Calibrations are saved in nonvolatile memory, so there is no need to repeat this procedure each time the module is turned on assuming that the module is still being used in the same general area where it was calibrated.

3.4 Pitot Anemometer Calibration

The pitot anemometer must be calibrated prior to use. This is an automatic procedure which takes just over one minute. Place the SmartTether module in a sheltered environment with still air. In the software, select the "Anemometer Calibration" command. The calibration progress will be indicated by a progress bar, and can also be observed on the module which will be blinking its LED in a triple-blink pattern. After approximately one minute, the calibration will be finished and saved in the module's memory.

Anemometer calibration can be repeated at any time, as long as the device is in still air. Calibrations are saved in nonvolatile memory, so there is no need to repeat this procedure each time the module is turned on.

3.5 Thermistor Calibration

The thermistor can be calibrated as needed, and should be calibrated before first use. There are two methods to calibrate the thermistor, both accessed through the SmartTether software. Both are single-point calibrations. The first option is to allow the module to equilibrate with ambient temperature and then use the internal calibration option, which matches the thermistor to the value reported by the temperature sensor inside the adjacent humidity sensor. The second option is to input a known air temperature measured by an independent, user-provided sensor.

There is also an option to adjust the beta value for the thermistor. This is only recommended in certain cases, and the user should contact Anasphere for guidance prior to making this change.

3.6 Sampling Configuration

The software allows the user to adjust simple parameters related to the SmartTether module. Most importantly, this menu allows the user to change the sampling interval used by SmartTether for automatic operations. Intervals which are integral divisors of 60 are allowed (i.e., 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, or 60 seconds). Sample timing in SmartTether 8.0 is ordinarily controlled by the on-board GPS receiver. Selection of the indoor mode (see section 3.2) establishes a fixed and fast (between 1 and 2 seconds) sampling period which is not user adjustable.

3.7 Miscellaneous

The humidity sensor in the nose recess of the module may have a protective white sticker over the sensor. Peel this white sticker off of the sensor prior to use.

4.0 Flight Operations

Once the flight module has been set up as outlined in Section 3 (most importantly, the anemometer and compass have been calibrated), the system is ready for flight.

⚠ CAUTION: SmartTether modules are designed to hang from the tether of an airborne platform and can therefore present a hazard to personnel and equipment on the ground if they should fall for any reason (platform failure, tether failure, or line attachment failure). Appropriate precautions should be taken to protect personnel and equipment on the ground, including the use of personal protective equipment such as hard hats.

4.1 Balancing

Flight modules are most easily balanced prior to attaching them to the line. To balance the module, first ensure that the batteries are installed. Then, loosen the plastic hub assembly that passes through the metal line attachment block by partly unscrewing the two plastic pieces (they are threaded). Once the plastic hub is loosened, it can be slid along the boom until balance is achieved. When an acceptable balance point is found, tighten the plastic hub assembly.

This is also a good time to check that the two set screws in the metal line attachment block are in place. These set screws should firmly hold the plastic hub in place but not be so tight as to prevent the module from pivoting.

Small errors in balance are allowable! If it proves too tricky to get the module to rest perfectly level, remember that the fins will work with the wind to easily compensate for any small balance errors.

4.2 Line Attachment

The flight module attaches to the line by hooking the line inside the hook at the top of the line attachment block, passing it between the knurled cam and the body of the block, around the body of the block, and finally inside the hook at the bottom of the block. Bring the cam against the line and tighten it in place with the thumbscrew.

Do not leave any slack in the line when performing this step; it should be pulled tight. If attaching to a line under high tension (for example, a kite), it is recommended that either a) an assistant pull on the line so that tension is low enough to complete the line attachment, or b) the SmartTether module be attached to the line before the lifting platform is airborne and putting tension on the line.

4.3 Data Collection

! NOTE: The SmartTether module relies on the reception of GPS signals to control its sample timing. The modules will not operate indoors or anywhere a clear view of the sky is not available unless the indoor operating mode is selected.

Software Control. The SmartTether software provides full user control of sampling parameters (e.g., sampling periods), real-time data display (including vertical profiles and time series plots), and saving data in files.

Data Format. Data is saved in comma-delimited .csv files for easy import into other programs.

5.0 Technical Specifications

5.1 Mechanical and Environmental

Mass without batteries, pitot version: 255 grams
Mass with batteries, pitot version: 275-295 grams depending on battery type

Mass without batteries, cup version: 425 grams
Mass with batteries, cup version: 445-465 grams depending on battery type

Operating temperature range: -40°C to +50°C

Maximum wind speed: There is no defined maximum wind speed. Modules have
been tested for stability up to 20 m/s but will remain stable at higher speeds. The
anemometer will stop indicating above its maximum value.

5.2 Electrical

Power consumption: 225 milliwatts average (75 mA at 3.0 V)

Power Supplies: There are two power supply options: either install two AA batteries in
the on-board holders, or supply 0.65 – 6.5 volts DC via J1 on the circuit board (no
connector is provided, but the pads are marked with polarity).

Operating Lifetime: Two AA lithium cells (Energizer L91) can operate the SmartTether
module for approximately 24 hours at 1 Hz.

Maximum telemetry range: 6 km in clear outdoor environment

Sampling Period: 1 second to 60 minutes, with specific available periods being 1, 2, 3,
4, 5, 6, 10, 12, 15, 20, 30, and 60 seconds, and 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, and
60 minutes.

5.3 Sensors

Pressure: resolution 0.1 mb, accuracy 0.5 mb, range 0-1100 mb
Temperature: resolution 0.125°C, accuracy 0.5°C, range -55 to +125°C
Relative Humidity: resolution 0.1%, accuracy 1.7%, range 0-100%
Wind Speed (pitot anemometer): resolution 0.1 m/s, accuracy 0.5%, range 0-14 m/s
(at sea level), 0-22 m/s (at 5,000 ft MSL); extended ranges with reduced
resolutions are available.

Wind Speed (cup anemometer): resolution 0.1 m/s, accuracy 0.1 m/s or 5% (whichever is greater), range 2-59 m/s
Wind Direction: resolution 1 degree, accuracy 2 degrees

5.4 Maintenance

To ensure the function and longevity of your SmartTether system some basic maintenance steps are required. When not in use, it is recommended that the system be stored in a cool, dry place. If desired, external system components (i.e., the housing, fins, boom, hubs, and line attachment) may be wiped down with a damp cloth to remove external dirt and debris. Additionally, after using SmartTether it is recommended that the batteries be removed from the flight module.

⚠ CAUTION: The temperature and humidity sensors are exposed in the recess under the nose of the module. While these sensors are tolerant of incidental contact, avoid the use of any liquids, solvents, or lubricants near them.

6.0 System Options

SmartTether has been designed to offer the flexibility of incorporating additional sensors with minimal effort. The following options are not standard, but can be included when ordering SmartTether modules. These options are enabled by the inclusion of a suitably-configured daughterboard which is installed on top of the main SmartTether circuit board. A minimal weight and power penalty is incurred by the inclusion of the daughterboard, and maximum sampling rate may be affected as well.

The additional sensors themselves will of course add their own weight and power needs. SmartTether can supply a very limited amount (several milliamps) of either 3.3 volt or 5 volt DC power to external sensors, but in most cases it is recommended that additional sensors have their own power supply. Contact Anasphere if you have specific power supply questions.

All of the following options are supported but are non-standard except for GPS. Contact Anasphere to specify the inclusion of any of the non-GPS options when ordering a system. In most cases, these upgrades must be completed at Anasphere.

6.1 GPS

A GPS receiver is always installed in SmartTether version 8.0 to provide sample timing control. This receiver can provide an alternate source of altitude data or time and location stamps. Altitude and time fields are available under every sampling time period, but are not broadcast with the data stream unless the user enables the fields; other GPS fields are available at sample periods of 2 seconds and slower.

6.2 Analog Signals

One or two 12-bit analog-to-digital converter channels can be provided. The range is shared for both converters, and can be either 0-3.3 or 0-5 volts DC.

6.3 Serial Ports

Two bidirectional serial ports are available. These can be used for direct RS-232 input (either logic- or standard-level signals), RS-232 output (either logic- or standard-level signals), or RS-485.

6.4 XDATA

SmartTether may be set up to receive data packets from XDATA-configured instruments or to send its data to a radiosonde able to accept XDATA packets. SmartTether is capable of operating in the middle of an XDATA daisy chain.

6.5 Counting

A single channel capable of counting pulses over a defined period is available.

6.6 Miscellaneous

The above options provide for the interfacing of a wide variety of instruments to SmartTether for supporting measurements. For example, particle counters can be interfaced via either the serial or analog ports. Geiger counters can be interfaced via the counting port.

7.0 Troubleshooting

No communications or erratic operation. Replace the batteries. Note that the LED in the switch may still illuminate even if the batteries are nearly depleted.

Software cannot acquire the module. The module must be outside with a clear view of the sky to receive GPS signals and thereby enable its internal sampling and timing loop. Ensure that the module has a clear view of the sky. Alternatively, select the indoor operation mode in the software.

Wind speed is erroneous or zero (pitot version). First, ensure that the pitot anemometer has been recently zeroed in still air. Second, ensure that both ends of the flexible plastic tube that connects the pitot tube to the pressure sensor are securely attached. The pressure sensor is under the board, and you will have to remove the brass screws holding the circuit board in place to inspect this connection. If the pitot probe tube has come off, it goes back on the upper port of the pressure sensor (the one farthest above the circuit board surface). The static reference chamber is (or should be) attached to the lower port.

> ⚠ **CAUTION: The circuit board is sensitive to static electricity. If removing or handling the circuit board, be sure to do so in a static-safe location.**

Wind speed is erroneous or zero (cup version). There are two wires which bring the anemometer signal to the circuit boards. Remove the Phillips head screw underneath the cup anemometer's bottom housing and remove the conical bottom housing. You will see two brass nuts/studs. Each one should have one gray wire connected to them. Ensure that one wire goes to each stud and is securely fastened with the nut. This connection is not polarity sensitive.

Wind direction (compass) values are erroneous. Re-calibrate the compass, and ensure no large metal objects (cars, etc.) are nearby which could distort the local magnetic field. Be sure you are using batteries of the same type as you are using in flight. Try using the more specific calibration procedure in section 3.3 if you have been using a more random selection of orientations.

8.0 Alternate Live Data Handling

Occasionally our customers wish to process live data using their own programs. Starting with version 4.0, the SmartTether software makes data available via a named pipe as it is received from the flight modules. While the SmartTether software is running another process may read the data from the pipe. A minimal example program follows, written in C, which will read from the pipe and print data to the screen.

```c
#include <windows.h>
#include <stdio.h>
#include <conio.h>

#define BUFSIZE 512

int main()
{
        HANDLE hPipe;
        char receiveBuffer[BUFSIZE];
        BOOL fSuccess = FALSE;
        DWORD charactersRead;
        LPTSTR lpszPipename = TEXT("\\\\.\\pipe\\SmartTether");

        // Try to open a named pipe
        hPipe = CreateFile(
                lpszPipename,           // pipe name
                GENERIC_READ,           // read access
                0,                      // no sharing
                NULL,                   // default security attributes
                OPEN_EXISTING,          // opens existing pipe
                0,                      // default attributes
                NULL);                  // no template file

        if (hPipe == INVALID_HANDLE_VALUE)
          {
              printf( TEXT("Could not open pipe. GLE=%d\n"), GetLastError() );
              return -1;
          }

        printf("\nConnected to server.\n");
        do
            {
                // Read from the pipe.
                // This call blocks until at least 1 character is ready.
                // A real application may need to run this in a separate
                // thread or use overlapped (asynchronous) I/O.
                fSuccess = ReadFile(
                        hPipe,                  // pipe handle
                        receiveBuffer,          // buffer to receive reply
                        (BUFSIZE1)*sizeof(char),     // size of buffer
                        &charactersRead,        // number of bytes read
                        NULL);                          // not overlapped

                if ( ! fSuccess && GetLastError() != ERROR_MORE_DATA )
                {
                        printf( TEXT("\nReadFile from pipe failed. GLE=%d\n"),
                                GetLastError() );
                        return -1;
                }
```

```
                //Null-terminate the received string
                receiveBuffer[charactersRead] = '\0';

                //Print the string to the console
                printf( TEXT("%s"), receiveBuffer );
        } while ( ! _kbhit()); //Continue until the user hits a key

    CloseHandle(hPipe);
    printf("\nFinished\n");
    return 0;
}
```

Note that the name of the pipe is "\\.\pipe\SmartTether". The data format is tab-delimited text.

9.0 Additional Information

9.1 Technical Support

We are available to answer your questions by phone (406-388-4177) or email (support@anasphere.com, info@anasphere.com).

9.2 Liability Disclaimer

Responsibility for the consequences of using the hardware/software and for the intended or achieved results of its use rests solely with the purchaser.

In no event shall Anasphere, Inc. or any person involved in the creation, production, or distribution of this Anasphere, Inc. product be liable for any claim of damages, including but not limited to any damages assessed against or paid by you to any third party, arising from the use, quality or performance of such Anasphere, Inc. product including hardware, software, firmware, or documentation, even if Anasphere, Inc. or any such person has been advised of the possibility of damages for any claim by any other party. Some states do not allow the limitation or exclusion of liability for incidental or consequential damages, so the above limitations may not apply.

The purchaser understands and agrees that Anasphere, Inc. is not responsible or liable for damage to equipment caused by the use of its products.

Purchaser understands that it uses Anasphere, Inc. products at its own risk and agrees to indemnify, defend, and hold harmless Anasphere, Inc. from any and all claims arising from the use of its products.

9.3 Warranty

Anasphere, Inc. warrants this product to be free from defects in materials and workmanship for a period of 6 months from the date of shipment. During the warranty period, Anasphere, Inc. will, at its option, either repair or replace products that prove to be defective. This warranty shall not apply to any defect, failure or damage caused by misuse, abuse, improper application, alteration, accident, disaster, negligence, use outside of the environmental specifications, improper or inadequate maintenance, normal wear, or incorrect repair or servicing not performed or authorized by Anasphere, Inc.

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