# FLIGHT-LINE DATA SYSTEM

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# FLIGHT-LINE COLLECTOR SYSTEM

# OPERATION MANUALS

***Revised April, 2020***


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# Flight-line Manual Contents

## HARDWARE WARRANTY

W R K hereby warrants and grants an express warranty to the purchaser of the WRK Flight-line Collector System as described herein as follows:

WRK hereby warrants that the WRK Spray and Granular Pattern Deposition Analysis and Graphics System shall be free from defects in material and workmanship upon delivery. Any components failing to operate satisfactorily during the first 30 days will be repaired or replaced at no cost to the purchaser. In addition, any equipment defects occurring during the next 30 days will be repaired or replaced at the cost of replacement parts only. WRK shall repair or exchange the product at its principle place of business following discovery and return authorization during the above periods.

In the event that the WRK Flight-line System or any portion thereof is not installed or used in accordance with the manufacturer's specifications, any and all warranties either expressed or implied shall be and are hereby voided. Only upon the proper installation and use of the items shall this warranty or any other warranty apply.

EXCEPT TO THE EXTENT EXPRESSLY PROVIDED HERE AND ABOVE AND IN LIEU OF ALL OTHER WARRANTIES, THERE ARE NO WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO, ANY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE FOR THE ABOVE DESCRIBED ITEM OR ITEMS.

**NOTICE**

WRK reserves the right to make improvements in the product described in this manual at any time and without notice.

# WRK Flight-line Manual

## SECTION I. GENERAL DESCRIPTION

The WRK Flight-line System is normally set up on an airstrip or open area where aircraft can safely approach, fly over, and depart the sampling line. However, this system can also be easily set up and used in growing crops when it is desired to measure the spray penetration and deposition at different locations within a plant canopy. This system is operated with batteries and thus can be set up and operated at remote sites.

The Flight-line Collector System collects spray pattern data as an aircraft flies over a collector placed at a right angle to the direction of flight (or in the direction of flight). The spray-drop collector is a 1-mm diameter cotton string suspended near the ground. A fluorescent dye (Rhodamine WT) added to the water in the aircraft spray tank is the tracer material. Tripods at the ends of the sample line provide support for the suspended string, one end providing support for the string dispenser and string supply cone (about 10,000 feet/two-pound cone, 3048 m/0.9 kg. *Note: may vary with string type*.), the other end support for a battery-powered motor-driven string windup unit. The standard length of the standard sample line string is 150 feet (46 m), but the length can be varied to suit the application need. Provision is also made for mounting 1" x 2" (25 mm x 50 mm) water-sensitive cards at intervals along the sample line to provide a visual display of the spray atomization and deposition pattern.

The Flight-line Data Acquisition System (sold separately) measures the aircraft ground speed and ambient weather conditions for helpful interpretation of the pattern results. A height measuring system (sold separately) consists of a manual sighting device and accompanying scale used for the measurement of aircraft spray height above the sample line.

## SECTION II. SPECIFICATIONS

- Tripod-mounted sample-line string dispenser and string windup units are used to deploy string spans of 150 ft (50 m), or more at about 2 ft (60 cm) above the ground. Shorter or longer spans may be used, as the need arises.

- The supply-end string dispenser unit holds a cone of string (up to about 10,000 ft, 3048 m, depending on the string-cone size).

- The string windup end-unit features a re-chargeable battery-operated DeWalt drill driver w/special spindle for string spools, and includes a charger and a spare battery. A specially designed bracket attaches the drill motor to the tripod.

- Three stakes (shortened electric fence posts) for mounting white plastic bags, provide a visual guidance means for the pilot to fly centered over a specific reference point on the sample line.

- The visual aircraft altitude measuring system uses two properly spaced tripods at one end of the sample line, one with a sighting device the other with a vertical scale. As the aircraft

passes, a visual sighting of a point on the aircraft is made through the scope. The aircraft boom or spray-release height is read directly from a calibrated scale on the other tripod.

- Other accessories: 10 reels for winding sprayed string (each reel can hold up to 6 spray passes), a 150-ft (50-m) tripod spacer-cable and 7 spot-card holder stakes or 7 water-sensitive mounting blocks with surfaces at 30°, 45° and horizontal angles. An odd number of spot-cards are recommended with one located at the centerline.

The flight-line collector system and the flight-line data acquisition equipment fits into two specially designed cases.

## SECTION III. FLIGHT-LINE SETUP

**Please note:** There is a place for <u>everything</u> in the provided cases. Take time to become familiar with the packing scheme for the cases and put in the cases only those items that are supposed to be there. This approach will greatly assist keeping track of the equipment.

A supply of expendables will also be needed at the flight-line. Before setting up the equipment, assemble a supply of the following items:

1. String (2.5-LB cone)
2. Markers (red & green will work best)
3. Data transport envelopes – preprinted or with sheets attached to record weather data and accept the string sample spool
4. Spot cards
5. Masking tape
6. White plastic trash bags for markers
7. Rhodamine WT dye, normally used but other fluorescent dyes can be compatible.

The string, spot-cards and green markers will be required at the left end of the sample line (as seen by the pilot). The red markers, masking tape, and sample spools will be needed at the right end of the sample line. Locate the unused data envelopes at the analysis center and the Rhodamine WT dye where the planes are to be loaded with water.

### Unpacking and Setting up the Flight-line Collector System

Open the Flight-line Collector case and remove the contents. (Figure 1). Items include:

1. Manfrotto tripods (2)
2. String dispensing unit assembly
   - String Bucket
   - String Tensioning unit
3. String Winder DeWalt Drill
   - Mounting Bracket w/Drill Handle Clamp
   - Spool Spindle in Drill Chuck

- String Cover (a cover to shield the spool during passes to prevent contamination of wound string)
- DeWalt Battery Charger

4. String Spools (10)
5. Spacer Cable (150'/50 m)
6. Three stakes for white trash-bag flight markers
7. Spot-card Holder Stakes (7)
8. Spot-card Holder Blocks (7)
9. Styrofoam Ball

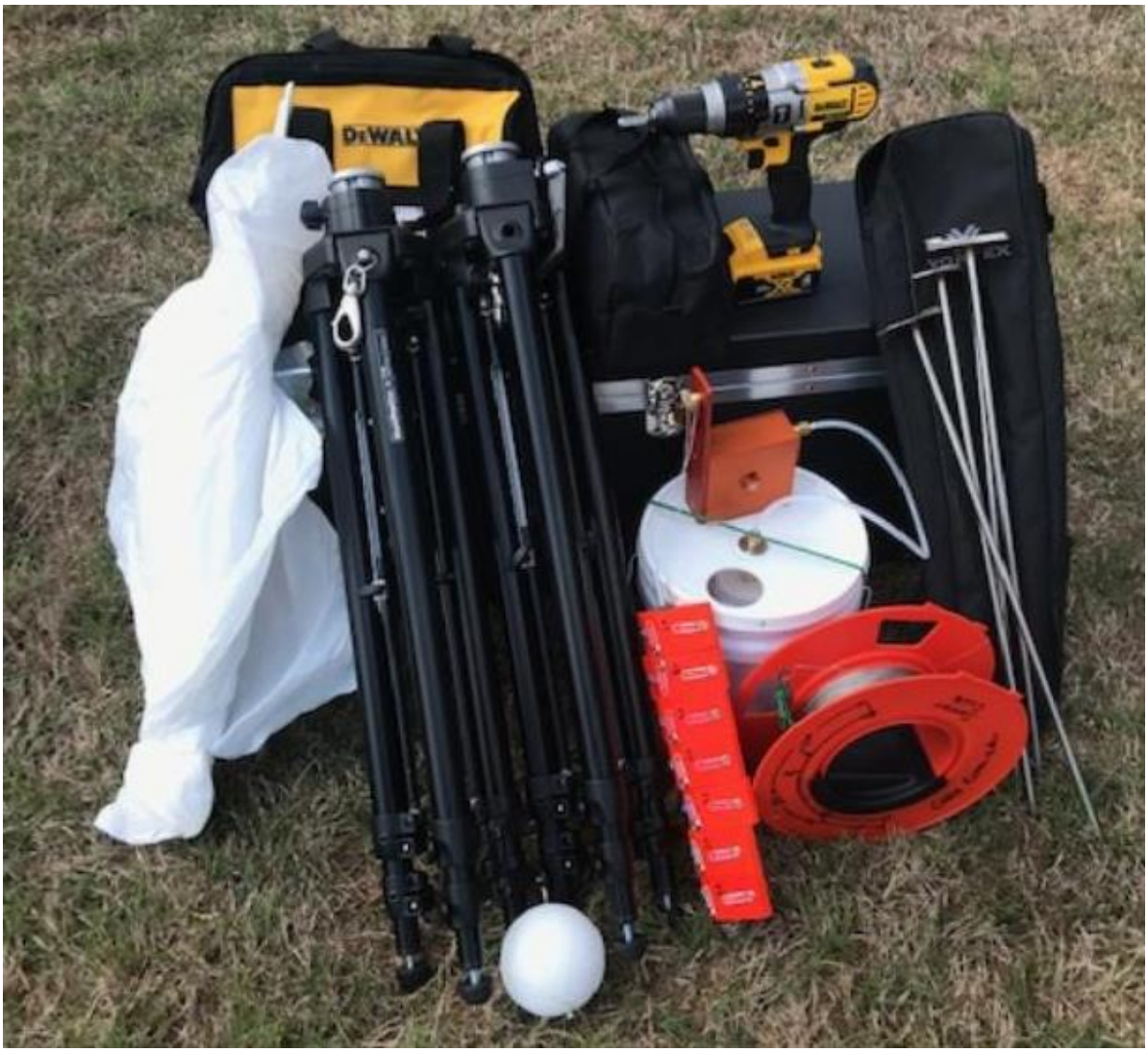

**Figure 1. Flight-line Sample System**

Deploy the sample line perpendicular to the prevailing or expected wind direction (Figure 2).

The aircraft will fly directly into the wind. Note that **LEFT** and **RIGHT**, both for the aircraft and the sample line, are with respect to the pilot during the spray pass. The tripod with the string dispenser and string supply will be placed at the left end and the tripod with the wind-up unit, at the right end. The marker tripods should be set up and lined up after the sample line position has been established.

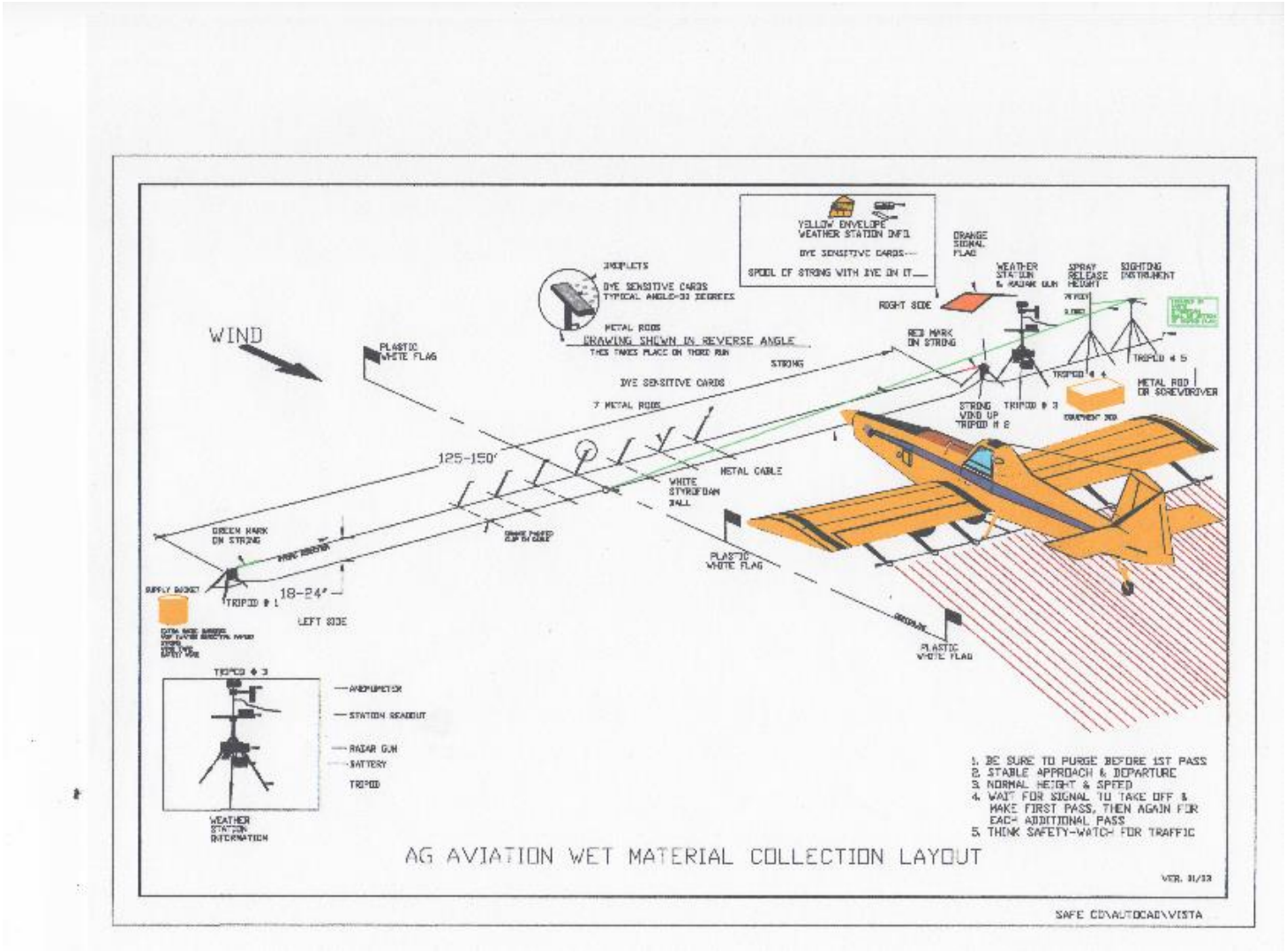


**Figure 2. Deposition Sampling Equipment Deployment**

### *Tripod Assembly*

Extend each telescoping leg section **only halfway**. Place the tripod on the ground with the leg angles fully opened out. Crank the mounting pad to the highest position. Attach the mounting

strap of the string tension unit directly over the level bubble of the **left tripod** and fasten with the knurled thumbnut  Attach the string bucket supply handle to the tripod by the upper attached snap. The plastic tube connecting the canister and the tension device should be in a gentle arc.  Mount the winder drill motor assembly on the **right tripod** using the knurled thumbscrew and adjust so that the string passes directly over the level bubble on the tripod head.  Position the clamping handle conveniently to allow easy access to the drill switch.

**Figure 3. String Winder System**

**Figure 4. String Supply System**

### *Tripod Spacing*

Place the tripods about 150 Ft (50 m) apart and in the proper position with respect to the wind, with the wind-up unit at the RIGHT end of the sample line. Attach the free end of the tripod spacer cable to one of the tripods and unwind it toward the other tripod. Attach the free end of the cable to the other tripod and carefully pull the tripods apart to tighten the cable between them. Locate the center of the sample line (double or large buttons) and attach the Styrofoam Marker ball to the center position on the spacer cable. Distribute and place the spot-card holders at each of the selected bead positions along and several feet upwind from the spacer cable. This distance allows for walking space between the string and the card holders. Angle the holders so that the card surface is about 30 degrees with the horizontal for wind speeds less than 8 MPH. If the wind is greater than 8 to 10 mph, then the angle should be steeper.

### *Marker-flag Holders*

Obtain three white plastic trash bags and tape them to the stake holders so that they are slightly open to the wind. Position the flag holders about 50 Ft (15 m) upwind and downwind from the sample line so that an imaginary line between the two marker tripods is perpendicular to the sample line and crosses the sample line at the center. Place the remaining flag a few feet upwind from the sample line center.

### *Re-orienting the Sample Line*

If it becomes necessary to re-orient the sample line because of a wind direction change, pick up the tripod with the string tension device and string case and slowly rotate around the winder end until the sample line is again perpendicular to the wind as judged by the wind vane at the RH end of the sample line. As the tripod is placed back on the ground, it may be necessary to straighten and re-tension the connecting cable between the tripods and possibly the string. Following any sample line re-positioning, the marker-flag holders will again need to be re-positioned at a right angle to the sample line center and the Flight-line Data tripod rotated appropriately.

### *Collecting Waste*

Place a plastic trash bag at the RH end of the sample line. The trash bag may need to be taped to the tripod or a case to prevent it from being blown away.

### *Unpacking and Setting up the Flight-line Data Acquisition System*

The Flight-line Data Acquisition Case contains the following items (Figure 5). This is also a good place for miscellaneous tools, extra batteries, etc., normally used at times at the flight-line.

1. Weather Tripod
2. Kestrel 4500 or 5500 w/rotating vane

3. Radar
4. Height System Tripods (2) (Included with Height System purchase)
5. Height-tripod Spacer Cable (Listed here but wound on spool in Flight-line Box)
6. Screwdriver Cable Peg (Included with Height System purchase)
7. Height Scale (Metric or Imperial)

### *Assembling the Flight-line Data Acquisition System*

If you purchased a Flight-line Data Acquisition System or if you wish to use your own system, then the following proven suggestions are offered. The suggestions are for the WRK system, but adaptation may be made for other units.


**Fig 5. Flight-line Data Acquisition System**

### *Positioning the Tripod*

Fully extend the weather-tripod legs and set up the tripod about 5 ft (1.5 m) downwind from the windup-end-tripod to minimize interference of operator movement with the equipment.

### *The Anemometer Assembly*

Attach the Kestrel wind vane to the top of the weather tripod (Figure 6). Unclamp and raise the tripod center post to a convenient reading position and tighten firmly. The Kestrel will provide wind direction, magnitude, ambient temperature, and relative humidity. ***Note that the Kestrel compass must be recalibrated after every battery change.***

**Figure 6. Weather and Speed System**

### *Hand-held Radar*

The hand-held radar should be laid on the equipment case or hung on the weather-tripod hook when not being used. Take care not to drop it, since it will likely be damaged if dropped. When the aircraft is lined up on the approach to the sample line, the radar should be lifted and aimed at the aircraft. Do not follow the aircraft with the radar as it passes by, since the more accurate

speed will be at the instant the radar locks onto the approaching aircraft. The aircraft speed will be indicated on the radar readout screen when the aircraft is within range.

## SECTION IV. OPERATING THE FLIGHT-LINE SYSTEM

### Sample Line Operation

***Fastening String to Windup Reel***

After pulling string from the tension unit across the sample line to the windup end tripod, place a

**Figure 7. Sample Reel Protective Cover**

take-up reel on the vertical spindle in the drill chuck. Ascertain the direction of reel rotation by momentarily triggering the drill. Hand wrap a few turns of string onto the reel in the proper direction and use a short piece of painter's tape to fasten the string end to the top-side of the reel. Then, operate the drill briefly to wind 3 to 6 Ft (1 to 2 m) of string onto the reel to provide a length of blank leader. Place the cover on the sample reel before the next spray pass (Figure 7).

***Adjusting The String Tension***

If there is **insufficient** tension on the string as it is pulled from the tension unit to keep it from sagging more than about 4 to 6 inches (10 to 15 cm) at the center of the 150-ft (50-m) span, then the tension unit should be re-adjusted. When **MORE** tension is needed, insert the tips of needle nose pliers into the two holes on the side of the tension unit and grip the knurled wheel just inside the openings (Figure 9). Pull on the string from the exit hole while holding the knurled wheel until the desired string tension is achieved. When **LESS** tension is needed, loosen the upper knurled thumbscrew on the tension unit faceplate to open the unit and expose the tension drum around

which the string is wound two times (Figure 8). Insert the tips of needle nose pliers into the two holes on the side of the tension unit to grip the knurled wheel just inside the openings as before and, using the fingers, rotate the tension drum counterclockwise until the tension is reduced to the desired level. Keep some tension on the string in the unit during this operation so that the string loops will remain on the drum surface and not wrap around the shaft behind the drum. An approximate force of one-pound (4.4 N) is the optimum tension for 150-ft (50-m) string length. The string will bow up to 12 inches (0.3 m) or more, in strong winds, but this will not affect the pattern readings.

**Figure 8. Tension Reel Access**

**Figure 9. Tension Adjustment**

### *Marking the String*

Before the aircraft makes a pass, mark each end of the string, adjacent to the winder and tension device, respectively. Make a 2-inch (5-cm) long solid mark that can be easily seen by the analyst with the string in motion. By using two different colors for marking the ends, the analyst can detect which end of the flight-line a particular mark represents. Use a green marker for the string-source end (aircraft left side) and a red marker for the winder end.

### *Before Winding*

Before winding the string following a pass, have the person working at the supply end check the string supply in the canister to verify that there is enough string on the cone to completely allow the end of the sprayed string to reach the winder without running out. There are several thousand feet of string on each cone and is easy to forget about the amount of remaining string. Following the procedure of checking each time will prevent several minutes of delay, as the string is re-threaded. The penalty for running out of string involves the rather time-consuming task of re-threading the system, as compared to merely tying a knot to place a new string cone into the string canister. **Remove the string cover from the reel prior to winding**. Replace the cover prior to the next aircraft spray pass.

### *Blank Leader Between Passes*

When winding following a pass, allow the drill-winder to operate for a short time after the LH end, green mark has passed to provide about 10 Ft (3 m) of blank string between passes. This length should be reduced to about 3-Ft (1 m) when the WRK String Spectrometer is used for the analysis.

### *Splicing New String Cone*

To splice in a new cone of string, remove the bucket lid, cut the string and remove the old string cone and slip the new cone in place. Join the string ends with a simple tight knot, clipping the string ends close to the knot. Test the knot with tension. Replace the string assembly in the canister and replace the lid. Carefully pull the string from the string-tension device until the knot appears.

### *Re-Threading the Tension Unit*

In the event that you run out of string at the supply end, re-threading is accomplished by feeding string from a new string cone out through the top of the string container, through the poly tubing and into the tension unit. Remove the poly string tube from both the tension unit and the bucket. Pull out enough string to pass completely through the tube, start the string into the tube and then "suck" on the other end. The string will be pulled through the tube. Reconnect the tube to the bucket connector, FINGER TIGHT ONLY. Remove the tube fitting on the tensioner and pass the string end through it. Screw the fitting into the tensioner, FINGER TIGHT ONLY. Remove the string exit bolt. With the tension unit cover removed, make two wraps of string around the tension drum and poke the string through the exit bolt. Screw the exit bolt back into the tension housing

FINGER TIGHT ONLY. Pull string through the unit to check the tension and operation. Replace the tension unit cover.

### *Using Water-Sensitive and Kromecote™ Spot Cards*

When placing the water-sensitive spot cards into the clips of the blocks, handle the cards by their edges -- avoid touching the card surface with your fingers (or anything damp or wet) as the cards are very sensitive to moisture in any form and will turn blue where they come into contact with moisture. Identify each card's position before placing on the blocks. As soon as the aircraft has passed, and the drops have dried to a dull appearance, the sprayed cards may be carefully picked up by their edges and placed into the data envelope. If the cards are to be retained for viewing for several days or more, the dry cards will need to be placed into plastic bags to prevent them from turning blue from the moisture in the air.

### *Signaling the Pilot*

Several schemes may be used to signal the pilots when to and when not to start a pass. Whatever system is used, it is very important that the person doing the flight-line signaling and all of the participating pilots know and understand just what the signals will be. One system is to use a colorful flag or banner mounted on a short staff to be waved when the flight-line crew is ready for the next pass.

SAFETY NOTE: It is the responsibility of the person doing the flight-line signaling to clear all of the people from the flight-line before the test aircraft begins the approach toward the sample line.

## Setting up and Using the Visual Aircraft Height-Measuring System

### *The Height-Measuring System*

This system has been designed to allow a quick and accurate measurement of aircraft height as an aircraft flies over the string collector or over the granular collectors. This system is based on the concept of similar triangles. The base-leg of the triangle is predetermined by the setup cable. The distance from the center of the sample line to the alignment scope is 100 Ft / 33 m. The distance from the measuring rod to the alignment scope is exactly 4 Ft /1.29 m). The height of the aircraft may be determined by sighting through the scope at the spray plume as the aircraft passes over the sample line. The tilting and rotational scope movement should be adjusted so there is an acceptable resistance or drag to the scope movement. This will allow the scope angle to remain in the same position until it can be swung back around to the sight rod scale to make an altitude reading. The scale on the sight rod has been configured so that the height may be read directly, in feet of altitude (or in meters), at the point where the red scope-dot intersects the sight-rod scale.
The following components comprise this system:

- Two tripods, with mounting brackets

- Scope with mounting bracket
- 25-Ft/8-m spacer cable
- PVC sight rod scale with mounting bracket
- Several spare CR2032 3V batteries (batteries specific to scope ty

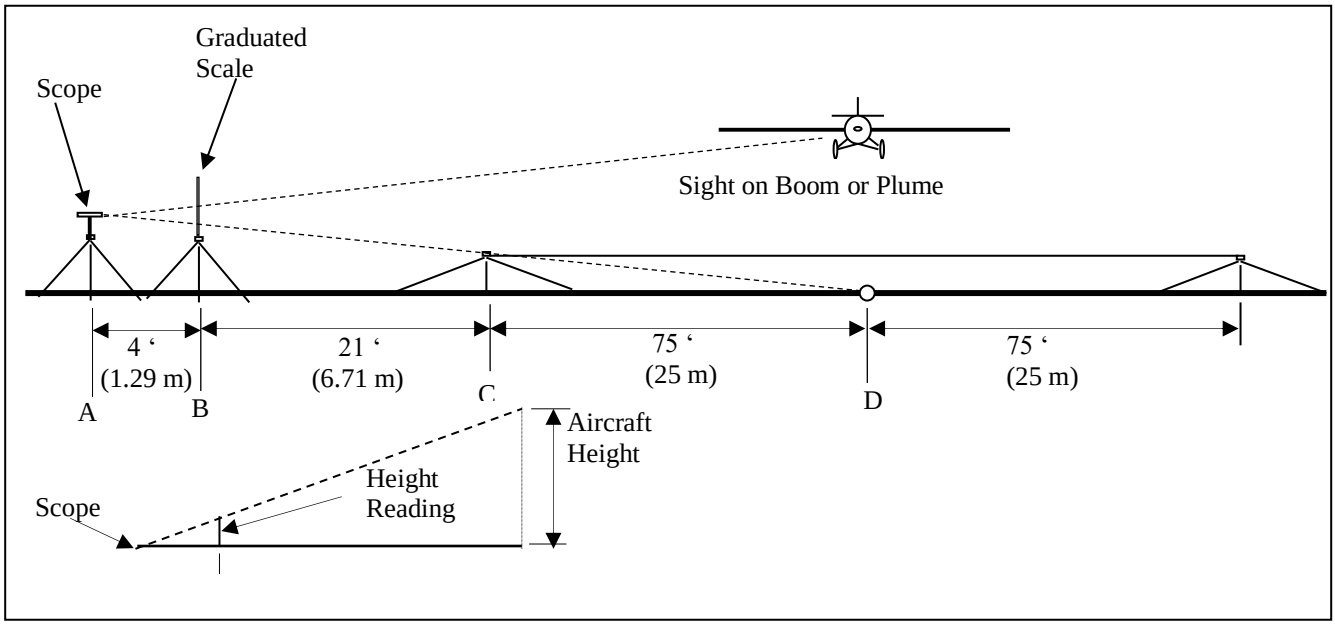


**Figure 10. The Height-Measuring System Geometry**

### *Height Measurement Setup and Operation*

a. (Refer to Figure 11) Extend the legs of the tripod and attach the scope (sight). Adjust the height of the sight to enable sighting through it easily. Check that the scope functions properly by rotating the index knob. This turns the sight **ON** and adjusts the intensity of the indicator. In case there is no indicator when the scope is on, the scope battery is likely discharged, and a replacement battery should be installed. Refer to the sight manual for this operation. (The sight should be turned **OFF** during extended periods of non-use.) Extend the legs of the other tripod and attach the PVC sight-rod scale.

b. Attach the spacer cable to the winder tripod (point "C" on the sketch). The altitude measuring system may be placed on either end of the sample line, but it is recommended that it be placed on the same end as the weather station and the string windup unit. In this way, all of the data-generating equipment will be located at the same end which will facilitate recording by the operator. The 25-ft

(8-m) spacer cable has a loop on each end and either end may be attached to the tripod. Hook the loop into the same snap as is used for the 150' (50-m) cable.

**Figure 11. Height-Measuring System Deployment**

c. Stretch the spacer cable out from the winder tripod in-line with the string. It works best if the free end is pegged down with a tent peg or screwdriver (point "A" in Figure 10). The pegged end of the spacer cable will now be 100 ft (33 m) from the sample line center (the distance from point "A" to point "D"). The tripod with the scope should be placed over the end of the spacer cable so that the face of the scope is directly above the cable end (point "A"). This alignment is not critical - - as long as it can be positioned within about 6 inches (15 cm) from the cable end, no significant errors in height measurement will be noted.

d. There is a bead placed 4 ft (1.29 m) from the end of the setup cable (point "B" in Figure 10). This bead marks the position where the height scale should be positioned.

e. Adjust the height of the sight to enable seeing through it easily with the sight crosshair on the white ball at the center of the sample line. Clamp the vertical tripod shaft in place and do not raise or lower the sight from this point on. Aim the sight at the white ball on the ground located at the center of the sample line (point "D" in Figure 10).

f. Leave the scope at this angle and rotate it so that it points at the sighting rod scale. Slide the vertical adjustment on the scale tripod up or down, as needed, to position it so that the zero point on the sight rod scale is in line with the sight crosshair. Clamp the vertical sight rod and do not change it. The system is now set up and calibrated properly.

g. Aim the sight at the aircraft as it flies by. The crosshair should be aimed at a point (i.e., the center of the spray boom of the aircraft). The aircraft will pass by very quickly and it will take some practice to follow through properly with the crosshair maintained on the aircraft boom. The top edge of the spray plume behind the aircraft will usually leave a good mark to follow.

h. Leave the sight tilt angle at this position and swing the scope around and aim it at the sighting rod scale. Read the altitude directly from the sighting rod scale. The sighting rod scale has increments of 5 Ft (1 m on the metric versions), but the scale can be interpolated to the nearest 1-Ft (1/2 m on the metric version).

i. When the sample line is moved or re-aligned to stay perpendicular with the wind, re-align the setup cable so that it is in line with the new sample line, re-position the tripods and re-calibrate (re-zero) the sighting scale rod as described in steps "e" and "f" above.

j. Remember to turn the sight OFF for extended periods of nonuse.

## SECTION V. GETTING IT GOING AGAIN

If a system problem occurs and the problem cannot be corrected using the information found in this manual, then if the problem can be localized, refer to the troubleshooting sections of the appropriate component manual or manuals. **BEFORE CONTACTING W R K** for assistance, be sure to have all symptoms documented and ***review the appropriate software manuals*** for operation parameters and procedures.

### Expendables List

The following expendable items are required to operate the WRK Pattern Analysis system (Minimum quantities are for an estimated 100 passes):

Red Marker Pens (2)
Green Marker Pens (2)
String (One 2-lb cone per fly-in day)
Painter's Tape
White Trash Bags
Rhodamine WT Fluorescent Dye (20 50-ml bottles)

Data Envelopes (50)
Printer Paper (1 ream)
Height Measuring Scope Battery

Miscellaneous expendable items may be obtained locally or ordered from WRK of Arkansas. Dye may be ordered directly from Milliken & Company, 920 Spartanburg, SC 29303 in bulk. The item identifier is “Darion Bright”.

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