Swath Kit User's Manual

How to use the Swath Kit for Windows to analyze agricultural aircraft spray patterns

Version 3.0.12
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Warranty
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Contents

1. The Basics

1.1 Introduction

The Swath Kit for Windows (SKWin) is a complete agricultural spray aircraft swath pattern analysis and spray system calibration tool. We at Droplet Technologies hope that you will find the equipment will prove to be an invaluable tool in preparing agricultural aircraft so that they perform their spray missions as effectively as possible

Although analyzing spray patterns with a Swath Kit is considerably quicker and easier than using traditional methods, there is still a learning curve that new users have to surmount before they can unleash the full power of this equipment. We recommend that you spend some time with this manual and the equipment itself and become familiar with all the procedures before setting out into the field. If you have any questions about the equipment that aren't covered in this manual, please refer to our web site or call us to get them answered. We hope that you will find using the Swath Kit a very satisfying experience.

1.2 Overview

One of the most difficult jobs in pesticide application is assessing the spray performance of the aircraft used to apply pesticides in agriculture or forestry. Not only are measurements difficult to make, but the time and effort required to get the results has often meant aircraft characterization has been overlooked or, at best, not been practical on-site. This is a serious shortcoming in our present pest management system given the high cost of applying pesticides by air. Solving this problem needs a tool that can make all the required weather and deposit measurements on-site and display results within a short time after the run is made. The tool should also be able to present the results simply to pinpoint problem swath patterns so that adjustments to the spray system configuration can be made quickly, and the aircraft re-tested. An incidental advantage to such a system is its teaching influence, allowing users to associate causes and effects, enabling first-hand learning about the factors which affect deposit patterns.

The Swath Kit is used as one part of a sequence of operations in preparing an aircraft for spraying. Prior to the use of an aircraft in aerial spraying operations, three vital tasks must be accomplished. Firstly, the atomizer type and size must be selected, based on the volume of spray to be applied per acre, the aircraft to be used and the droplet size spectrum required.

Secondly, the aircraft needs to be calibrated to ensure that the correct output is achieved, given the application speed of the aircraft and the distance between successive spray passes of the aircraft (lane separation).

However, the aircraft should not be flown operationally until the shape of the deposit pattern beneath the aircraft has been inspected. This third task is a much more difficult problem if more than just a visual inspection of the deposit shape is to be made. The Swath Kit is primarily employed for this third task, although its mission planning facilities greatly help the performance of the first two tasks as well.

1.3 The Three Major Swath Kit Tasks

The Swath Kit can be divided into 3 parts according to the 3 broad tasks which comprise this next characterization phase of the aircraft set-up.

1.3.1 Trial Detail and Weather Recording

Much spray trial data are lost from the pool of available knowledge about spray performance because insufficient supplemental information is recorded which explains the conditions of the trial. Recording of the spraying system settings, speed and height of the aircraft and conditions of the trial are therefore vital to explain the results.

The weather must also be monitored during a trial to ensure suitable conditions exist for the test. The parameters wind speed, wind direction, temperature and relative humidity are the minimum measurements required to describe the weather. The easiest way to record measure these data is with portable hand-held instruments.

Using a Met Kit weather recording station enables the users to visually display weather data and trends. (The use of the Met Kit is covered in a separate user's manual supplied with the Met Kit package.)

1.3.2 Deposit measurement

After an aircraft has made an application over a card-line, the deposit on the cards must be measured. Deposit can be presented in a number of different ways: volume of spray per unit area, number of droplets per unit area or percentage of the surface area covered with spray. Also of interest are the sizes of the droplets. An image analyzer, a tool which can look at a card and make measurements based on that image, can provide all these measurements.

1.3.3 Pattern Assessment

When all the cards have been measured, the pattern of the deposit beneath the aircraft can be assessed. This is typically the main reason why spray trials are conducted. Solutions to problems in the pattern, such as the elimination of peaks or valleys and assessment of the effective width of the pattern, can be made at this stage in conjunction with the weather and trial detail recordings.

1.4 Notes on Data Handling

Understanding the logic of data storage in the Swath Kit for Windows is critical to its successful use. The Swath Kit program is based on a modular system. These modules can be set up once and used many times over. For example, you may consistently work with a Cessna Ag Truck, which has a standard boom with 50 spaces for nozzles, pump type and N-Number. Give this 'custom aircraft profile' a name and it is now a module ready for use again and again for trials.
The information for a trial (a trial is defined as an aircraft spray run) comes from the following sources:

Aircraft database (installed with the Swath Kit program)
Atomizer database (installed with the Swath Kit program)
Custom Aircraft Profile
Mission Profile
Weather Data (only with Met Kit)

Measured Deposit

1.4.1 Modular Data Entry

The modular system used with SKWin means that there has to be some information preparation before a trial starts. However, the advantages of such a system are far less data entry during the operation of the field trial – where time really counts. It also enables trial data to be comprehensively recorded and simplifies retrieval from the database.

1.4.2 Weather Recording (Met Kit only)

A weather data file is an important part of the trial data. The weather system can be used to record weather continuously throughout a series of spray trials, or started and stopped in sequence with actual spray runs. One operational procedure is essential whichever recording method is used – recording the exact time that the aircraft flies over the card line so that the relevant part of the weather data file is referenced during the spray trial analysis phase.

2. Program Set-up

2.1 Preparation for Creating a Trial

2.1.1 Building Blocks

The Swath Kit program uses a modular construction made up of 'building blocks' of data. In order to set-up a trial, you must first do some information preparation. Once the preparation is completed, you will be able to put together new trials easily from existing information.

2.1.2 Definitions

Here is a description of each of the different building blocks used to make up Trial information.

- **Aircraft:** Make and model of aircraft, supplied in an existing database in the Swath Kit for Windows software. Not editable by user

- **Custom Aircraft:** An Aircraft from the database which has been customized by the user by entering the tail number, pump type, and spray boom details.

- **Mission:** A Custom Aircraft prepared for a specific application by defining the volume rate, atomizers, lane separation and target airspeed.

- **Trial:** An individual run in a series for a particular Mission. The Trial data contains Mission data, plus the deposit data and conditions of each specific run.

Figure 3.1 shows how the information used to form the final Trial profile is assembled. The basic principle is to progressively build up a Trial from the different building blocks defined above. Some of the building blocks come from built-in databases, such as Aircraft and Atomizers. Some come from databases you will create, such as the Material database.

Later you will add some information yourself, such as the aircraft height and speed, the orientation of the card line and deposit data as measured by the Blue Box image analyzer (and weather data as recorded by the Met Kit if you have one).

As you can see from figure 2.1, there is a sequence of four stages during which the final trial is built up. Although it may seem like hard work initially, because the data in a profile is comprehensive, subsequent spray trials can be easily performed because you can reuse your Mission and Custom Aircraft building blocks.

Figure 2.1

The different stages of building a Trial. The parameters in bold type are added at each stage

AIRCRAFT	CUSTOM AIRCRAFT	MISSION	TRIAL
	Aircraft	Aircraft	Aircraft
	N-Number	N-Number	N-Number
	Pump Type	Pump Type	Pump Type
	Boom & Nozzle	Boom & Nozzle	Boom & Nozzle
	Locations	Locations	Locations
		Spray Volume	Spray Volume
		Rate	Rate
		Lane Separation	Lane Separation
		Target Airspeed	Target Airspeed
		Atomizer & settings	Atomizer & settings
			Measured aircraft speed & height
			Spray Material
			Weather Data
			Deposit Data
			Notes

SEQUENCE

2.1.3 Sequence of Events

Here is the sequence of events that takes place when you build a trial. The SKWin database contains a number of examples that you can use to construct trial profiles before running some trials for real.

1. Create a *custom aircraft profile* for the aircraft that you intend to calibrate and characterize by selecting the *aircraft type* from the aircraft database. Customize the aircraft by entering its tail number and pump type. The number of nozzle locations that may be used is also entered (measure these from the centerline of the aircraft). Give your custom aircraft profile a name: E.g. *N431EQ: Boom 1*. Subsequently when you use that aircraft/boom combination, you just pull it out from the database without any data entry or editing.

2. Build a *Mission Profile.* Select your *custom aircraft profile*, combine it with *atomizer type* (from the atomizer database), desired volume rate, lane separation and target application airspeed to make up a *mission.* Give your mission profile a descriptive name:
   E.g. *N431EQ: Boom 1 - AU5000.-10L/ha*

3. Create a material description that gives information about the spray mixture. This description will contain information about the spread factor, active ingredient concentration and the units you want to see your data displayed

in. Some standard materials will be provided with the SKWin database and can be directly selected.

4. Finally, use the *mission profile* to build a trial. As you perform individual runs (trials), the data in the profile provides most of the information required for a trial. Fill out remaining information that specifically describes your trial (such as estimated aircraft height and airspeed).

After these 4 steps you can run one trial or a series of trials (runs). After such a series, you will have a set of cards corresponding to each trial. Measuring the deposit on the cards will complete the data for each trial.

Each of these stages are discussed in detail below.

2.1.4 Performing a quick trial with minimum preparation

As builders of the Swath Kit system, we have tried to make it an efficient recorder of all the information associated with a spray trial. However, there may be some instances where you may need a quick pattern analysis to be made at very short notice. So the question is: *How much of the required data input do I need to get a set of cards analyzed for a pattern?*

It only takes two or three minutes to set up a custom aircraft and a mission. To save time, you can select the type of nozzle you need, but you don't need to enter the correct number or spacing (e.g. you can select Spraying Systems Flat Fan 8003, and leave the default number at 2). Then create a new trial, plugging in the mission you just created, enter the name of the trial, the time of the aircraft overflight (very important if you have a Met Kit weather spool file) and the center card of the line. You can then press the measure tab, select the material sprayed (you cannot make any short cuts here – create the material profile if it doesn't exist) and read the cards.

The caveat here is that you will not be able to use the calibration assistant routine (see below) section 2.3.2), nor run the simulation and of course there will be no accurate record of the aircraft set-up. We encourage you to use the full data entry process as a standard operating procedure.

2.2 Creating Custom Aircraft Profiles

Although two examples of the same aircraft will share many common characteristics, their spray systems may be very different. The Swath Kit uses custom aircraft profiles to identify individually configured aircraft. Such a profile consists of the following elements:

1. Aircraft type
2. N-number (or other national registration)
3. Pump type
4. A listing of nozzle mounting locations.

Note that one aircraft may have several spray booms - in such a case, create a custom aircraft profile for each combination of aircraft and boom that you will be testing.

When you have selected a new custom aircraft, there is an Edit button (labeled '…') which enables you to import an existing custom aircraft to use as a template if you so wish. This avoids having to repeat the entry of data that may already exist when you want to create a new custom aircraft profile that is similar to an existing one.

There is no limit for the number of profiles you can have. Save the aircraft profile under a name which you can easily identify in the future - you can use up to 64 characters, numbers and spaces.

Figure 2.2

Menu sequence for creating a new Custom Aircraft

To create a Custom Aircraft profile, click on the **Database** menu option, and select **Custom Aircraft, New**. NOTE: The tabbed sheet will permit editing on Aircraft and Atomizer Layout only, because these will describe a unique aircraft and boom combination.

Enter a description for your custom aircraft: e.g. *'N431EQ: Boom 1'*. Use the pull-down list to select the aircraft Make & Model from the aircraft database that came with the Swath Kit. Fill out the N-Number and pump type. Finally, click on the Atomizer Layout tab and fill out nozzle locations. Once saved, this Custom Aircraft is available for use in Missions.

If you cannot find the correct Make & Model of the aircraft – use the closest type. This information is only descriptive; it does not affect the calculations of the Swath Kit.

2.2.1 Atomizer Locations

When you create a *custom aircraft,* you determine where the atomizers will be located. It is the equivalent of buying a stock ag plane and hanging your own boom on it. Your boom on your aircraft defines the nozzle locations on your custom ag plane.

These atomizer location data are included in the Swath Kit set-up to make a record of the exact spray system configuration that can be referenced in the future. It is possible to analyze spray patterns with the Swath Kit without entering these data (section **Error! Reference source not found.**) but the ability to use all the integrated tools will be limited.

Referring to Figure 2.3. the left column defines the side of the aircraft as viewed from the pilot's seat. Click on a nozzle row then double click to change between Left and Right. The horizontal distance represents the position of the nozzle in relation to the aircraft's center line. The vertical displacement is the distance from the airfoil trailing edge (or from the rotor plane for helicopters). Positive values represent positions below the trailing edge of the wing, negative ones above the wing. Helicopter booms are always mounted below the rotor blade and therefore always have a positive value.

You can Insert a nozzle at the cursor location using the Insert button, or delete the current nozzle location with the Delete button. The Sort button will re-list the nozzle locations on the basis of horizontal position on the boom.

Each nozzle location is sequentially numbered in the left column to help you locate position on the boom: 1 is the pilot's far left nozzle. The total number of nozzles entered is also shown at the right of the window.

Note: Insert and Delete will not be available when Editing a Custom Aircraft that has already been used with a Mission.

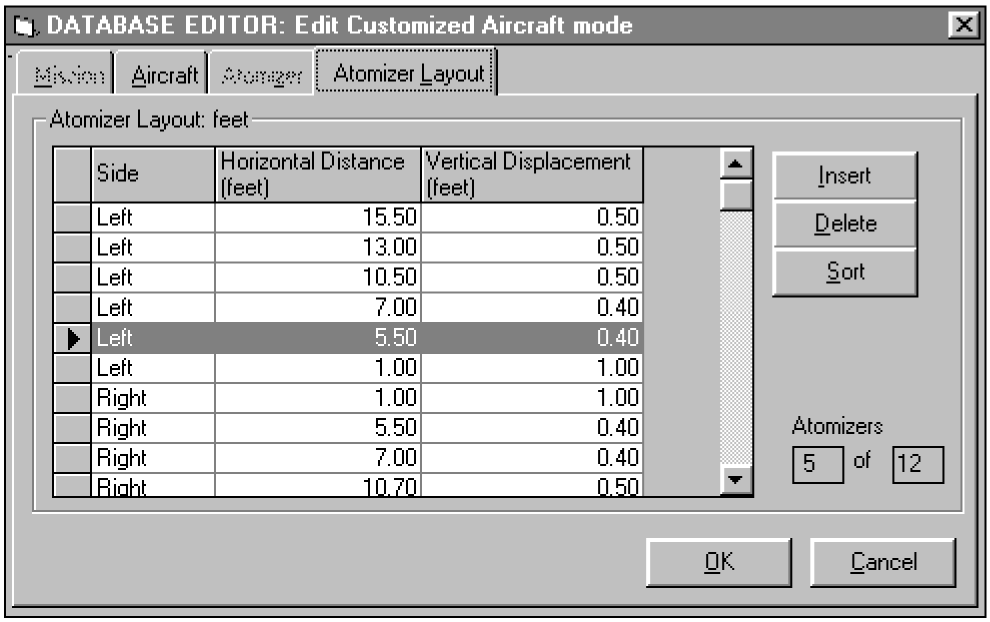


Figure 2.3

Atomizer layout editing screen showing horizontal and vertical positions of atomizers on left and right wings. The 5th atomizer out of a total of 12 is being edited.

If you select metric units as the default measuring system, all dimensions will be in meters in the table.

2.2.2 Aircraft & Atomizers not included in the database

Although the Swath Kit comes with a comprehensive database of aircraft and atomizers, it is possible that you will encounter situations where either the aircraft or atomizer that you are using is not included in the database. Contact Droplet Technologies to obtain an update which can be entered into the database (Sections 6.1 and 6.2). However, to keep working select an aircraft or nozzle that most closely matches one that already is in the database, and make a note under the Notepad tab describing the mismatch.

2.2.3 Editing a Custom Aircraft

A Custom Aircraft may be used in one or more Missions, hence in one or more Trials. Changes can be made to the Custom Aircraft profile by choosing **Database, Custom Aircraft** and **Edit** whether it has been used or not.

Note: Once you have defined (and used) a custom aircraft, it is a good idea to refrain from modifying that custom aircraft profile, particularly if you have exported the data.

If the Custom Aircraft has already been used in a Mission or Trial then changes will be seen next time a Trial is opened. If a trial has been exported prior to the edit then the trials will appear to contain different Custom Aircraft with the same profile names. Edited aircraft are stored internally in the database with new unique codes.

Note: The Edit feature is only available when no Trials are currently open. Close all Trials before editing.

Note: Insert and Delete will not work when the Custom Aircraft being edited has already been used in a Trial because the nozzle On/Off data would be lost.

2.2.4 Deleting Custom Aircraft

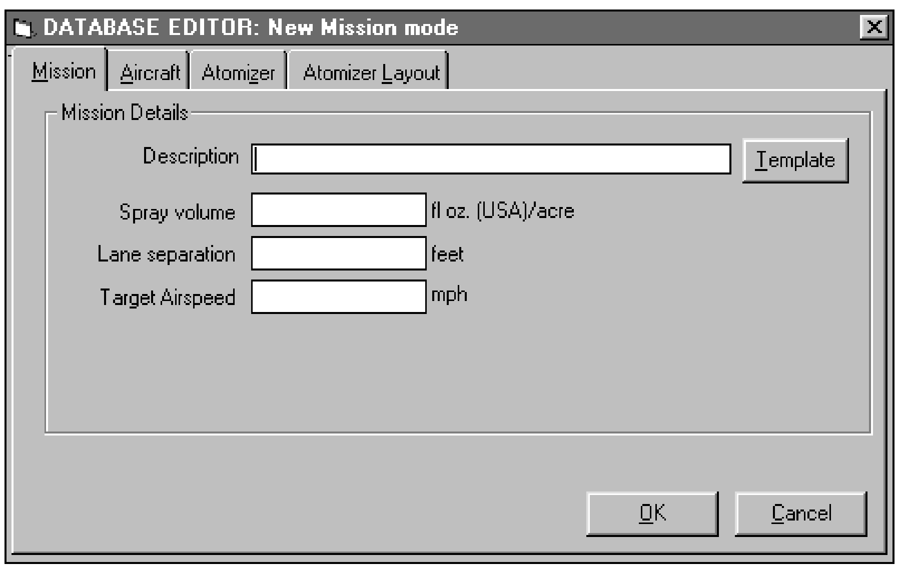
A Custom Aircraft can be deleted from the database provided it is not already being used in Mission. Choose Database, Custom Aircraft and Delete to select from a list of unused Custom Aircraft.

2.3 Creating Mission Profiles

A Mission Profile represents the application configuration that you want to test – it's 'how you want to spray'. The Mission Profile is used as the main building block of Trial information.
To create a mission profile, click on the Database menu option, and select Mission, New. The profile has 4 tabs which identify the different components of a mission:

Figure 2.4

The 4 tab screen you get when you select a New Mission from the Database menu



The four tabs are as follows:

1. Mission: The mission description plus added mission parameters - Spray volume, Lane Separation, and Target Airspeed. Enter the details in the spaces provided and be careful to observe the correct units.

2. Aircraft: Select a Custom Aircraft Profile that has already been created. You cannot edit the contents of the Custom Aircraft tab.

3. Atomizer: Select the Atomizer by manufacturer and type from the database.

4. Atomizer layout: Use this tab only to visually confirm the atomizer location points. Note that the atomizer layout can only be edited from the Custom Aircraft editing screen. The atomizer locations shown reflect the Custom Aircraft chosen on the Aircraft tab.

Once you have input these parameters, save the mission profile under a name which you can easily identify in the future - you can use up to 64 characters, numbers and spaces. Press the Update button when you have finished.

2.3.1 Atomizer Selection

Choose from the list of atomizers presented in the drop-down list.
The Swath Kit for Windows contains a predefined list of atomizers that can be employed in your Trial. Each atomizer is related to data describing flow rate characteristics. You must choose the correct atomizer so that SKWin can calculate the flow in the aircraft's spray system.

The flow rate calculations are performed on the basis of a well known relationship between pressure and flow using the manufacturer's data for water as the baseline. If the exact manufacturer's nozzle is not present then look for a similar size and design from a different manufacturer. Atomizers currently can only be added to the database by the user by downloading update information (see Importing Atomizers) from the Swath Kit World Wide Web site, or from a diskette supplied by the Droplet Technologies. You cannot add nozzles in the same way that you can add custom aircraft for example.

If you need help in selecting the correct atomizer, use the Calibration Assistant .

2.3.2 Calibration Assistant

When building up a Mission Profile, you have the help of the Calibration Assistant. The Calibration Assistant will help you select the nozzle type, pressure and number of nozzles for a spray mission. To be effective, the Calibration Assistant will need to know your required application rate, lane separation and airspeed. Fill these out on the Mission Tab.

To start the Calibration Assistant, Press the Assistant button on the Atomizer tab.

Next to the pull-down box of Atomizers you will see a check box labeled OK. When the selected nozzle is suitable for the current Mission (i.e. it can supply the flow rate) the box is marked with a check. Use this to get an idea of the range of nozzles that you could use for a Mission. Select a specific nozzle from the range of OK nozzles presented which will match the droplet size characteristics desired.

Pick from the smaller orifice size for fine droplets and large orifice size for bigger droplets. Note that the limits that define an atomizer's capability are the maximum and minimum pressure for the atomizer and the aircraft, and the predefined relationship between pressure and flow for any given atomizer. Notice also that the number of atomizers open will also affect which atomizer you could use. If you decrease the number of atomizers open then the output per atomizer must increase to maintain throughput.

Figure 2.5

Calibration Assistant editing screen

The lower half of the window shows the flow rate requirements based on what application volume you've chosen, how fast you intend to fly and what lane separation you are calibrating for (see Mission tab). It also tells you the equivalent flow per nozzle that is required. It then tells you what the expected flow per nozzle is, given the specific type of nozzle chosen, the number that are open, and the current pressure. Use these numbers to *manually* adjust the nozzle setup to match required flow to expected flow. Increase or decrease pressure, or change nozzle, to manage expected flow per nozzle; increase or decrease nozzle number to change required flow per nozzle. If you want the program to try and make a selection for you, use the built-in Calibration Assistant program.

To use the Calibration Assistant:

1. Ensure the Mission parameters and Aircraft have been entered.
2. Press the Assistant button.
3. Select the estimated number of nozzles that you wish to have open.
4. Select the nozzle (remember, the nozzles with the check mark are capable of meeting your needs).
5. Either manually adjust the pressure and nozzle number to match the desired flow rate with the flow rate required by the Mission settings, or press the *Suggest Pressure* button to automatically select a pressure and nozzle number. The Suggest Pressure button will first manipulate pressure then, if necessary, will change the number of open nozzles in an attempt to bring the flow rate within 3% of the desired flow. If no combination of pressure and nozzle number can be found to fit the required flow, a Suggestions window will be shown.

Press OK when the Mission Profile has been completed.
There are two more buttons on the screen which help you with your task.

2.3.2.1 Lock and Release

The Pressure and Atomizers Open fields are limited by manufacturers limits and typical limits for the aircraft, i.e. you can't hang 50 Micronairs on an Agtruck (and expect it to fly) and you can't expect to use 300 psi through an 8002 flat fan. However, there may be times when you want to either release the limits and explore flow rates, or limit the conditions further. For example, you may wish to let pressure increase beyond the preset upper limits, or you may want to fix the number of atomizers at fewer than the maximum positions on the boom. Use the Lock and Release check box to accomplish this.

2.3.2.2 Print Calibration Sheet

When you have configured the application conditions correctly you may print out a calibration sheet that will lead you through a likely procedure to verify the application settings. The recommendation given depends on the type of pump the aircraft has (see Creating Custom Aircraft Profiles) so ensure that the pump type is correctly set.

By measuring the actual flow from the aircraft you are able to ensure that the application rate is correct. The Calibration Assistant's predicted flows may vary from actual for the following reasons:

1. Flow predictions are based on the manufacturers flow equations. These are often calculated values, not measured.
2. Flow rate depends on the physical properties of the spray solution. Viscous solutions will have very different flow characteristics compared to the water used during manufacturer's testing.
3. Pressures given in manufacturer's literature are taken at the nozzle whereas boom pressures are often taken at one position and not at the nozzle.

Use the printout to both guide you on the procedure for calibration, as well as record information for adjusting the output.

2.3.3 Editing a Mission

A Mission may be used in one or more Trials. Changes can be made to the Mission by choosing **Database, Mission** and **Edit** whether it has been used or not. If the Mission has already been used in a Trial then changes will be seen next time a Trial is opened. If a trial has been exported prior to the edit then the trials will effectively contain different Missions with the same names (not good!); edited Missions are stored internally with new codes.

Once you have defined (and tested) a Mission profile, it is a good idea to refrain from modifying that profile. Just as with Custom Aircraft profiles, you do not want to have several different identically named profiles which contain different set-up information.

2.3.4 Deleting Mission

A Mission can be deleted from the database providing it is not already being used in a Trial. Choose Database, Mission and Delete to and select from the list of unused Custom Aircraft.

2.4 Materials

Material profiles store information about spray material/target combinations and the units used in their graphic displays. They are created by users and there is no limit on the number of profiles you may have. The material used in a trial can be changed freely after the spray cards are read, giving the user great freedom in interpreting the data.

For example, a particular material may exist in three different profiles; one profile may have the deposit data shown as oz/acre, a second may display it as L/ha and the third may show active ingredient in grams/acre.

A second example could be where you are spraying a material whose spread factor is greatly affected by temperature and humidity. The three material profiles may be named 'Spraymix XX – wet and cool', 'Spraymix XX – temperate' and 'Spraymix XX – hot and dry'. In each case you may want to display the deposit using the same units but you would use a different spread factor for each profile.

2.4.1 Creating & Editing Materials

To create a new material or edit an existing one, Go the Database | Material pull-down menu. The following boxes (fields) will be available for editing.

Description (64 characters)
Enter a suitable name. If necessary describe the collector material too. 'Water' is too vague. 'Water on water-sensitive cards' is much better.

Conversion Factor and Units
The conversion factor is the volume or amount of active ingredient per liter of spray. If you want the data to be in liters, then enter 1 in the box (there is 1 liter of liquid in 1 liter!). If you want the data to be in fl oz, then enter 33.8 (there are 33.8 fl oz in a liter). How about US gallons? Put 0.264 (that's right, there is 0.264 US gallon in a liter). The area units will be automatically inserted for you according to your choice of units. US/Imperial default to acres, whereas Metric units default to hectares. If you are using User-defined units, you have a wide range of choices – even expressing data as nanoliters/sq. cm if desired.

An alternative to expressing data as volume rate (volume per area) is the description of data as active ingredient per unit area. The Swath Kit uses the active ingredient concentration in the spray mix to calculate material recovery.

The units you choose depend on the way you want active ingredient per unit area to be reported. For example, if you are applying 30 oz of a Product X in 5 gallons of total spray per acre then the conversion factor will be 1.583 oz per liter. (30 oz ÷ (5 × 3.785)). The units will be oz Product X.

Conversion units is a descriptive term which will appear in all your graphs and data files. In the above Product X example you would write 'oz Product X' in the Conversion Units field. The data will be shown as oz Product X/ac if you choose US units for display.

Spread Factor
See below for further discussion of spread factors.

2.4.2 Spread Factors

The spread factor is a polynomial formula describing the relationship between stain diameter and airborne droplet diameter. It is the means by which the Swath Kit program interprets stains on deposit cards. Unless it has a very dry consistency, a droplet will spread out when it hits the card. Knowing the degree of spread and how it varies with droplet size enables the calculation of how much liquid fell onto the targets. Because of its crucial role in converting stain area dimensions to volume data, it is the most common source of error in image analytical assessments of spray deposits. The polynomial relationship takes the following form:

Droplet Diameter = ß0 + (ß1 x Stain Diameter) + (ß2 x Stain Diameter^2)
(where ß0, ß1 and ß2 are constants).

The square term allows for increased (or decreased) change in spread factor with increased droplet size. A formula where ß0=0 and ß2=0 and a value for ß1 will produce a linear relationship between droplet size and spread factor. Note that in some scientific literature the inverse notation is used; e.g. a material whose droplets spread to double the diameter will be described as having a spread factor of 2. In Swath Kit notation such a spread factor will be described as having a linear spread factor of 0.5.

To delete a Material, use Next or Previous to display the Material and press Delete.

Note: You will not be permitted to edit or delete a record that has already been used. You must first delete the Trial then delete the unused Material.

2.5 Creating Trials

A new Trial is created for every spray run. Each trial holds information specific to a single trial, as well as the building blocks of Mission and Custom Aircraft used to build that trial.

When you are making repeated or replicate runs, then you simply use the Replicate button to create a replicate of an existing trial.

Sequence of steps to Set-up a New Trial:

1. Click on the blank sheet icon to get a blank trial screen, or select File and New
2. Plug in a Mission on the Mission tab
3. Fill out the relevant details on the Trial screen
4. Turn off any nozzles you are not using on the aircraft (On/Off button on the Mission screen)

   SPRAY TRIAL TAKES PLACE AT THIS STAGE

5. Enter weather data (Weather tab)
6. Add any notes (Notepad tab)
7. Press Update button to save data

   These steps are described in detail in the following sections.

2.5.1 Creating & Editing a New Trial

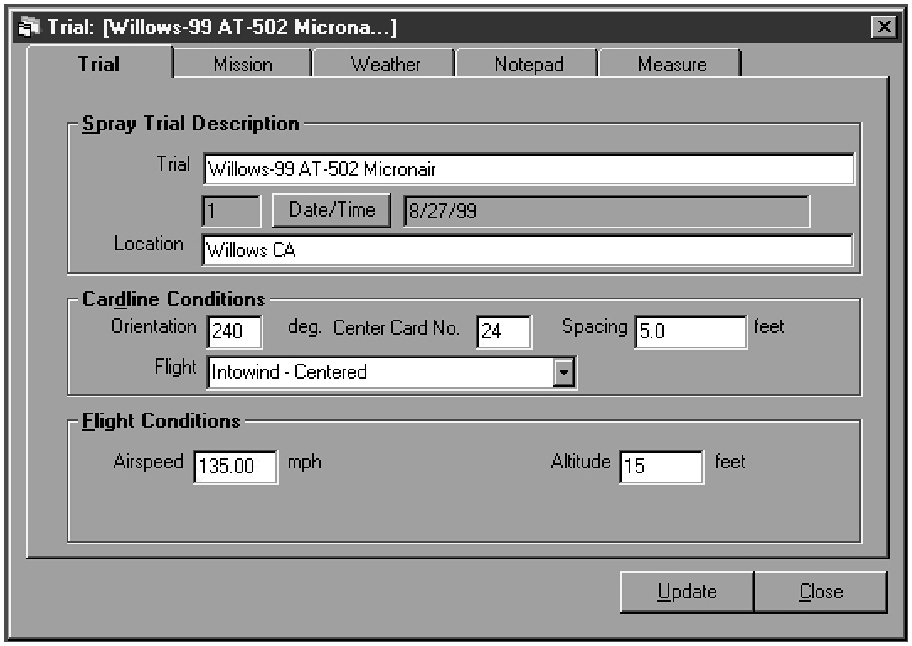
Click on the blank sheet icon to get a blank trial screen, or select File and New.

Once you have created a blank trial, enter a name for your trial in the Spray Trial Description area. Use up to 64 characters. Be clever here and you'll make life easier down the road. For example, if you intend to run a series of tests at an airfield called Willows, consider the following format: WILLOWS 99: Config-01, then WILLOWS 99: Config-02.

Because listings of Trials are often sorted by their name this strategy will ensure all your WILLOWS 99 data appear together. The same trial name can be used for several replicates, which differ from each other only by their replicate number. Pressing the replicate button will increment the replicate number, but will keep the trial name the same. Figure 2.6 shows details of the trial screen.

Figure 2.6

Trial Information details. These data can be entered after the actual trial takes place. Make sure that you have recorded all the required details in your notebook.



Before the trial, you can fill out the other information on the Trial tab: Trial location and cardline conditions. The Date/Time and Aircraft speed and height will be entered after the trial. The date and time refer to the time when the aircraft flew over the cardline. This time should be recorded manually by the person supervising the spray trials.

It is crucial that your weather data recording device is synchronized with the timepiece you use for recording the time of aircraft over-flight. This is the only link with the two sets of data (the time recorded on the trial tab, and the weather data spool file). Remember when you travel to different time zones to reset the times in your computers to local time!

Each new Trial requires a Mission to be attached. The Mission will add the information needed to describe what aircraft, atomizer and basic application conditions were targeted for a Trial. The window is divided into two areas, Mission Description and Atomizer Conditions. By pressing the Select button on the Mission tab of a Trial you will be presented with a list of the available Missions. For a Mission to appear it must first have been added to the database (see Creating Mission Profiles, section 2.3). Each column can be sorted by clicking on the field name (very useful when there are many missions in the database).

Double click on the mission profile which pertains to the present trial. All the boxes of the mission will then be filled. Note that the mission description’s fields are not editable at this level – you must use existing Mission Profiles.

Since the interpretation of deposit data depends on an accurate presentation of the

Mission – the flow rate of your spray system and nature of the atomizers – SKWin will not permit the selection of a new Mission *after* deposit data have been read.

2.5.2 Cardline Conditions

The cardline conditions refer to the orientation, centerline and spacing of the cards. The flight conditions are the airspeed of the aircraft and height above ground. The Flight field refers to the way the aircraft flew over the cards. There are 4 options:

- Directly into wind over the centerline.
- Into wind, but laterally offset to allow for slight crosswind.
- Crosswind.
- ‘Field’ - multiple runs sprayed as if spraying an actual field.

2.5.3 Field Setting: Multiple Spray Runs

One of the Cardline Condition options is the Field setting. This is performed by flying several passes over the cards with a particular lane separation.

2.5.4 Nozzle On/Off

By Selecting a Mission for a Trial you will be telling the Swath Kit what atomizers are being used and their locations on the boom. However, during the course of analyzing an aircraft’s spray pattern it may be necessary to turn some of these nozzle locations on or off to avoid peaks and troughs in the spray pattern. Each Trial is recorded with its own nozzle On/Off data that record exactly what nozzles were used out the total nozzles available.

Press the [On/Off] button on the Mission tab of the Trial. The screen will show the available nozzle locations (non-editable) and a graphic showing whether the nozzle is on or off. Select each nozzle with a click of the mouse; double click it to turn it on or off.

Note: If you are using a mission with rotary atomizers you will also be able to enter unique rpm and VRU settings for each individual nozzle in the ‘On/Off’ screen.

2.5.5 Notepad

Use the Notepad tab to record any Trial specific notes. This is a useful place to record any observations you may have made during the trial. E.g. ‘The pilot cut off the spray too early’, ‘Atmosphere becoming unstable - fair weather cumulus beginning to form’, ‘Clear sky, bright sun’ etc. Remember that what seems a piece of trivia can be an important fact when you recover the data a year after performing the trials. So remember - transcribe your field notes to the notepad!

The Measure tab is used to setup conditions for Image Analysis.

Note that data entered into the Trial tabs is not immediately entered into the database. Press the Update button to update the database with new entries.

2.5.6 Replicate

Replication allows you to perform more than one run using the same inputs for Mission and Custom Aircraft. Each replicate Trial will still have its own deposit, its own weather, and its own trials specific setup like cardline orientation. Using replicates permits you to easily link information from common treatments and prepares you for another spray run with a single button click.

2.6 Adding Weather Data (Met Kit owners only)

During field trials, the weather station is set up to continuously record a weather spool file for as long as the aircraft is performing spray runs. Record the time accurately when the aircraft flies over the card line for each of the runs. Weather files are associated with trials by the date and time of the run.

To associate weather with a trial go to the Weather tab and press the Attach button. The program will search the database for weather information already loaded that matches the date and time of your spray run. If found, you'll be prompted to accept or reject the finding: the original file name is presented as the source of the data.

If no data are found, you will be prompted for the file name and subdirectory of a weather spool file. Use the browse button to locate the appropriate SPL file. These data will then be imported and made available for future use within the Swath Kit. The summary information displayed depends on the available weather data and the size of the Weather Window. Increase or decrease the time with the spin arrows as required.

If you did not record any weather data, you may edit the Summary Weather Statistics boxes, and enter estimated (or measured) averages for the weather conditions.

2.6.1 Weather Summary Statistics

The Weather tab of a Trial contains a summary of the weather data for each of four parameters:

1. **Average Wind Speed:**
   This is a actually a resultant wind speed, not a simple average, formed by dividing the horizontal distance that a droplet would be displaced from it's point of release after a defined window of time, by the period of that time window (see Weather Window) This figure differs from a simple arithmetic average of the wind speeds because it considers not only the strength of the wind but also its direction at each two second interval. It's is the combination of these two effects that determine how far a droplet will travel in a given time period, thus making it a more representative measure of 'average' speed of the horizontal winds moving a spray cloud.

2. **Average Wind Direction:**
   This describes the resultant wind direction, the overall wind direction over the Weather Window of the spray trial. It differs from a simple arithmetic mean of the directions because it is formed from a combination of wind direction and wind speed information. Thus, a wind direction of 180 degrees at 10 MPH is given more influence than a different direction at 2 MPH. This is a more representative statistic because it describes the overall direction that a droplet cloud would drift after ten minutes, something an arithmetic mean does not do.

3. **Average Temperature:**
   A simple average of the temperature over the Weather Window recording period.

4. **Average Humidity:**
   A simple average of the relative humidity over the Weather Window recording period.

2.6.2 Weather Window

The weather window is the size of the data window used for summarizing and displaying weather data, in minutes. The minimum is two minutes and the maximum is limited to the data available. Use the spin buttons to increase or decrease the size of the window. As the size is changed the summary information will be recalculated to reflect the new averages. The window should be long enough to adequately describe the window of time needed to deposit most of your spray – 5 minutes should be adequate for most sprays.

3. Image Analysis of Spray Deposits

3.1 Image Analysis Basics

Before analyzing your first set of cards, it is a good idea to review the principles of how the Swath Kit uses image analysis to obtain data about a swath pattern from a set of spray cards. The principles touched on in this paragraph are all discussed in greater depth in other sections of this chapter.

The deposit stains formed by the droplets have to exhibit a contrast that can be picked up by the TV camera / frame-grabber combination. The image is fed to the SKWin program, which on the basis of calibration values decides what part of the image was actually caused by droplets, and rejects the remainder as background. The program then calculates the area of each stain, transforms its area to a circular form and calculates its diameter. It then applies a spread factor to account for the spreading of a round droplet to form a larger stain, and calculates the volume of the droplet that caused the stain. It proceeds to do that for every stain measured (sometimes tens of thousands in each trial).

The program keeps a running total of the volume of all the droplets it has measured, the number of droplets and surface area covered by the stains. To make calculation of droplet sizes possible, the program distributes the range of droplet sizes into 20 <u>bin classes,</u> which can then be used for statistical analysis. There is a default bin class distribution, but any progressive sequence of numbers can be used to set the upper and lower limits of the size class bins.

Although data are binned, the program keeps a record of every droplet measured (unless pre-filtering was used – see section 3.5). These data can be used to recalculate the readings of the cardline if, for example a new spread factor is applied, or a new filter setting is applied.

The swath pattern is built up from individual card data based on three parameters – volume (or mass) per unit area, droplet density or proportion of area covered. The program takes the same swath pattern, and repeatedly adds it, staggering successive patterns according to the aircraft's desired lane separation. The graphic display and statistics reflect the choice of swath orientation (racetrack or to-and-from flight) and lane separation.

3.2 Adding a Material to a Trial

Before reading cards, you have to select a material that will enable the Swath Kit program to convert the stain diameters to droplet diameters (using a spread factor – section 2.4.2) and display the deposit in the desired units. If the material profile does not exist, you may create it at this stage (section 2.4.1).

If you already have a Trial in which cards have been read then you can change the Material by pressing the Select button on the Measure tab.

3.3 Image Analysis Preliminaries

3.3.1 Bin Size Selection

When the image analyzer analyzes a droplet stain, it calculates the droplet diameter and puts the droplet into a size-class category (bin). Most agricultural deposits are well accounted for by the default size class (that is the one that comes standard with the Swath Kit program). There are 20 so-called bin sizes.

All bin size series must become progressively larger, but the increase between adjacent bin sizes may vary by linear increments or logarithmically. The default series is the ‘root-two progression’, where the boundary sizes increase by the square root of 2 (1.414). So the first boundary size may be 10 to 14.14 μm (10 × 1.414), the next 14.15 to 19.9 9μm (14.14 × 1.414) etc.

Alternatively, you may have a bin size that increases arithmetically, e.g. 20 – 40 μm, 41 – 60 μm, 61 – 80 μm etc.

If you intend to move away from the default class distribution, choose a size class carefully to ensure that the expected range of droplet sizes can be accommodated by the range of size bins. If you are uncertain, select the **Default: Root-two progression of 10 to 7239.7 um** option that can accept most agricultural droplet sizes.

To choose the desired bin size file, select the **Tools** and **Options** menu, then select the **Measure** tab. Choose the bin size class with the arrow. Pressing the View button displays the 20 bin classes of the desired series.

3.3.2 Importing Size Class Files (Advanced Topic)

If the existing size class files do not meet your requirements, then you can create a file with your desired bin size classes with a text editor. An example of the format is given below. The file consists of 21 lines which define the size classes. The first line (record) defines the bottom value of the first (smallest) bin, and the last line defines the <u>upper</u> value of the largest bin. Each line has 4 comma-delimited fields.

Field 1: A 6 letter unique name
Field 2: Record number (0-20)
Field 3: A short description of the mathematical series
Field 4: Numerical value to a maximum of 2 decimal places

"CLAMIL", 0, "LOG RANGE TO 1000 microns", 10
"CLAMIL", 1, "LOG RANGE TO 1000 microns", 12.59
"CLAMIL", 2, "LOG RANGE TO 1000 microns", 15.85
"CLAMIL", 3, "LOG RANGE TO 1000 microns", 19.95
"CLAMIL", 4, "LOG RANGE TO 1000 microns", 25.12
"CLAMIL", 5, "LOG RANGE TO 1000 microns", 31.63
"CLAMIL", 6, "LOG RANGE TO 1000 microns", 39.82
"CLAMIL", 7, "LOG RANGE TO 1000 microns", 50.14
"CLAMIL", 8, "LOG RANGE TO 1000 microns", 63.13
"CLAMIL", 9, "LOG RANGE TO 1000 microns", 79.47
"CLAMIL", 10, "LOG RANGE TO 1000 microns", 100.05
"CLAMIL", 11, "LOG RANGE TO 1000 microns", 125.97
"CLAMIL", 12, "LOG RANGE TO 1000 microns", 158.60
"CLAMIL", 13, "LOG RANGE TO 1000 microns", 199.68

"CLAMIL", 14, "LOG RANGE TO 1000 microns", 251.40
"CLAMIL", 15, "LOG RANGE TO 1000 microns", 316.51
"CLAMIL", 16, "LOG RANGE TO 1000 microns", 398.48
"CLAMIL", 17, "LOG RANGE TO 1000 microns", 501.69
"CLAMIL", 18, "LOG RANGE TO 1000 microns", 631.63
"CLAMIL", 19, "LOG RANGE TO 1000 microns", 795.22
"CLAMIL", 20, "LOG RANGE TO 1000 microns", 1001.18

This file should be created with a text editor (NOT word processor) and should have a hard carriage return at the end of each line (not wrap-round text).

3.3.3 Image Analysis Hardware

The **Tools | Options | Measure** tab enables you to choose the appropriate data input hardware that you are using. As of September 1999 the only alternative input to the MRT Videoport professional frame grabber is the Sartorius electronic balance which gives a serial data stream input to the laptop's COM port.

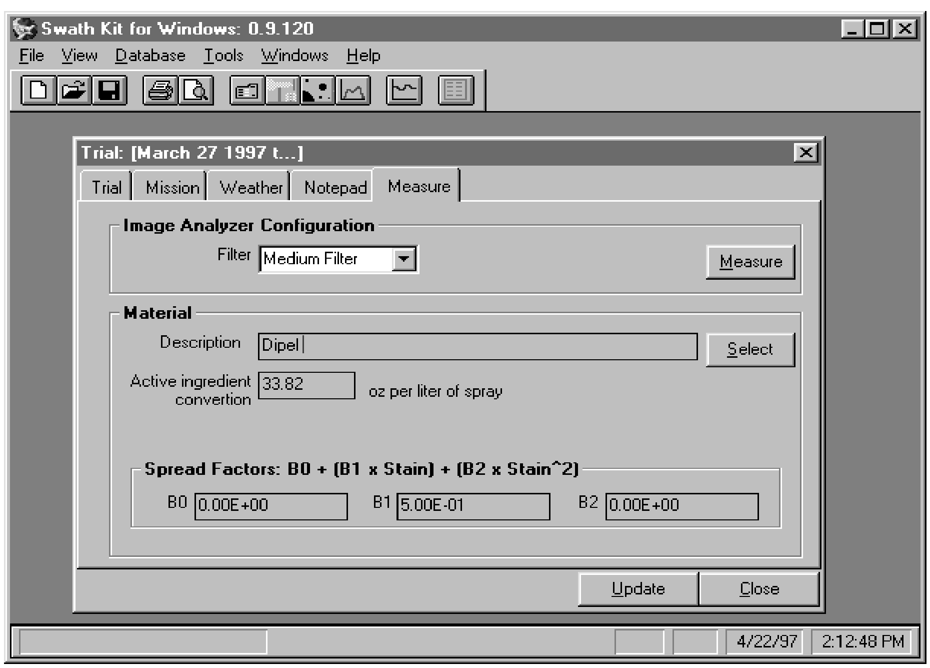
3.4 Measuring Deposits

The setting up of the image analyzer is normally done when you have a trial data card set that you are about to read. Typically, a spray trial series will have many similar trials, so that the settings detailed below are normally preformed on only the first of the trials. However, you may want to fine tune the settings periodically.

Make sure that the cards are arranged in sequence from the lowest number to the highest number. If you haven't already done so, set up a trial as detailed above (Section 2.5). If you previously created a trial, Select it from the list and press Enter. The 5-tabbed screen will be visible as shown below.

Figure 3.1

Select the 'measure' tab to start reading sprayed cards



Click on the **Measure** tab. Before measuring deposit first select a material and the Filter required. Press the Select key and you'll be presented with a list of available Materials. Selecting a material will load the spread factor and active ingredient conversions in to your Trial.

To start measurement press the Measure button.

Note: To access and edit the Materials database you select **Database** *and* **Materials***.*

For details of deposit measurement, refer to: Image Analysis Set-up

3.5 Filter Settings

The Swath Kit allows you to choose two types of filtering; pre-filtering and data filtering. To understand the difference between these two types it is worthwhile knowing how the Swath Kit reads and stores droplet data. Every stain that is read is stored in a database and is identified by trial and card tags. The Swath Kit program then can ignore some of the smaller stains (by applying a data filter), calculate droplet sizes by applying a spread factor and analyze the data for volume rate, droplet sizes etc.

3.5.1 Data Filtering

Data filtering is normally performed when you have some dust contamination, or some faint deposits are being binarized as false one and two pixel stains. Four data filter options are available on the Measure tab of each trial: None, Fine, Medium and Coarse.

None: No filtering performed and all objects read will be used as droplets.
Fine: All droplets smaller than 21μm are removed
Medium: All droplets smaller than 50μm are removed
Coarse: All droplets smaller than 72μm are removed

Because only a data filter is used, the level of filtration may be changed at any time.

3.5.2 Pre-Filtering

Pre-filtering is a setting which can be toggled on and off during the image analysis process. When set, it ignores any droplets smaller than 10 pixels in size, whether the shape is circular or elongated. The filtered stains are not recorded and cannot be included later as with data filtering. Typically this setting would be used when large stains are being counted (e.g. with herbicide applications) and the very small stains have little relevance to the dataset.

If in doubt, leave this setting as ‘off’. You can then always select a data filter to remove the small stains from the calculations made with the data set.

Note: The actual size of the stain removed during filtration (both data and real filtering) depends on the setting of the microns per pixel camera calibration.

3.6 Tool Bar

Figure 3.2 shows the icons which appear under the Measure Tab image analysis toolbar. In sequence from left-to-right they are:

1. Image Settings: this icon sets the brightness, contrast and threshold of the image. To use it set the threshold to zero, and use the brightness and contrast to get the best possible image. Then set the threshold level (displayed as a red

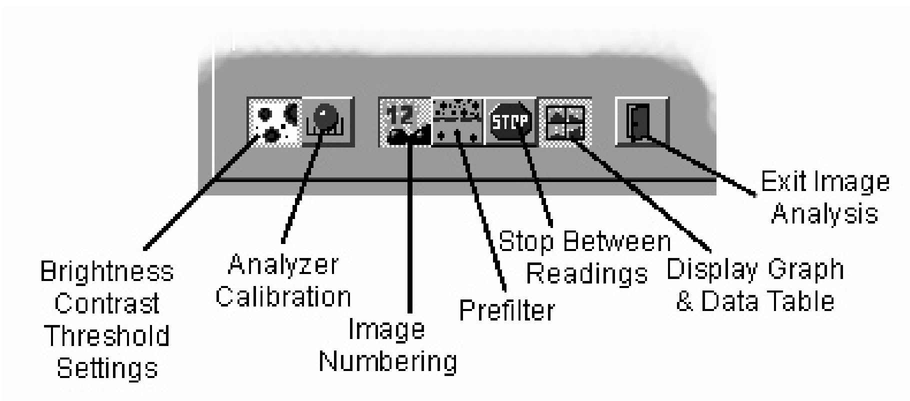
overlay on the image) until the most accurate 'binarized' representation of the image is obtained.

Right click on the image to zoom in up to 400% to examine the edges of the droplet stains, and verify how accurate the threshold level is. Pressing the shift key toggles the binarized red overlay off and on.

2. Calibration button: Use for calibrating the image analyzer. You will use this after every change of lens.
3. Image Numbering: Toggle to set the number labels on all images being read.
4. Pre-filter: 10 pixel pre-filter which removes images smaller than 10 pixels in size.
5. Stop Button: Pauses after pressing the read button so that user can examine the image. Pressing the read button will continue the reading process.
6. Graph and Data Display: Starts a display of graph and data tables while the cards are being read.
7. Exit: One way to quit image analysis and return to the trial window.

Figure 3.2

Image Analysis tool-bar which appears on the Measure tab.



3.7 Calibrating the Image Analyzer

Calibration of the image analyzer only needs to be done once, as long as the same lens and focus distance is used. If you change the lens or move the camera relative to the image analyzer faceplate, you will need to recalibrate the system.

The process of calibration is very easy, and is used to set the exact size of a single pixel for the Swath Kit program. A pixel (picture element) is the smallest element on the video image. To automatically calibrate the image analyzer, click on the Measure tab and then click on the Measure button. The image analysis window will appear. The IA window has a series of icon buttons arranged in a row across the bottom (Figure 3.2). Place a calibration test card which has an array of identical spots (500 - 1,000 spots per cm^2) to the faceplate of the image analyzer and click on the calibrate icon.

When the calibration screen appears (Figure 3.3) enter the exact number of droplets/cm² in a text box using the supplied test card. Press the Read button to complete the process. It is the droplet *density* which is used to set the calibration, so the threshold setting is not crucial for this process. However, the threshold should be set so that every spot is binarized to some degree i.e. shows a solid red area on the screen.

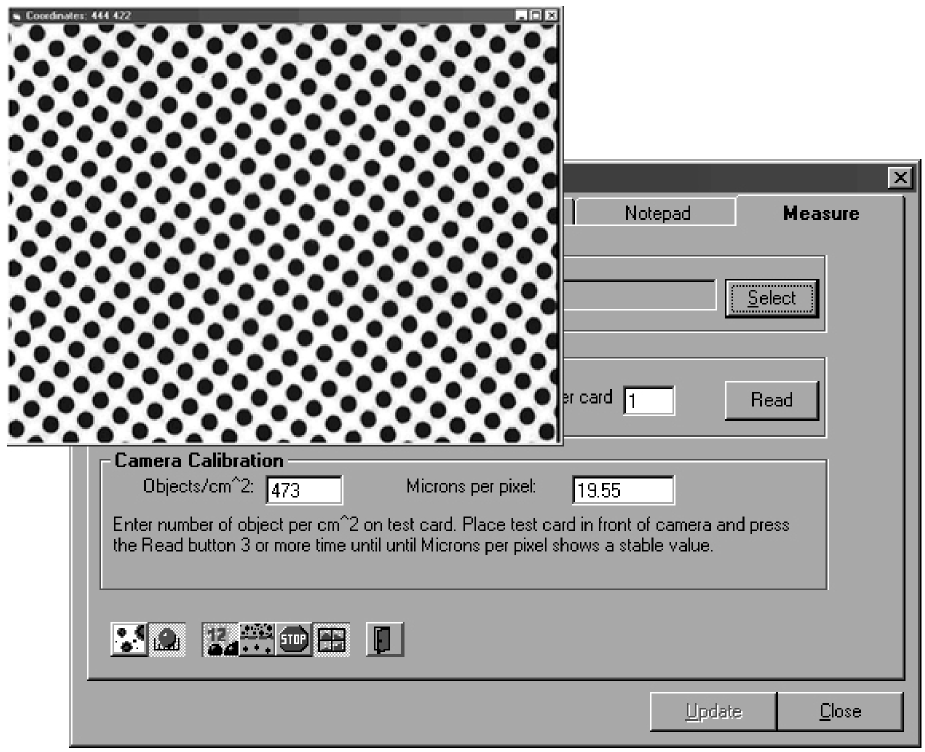
Figure 4.3 shows the Image Analysis Settings screen, and the pop-up screen which appears when the Auto Calibrate button is clicked.

NOTE: You may still need to reset the threshold for your spray cards; however, the microns/pixel calibration should not need any further read adjustment.

Figure 3.3

When you press the calibrate icon (the droplet + ruler) you will get a chance to enter the droplet density (473 in this case). Pressing the read button will calibrate the image analyzer.

When you press the icon again the pop-up save box appears.



3.8 Setting the Threshold

Setting the threshold is critical to the success of reading card deposits. The picture you see on the screen is made up of 256 shades of gray, from blackest black to the purest white, and 254 shades in between. The camera sees the background as several light shades of gray, and a droplet as several shades of darker gray on that light background. You'll notice that all is not black and white. Imperfections or shadows on the card may have quite dark shades, and the edge of the droplet may have quite light shades of gray. The image analyzer needs to be able to 'binarize' the picture, i.e. turn all darker shades of gray into black (the droplet stain) and turn all lighter shades of gray into white (the background). It needs to be told which of the 265 shades of gray represents the transition (or threshold) between background and droplet stain.

Figure 3.4

The effect of changing the threshold setting (shown by the numbers) on the apparent size of droplets. The higher the threshold setting, the paler the shade of gray that is considered to be a droplet stain.

The most accurate threshold level in figure 4.4 is represented by a gray scale level of 176 (second from the bottom). There are a total of 256 shades available from white to black.

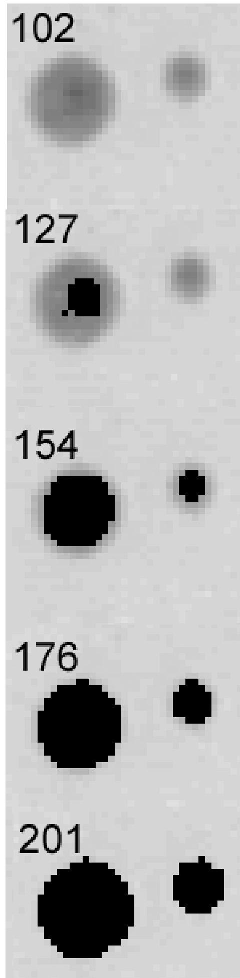


Figure 3.4 shows two droplets zoomed to 400% standard sized (a feature available by right clicking the image analysis window). The pixels showing different levels of gray can be seen in the top picture. The threshold level is set at 102, which in this example is below the binarization level (i.e. all pixels are below threshold which identifies the image as a droplet stain). Increasing the threshold gradually to 127, 154, 176 and 201 respectively increases the apparent size of the stain (shown by the black overlay). Increasing the threshold further would result in the background being included as a droplet stain.

If the threshold is set too high you are forcing the image analyzer to accept background (around the periphery of a droplet) as actual droplet. Thus the droplet will be recorded as being oversized. If the threshold is set too low, then you are assuming the dark gray is background when it is actually the lighter gray on the edge of a droplet.

The threshold that adequately describes a small stain may be slightly different to that which describes a large stain. Because the accuracy of mass per unit area is very heavily weighted to large droplets, it is advisable to make your estimation of threshold on the basis of larger stains, even if that means not detecting some of the very small droplets you see on the screen that do not turn black when binarization is switched on.

To aid in correct selection of threshold, the screen shows a normal black and white video picture but with a red colored droplet overlay marking the size of the measured droplet at the current threshold. Clicking on the threshold icon opens a slider which is used to set the threshold. Additional tools are available with the zoom button (offering you 150%, 300% and 600% zoom factors so that you can study individual droplets) and a binarize toggle button. Use this button to determine if you have set your threshold correctly. The binarized red overlays should be the same size as most of the droplet stains on your card.

Figure 3.5 shows the Threshold set-up screen. The threshold is set with the sliding bar on the top.

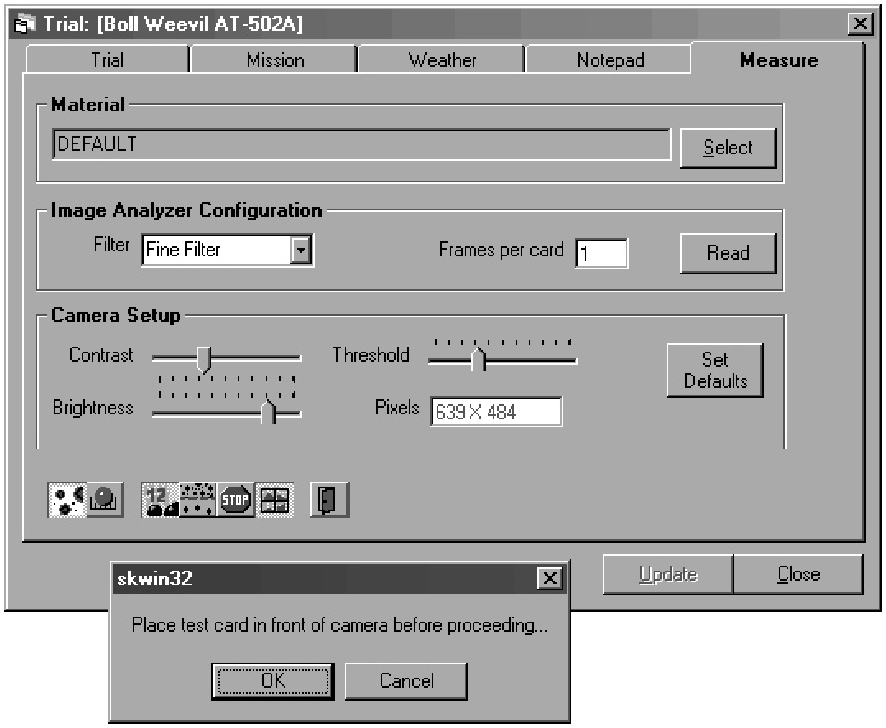


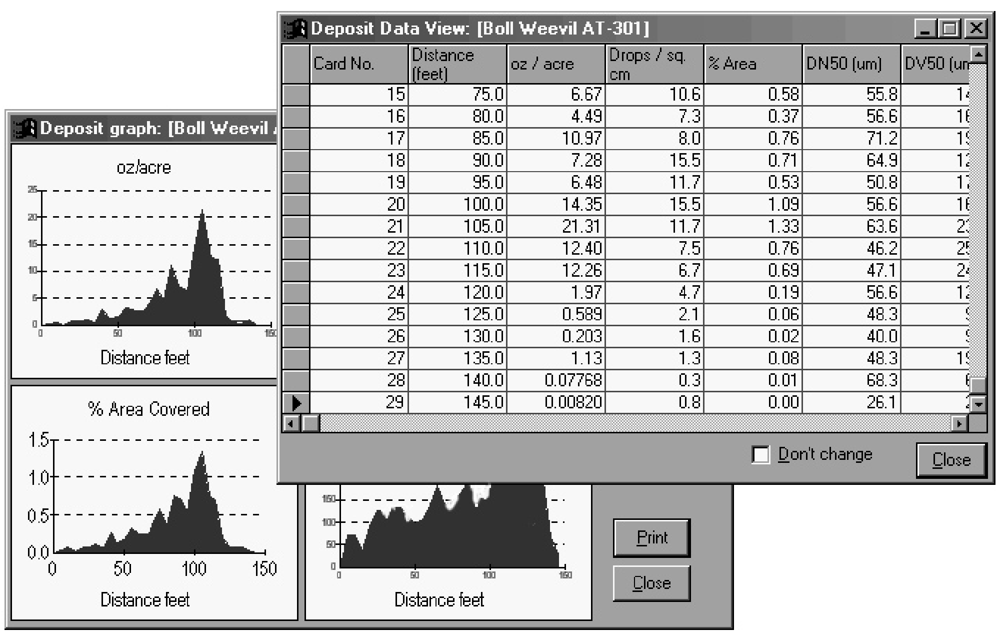
Figure 3.5

When the Image Settings icon is pressed, the camera set-up options appear. Adjust the sliding controls as required.

A typical spray card is required for accurate setting of these values.

3.9 Reading Spray Cards

Once the threshold for the card set that you are about to measure has been established, press the Read button on the image analysis window to start the reading the cards. Press the graphic icon (Figure 3.2) to open a deposit graph and data screen (Figure 3.6) Use the spin arrows on the top left hand corner of the screen to select the first card that is to be read. By convention, the farthest card to the left of the pilot's view is numbered 0 or 1.



Card No.	Distance (feet)	oz / acre	Drops / sq. cm	% Area	DN50 (um)	DV50 (um
15	75.0	6.67	10.6	0.58	55.8	[illegible]
16	80.0	4.49	7.3	0.37	56.6	[illegible]
17	85.0	10.97	8.0	0.76	71.2	[illegible]
18	90.0	7.28	15.5	0.71	64.9	[illegible]
19	95.0	6.48	11.7	0.53	50.8	[illegible]
20	100.0	14.35	15.5	1.09	56.6	[illegible]
21	105.0	21.31	11.7	1.33	63.6	[illegible]
22	110.0	12.40	7.5	0.76	46.2	[illegible]
23	115.0	12.26	6.7	0.69	47.1	[illegible]
24	120.0	1.97	4.7	0.19	56.6	[illegible]
25	125.0	0.589	2.1	0.06	48.3	[illegible]
26	130.0	0.203	1.6	0.02	40.0	[illegible]
27	135.0	1.13	1.3	0.08	48.3	[illegible]
28	140.0	0.07768	0.3	0.01	68.3	[illegible]
29	145.0	0.00820	0.8	0.00	26.1	[illegible]

Figure 3.6

The Graph/data display screen. Select the correct card position by clicking on the appropriate number. Press the 'Read' button to read the card.

These screens appear when the Graph & Data display buttons are pressed.

Remember, if you have chosen multiple fields per card, then you will have to move the card to show multiple positions on that card. Note that if the cards are read sequentially, the program will automatically step down to the next card number. You can, however, read the cards in any sequence you wish and overwrite incorrect readings simply by resetting the card number with the spin arrows in the card number box and re-reading.

If you feel that you want to read fewer fields than the default selected (say 2 fields out of 4), you can reduce the number of fields by putting a smaller number in the fields box.

When you have finished counting the cards, or you want to stop half way, press exit icon and the card data will be automatically saved to disk. You can press the Measure button to continue reading – make sure that the card number indicated in the card id box corresponds to the one that you are reading. If not, then adjust the card number with the spin arrows, or type in a new number.

3.10 Fine Tuning

On the Image Analysis screen toolbar (Figure 3.2) are several boxes that enable the card reading process to be customized to the user's requirements.

3.10.1 Split Overlapping Droplets

The image analysis system has the ability to check the shapes of the droplets, and if they appear to have a 'waist' to them, to split them to form two droplets. It is recommended that this option is selected for all situations.

3.10.2 Pause Between Readings

Selecting this option (a Stop sign icon) stops the stain reading procedure after frame grabbing so that the captured image can be examined. Individual droplet stains can be examined by clicking on them. Deselecting this box speeds up the card reading process, and should be used if the sprayed cards are of good quality, and you want to maximize your productivity.

3.10.3 Label Objects

When this option (A droplet icon with a number) is selected, each droplet will be labeled with a number. Decide for yourself if you want to have the droplets labeled.

3.10.4 Pre-Filter Image

This option automatically removes objects of area 10 pixels and smaller from measurement. It differs in function from the **Filter** in the Measure tab of the Trial window (Section 3.5), because that option only affects which droplets are *processed* to yield the deposit information; all droplets seen by the video system are still recorded, and a change of filter is possible after card reading..

Use this option if you have a lot of dust or unwanted spots (real or artifacts) on your cards, and when your droplets are considerably bigger than 10 pixels in size. This will help minimize the amount of data recorded by the system.

3.11 Zoom, Resize and Other Image Tools

When displaying the card image, several tools are available to aid the clarity of the image. The image analysis window can be made larger or smaller by setting the cursor on the lower left-hand corner of the screen and moving the cursor diagonally.

Pressing the zoom icon will enlarge the image (in the same sized frame) by a factor of $\times 2$. Pressing the zoom icon button again will return the zoom factor to the default 100%.

When the mouse cursor is pointed at a specific stain image on the screen, and the left mouse clicked, information about that stain is shown on the screen. The information shows the stain diameter, the droplet diameter (after applying the current spread factor). The Swath Kit measures the area of the stain, assumes that the stain is circular, then calculates the stain diameter based on the circular area. Click on 'OK' to cancel the information label. Note that you must have the 'Pause between reading' option box checked in the Image Analysis Settings screen to use this option.

4. Viewing & Analyzing Trials

4.1 Opening Trials

Choosing **File** and **Open** or pressing the folder button on the toolbar will display a window of all current Trials. By default, the listing is sorted by Trial Description. The list may be re-sorted by clicking on the heading of any of the columns (See figure 4.1). Double clicking on the line will also select the trial.

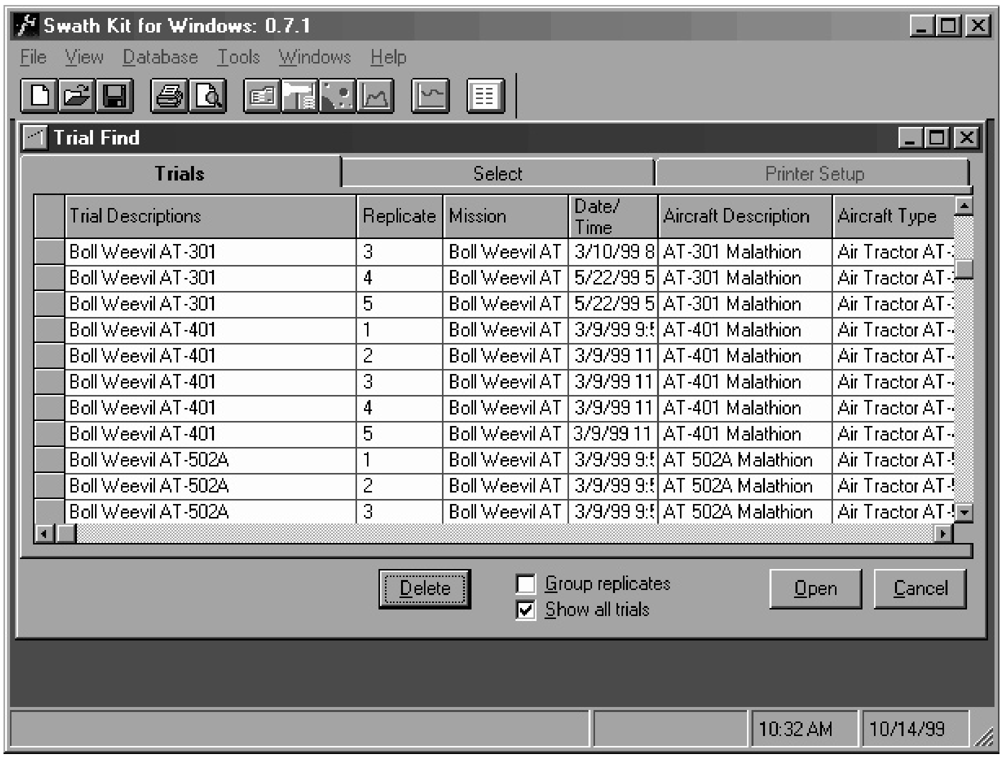


Figure 4.1

The Trial selection table obtained when the open file icon is clicked. Not all the descriptive fields are shown in this figure. The table can be sorted by clicking on the field name at the top of each column.

In addition to the Trial Description and Replicate displayed in the left of the window, each listing shows added attributes that help describe a Trial in the right half of the window:

Trial:
Date and Time of Trial and Mission Description associated with the trial.

Aircraft:
Manufacturer, Model, and Custom Aircraft Description .

Atomizer:
Manufacturer, Type and Restrictor.

A powerful feature that you can use to home in on a sub-set of your data is available. Click the **Select** tab and enter phrases to restrict the search for trials. For example, in Figure 5.1 selecting *Aircraft type begins with* "Air" would eliminate the Cessna Ag Husky records, and just show the Air Tractor records. Note that these restrictions are overridden when the Show All Trial option is checked.

4.2 Displaying Trial Data

Each trial has 4 possible data/graphic windows through which a Trial's data can be viewed or analyzed. These windows are as follows:

Trial Window: Contains all the Trial, weather and image analysis settings

Graph Window: Used to display weather, droplet spectrum and deposit data.

Analysis Window: Used to display and analyze deposit data. Options for data handling are: displaying a single pattern, displaying an overlapped pattern at a single lane separation, or displaying the mean deposit and coefficient of variation for a range of lane separations.

Data Window: Used to display numerical information underlying the Graph Window or Analysis window.

Each Trial opened can have a separate Trial tab, Graph and Analysis window; there is only one Data window that must be shared with all open Trials. Note that the Trial Description is shown on the caption bar of each window and is listed on the Windows menu.

4.3 Trial Data Window

A Trials data consists of that information unique to a single spray run. It is displayed through tabbed windows: Trial tab; Mission Tab; Weather tab; Notepad; Measure tab (see Creating Trials for use of these tabs Section 2.5).

4.4 Graphing Data

The graph window can present one of three data sets: weather, spectrum or deposit. Use the View menu option or the icon buttons to select a view. Note that the menu items or buttons will be disabled if data are not available. The Data button will bring up a data view showing numerical values represented in the graph.

Each View shows a series of 4 graphs. To enlarge any graph to fill the whole window, click on the graph with the left-hand mouse. To restore the original size, use the left-hand mouse click again. You can press the smooth button in the deposit view to even out the peaks and valleys in a swath pattern–the smoothing algorithm uses a 2 value moving average.

Also, while the formatting of the graph is automatic, you may adjust the look and feel of the graph by clicking on the graph with the right-hand mouse. This action displays Property Pages that permit individual adjustment of the format of the graph. A separate help file is provided to explain the detail of the Property Pages and is accessed by pressing Help on the Property Page screen. NOTE: You have to uncheck the Tool | Options | Settings box (Use default graph settings and disable property pages) before you have access to the property pages with the right mouse key – see Section Error! Reference source not found..

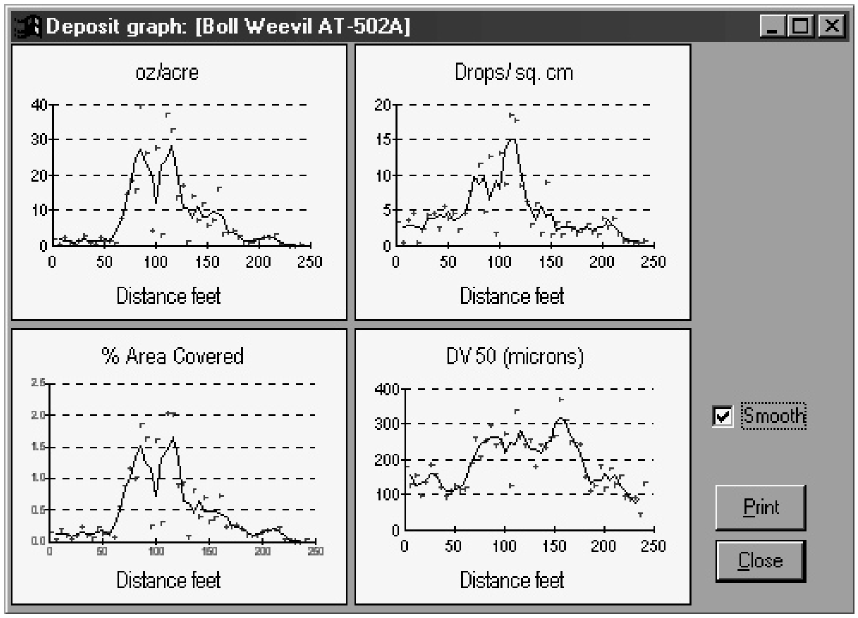
4.4.1 Deposit

The deposit window shows the deposit for a single spray pattern using four parameters: user defined active ingredient units; droplets per unit area; percent area covered and Dv0.5 (Figure4.4.2). The X-axis is distance across the swath. Units of length and area are determined by the Options settings. Units for the user defined active ingredient parameter are determined by the Material chosen for the Trial. You can have many different displays of the same trial data set (Section 2.4.1)

Figure 4.2

A typical deposit graph. Although the droplets/sq. cm make the swath appear to be wide, the oz/acre, % area covered and DV0.5 show that the left part of the swath is made up of very small droplets, which contribute little to the main pattern.

In this example the 'smooth' box has been checked for a moving average display.



Right clicking on the graph displays the Property Pages which can be used to adjust the look of the graph. Checking the 'smooth ' box displays a moving average (consisting of data points and a line display) in place of the default solid display.

Left clicking one of the four panels will zoom the display so that only one of the four panels is visible. You can also grab the lower right hand corner of the graphs with the mouse cursor, and enlarge or shrink the graphs to any size and shape that you like.

4.4.2 Droplet Spectrum

The spectrum window shows percent number and volume, and cumulative percent number and volume for all droplets in the pattern (Figure 4.3). Also shown are the $DV_{0.5}$ and $DN_{0.5}$ for all droplets in the pattern. (These are alternative designations for vmd and nmd respectively). The important point to remember is that these data represent all the droplets read for the cardline so far, not just the last card or any other single card. It therefore represents an unbiased picture of the whole spectrum which reached the ground. This may differ from the spectrum of the droplets released at the aircraft due to the effects of evaporation, and droplets that were not caught by the collectors.

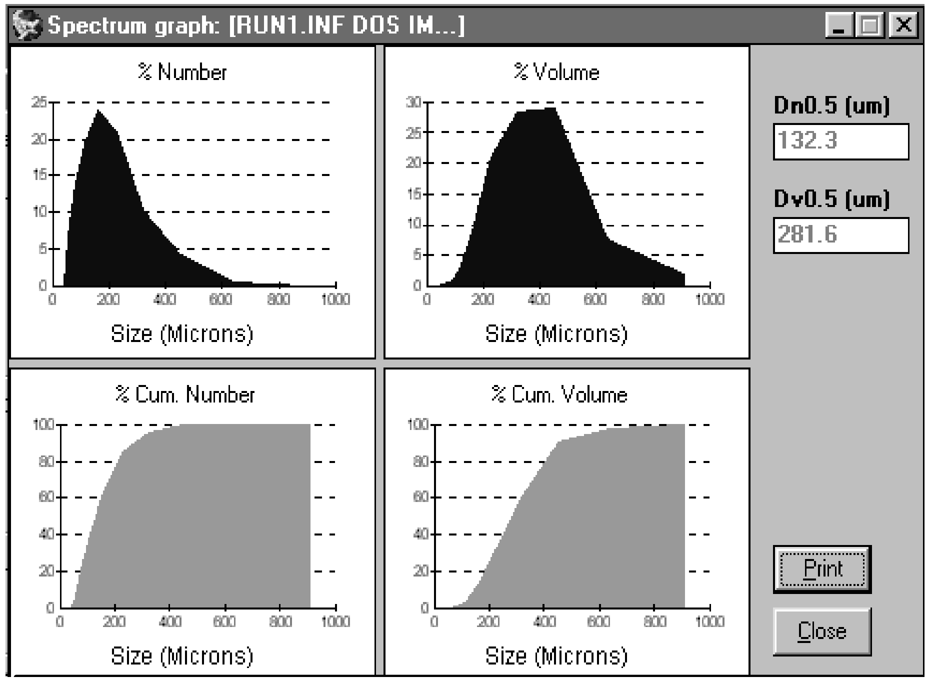
The top two graphs show the frequency distributions of the droplet spectrum for number of droplets (left) and volume of droplets (right). The vertical axis represents the percentage of either total number or volume represented in each size class. Each size class is a single bar of the graph.

On the bottom of the window, the cumulative frequency displays are shown. That is, each size class fraction is added to the previous one until 100 % of the spectrum has been accounted for. With the cumulative distributions you can see the median values such as the Number Median Diameter or the Volume Median Diameter. These values are found by taking a horizontal reference line at 50% and seeing where, on the horizontal size axis, this reference line cuts the distribution. This intersection is called the median and is marked by a vertical reference line. At this line, you will have 50% of the droplet number (nmd) or volume (vmd) in sizes bigger than the median, and 50% in sizes smaller than this median value. If you find that the cumulative graphs don't reach 100%, there must be some droplets greater than largest bin size which are not shown – select a different series for the bin size class distribution (Section 3.3.1) and look at the graph again.

Figure 4.3

A typical graphing of the droplet spectrum. The individual graphs are smoothed histograms of droplet distributions in each of the size categories used. The bottom graphs are cumulative distributions of the top graphs.

Click with the right button to pull up a menu of display possibilities.



4.4.3 Weather

Four weather parameters are shown: wind speed, wind direction, temperature and relative humidity (Figure 4.4). The units shown depend on the settings in the Options Units. The weather window also shows the start and finish time of the data set as determined by the time of application (start) and Weather Window (start plus interval of window). The X axis shows time in seconds. The assumption is the start of the weather is graph corresponds to the time when the aircraft flew over the card line.

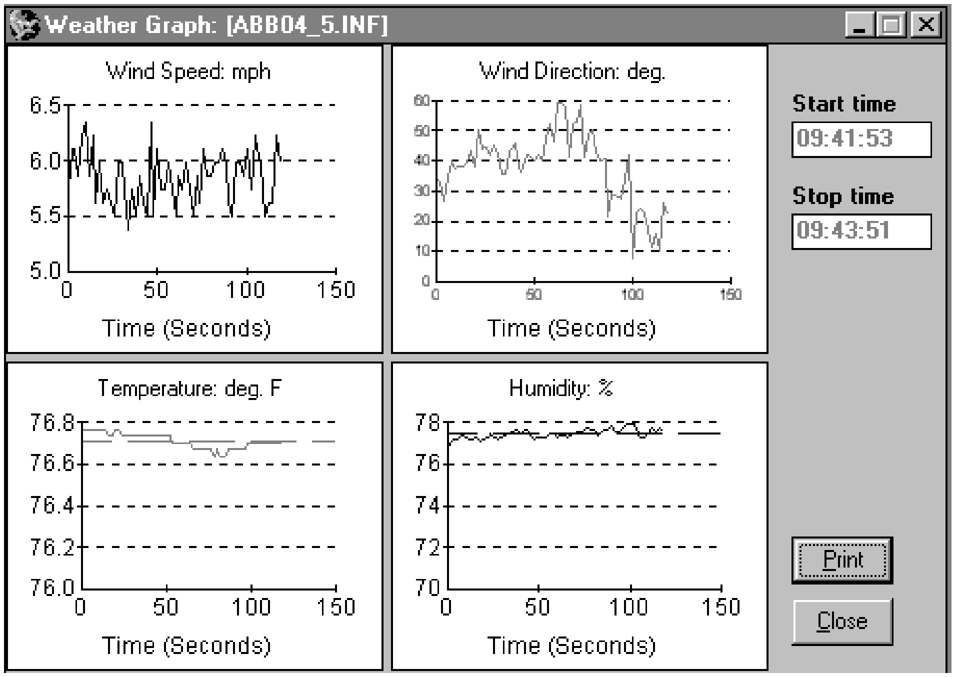


Figure 4.4
A typical weather graph with a weather window of 120 seconds.

Click on one of the 4 graphs with the left mouse button to enlarge it to fill the entire graph area.

Click with the right button to pull up a menu of display possibilities.

4.5 Displaying Numerical Data

Numerical data can be viewed for either the Graph Window or the Analysis window. This allows access to all underlying numbers used for weather, spectrum, deposit, overlap and analysis data. To display the data window, press the Data View button on the button bar or select the View | Data View menu item. These options will only be enabled when there are data to be viewed, that is, when a Trial is opened that has data and that has a Graph Window or Analysis Window opened.

There is only one Data window. If more than one Trial is open, or if both the Graph and Analysis windows are shown for a Trial, then the Data window will automatically display numerical data for whatever Trial has focus. That is, the data shown will change as you click on different graph or analysis windows. To freeze the display so that it doesn't change when you select a different graph, click the Don't Change option.

Figure 4.5

Numerical data can be viewed for either the Graph Window or the Analysis window by clicking the Data View button on the Trial Sheet.

Typical droplet spectrum data is shown in this figure.

Spectrum Data View: [FORAY12.INF]

Sizeclass (um)	Number	Volume (um^3)	% Number	% Volume	Acc % Number
10.0	0.0	0.00E+00	0.0	0.0	
14.1	0.0	0.00E+00	0.0	0.0	
19.9	0.0	0.00E+00	0.0	0.0	
28.2	120.0	8.89E+05	10.9	0.0	
40.0	156.0	3.05E+06	14.2	0.1	
56.6	173.0	1.01E+07	15.7	0.5	
80.0	157.0	2.62E+07	14.3	1.2	
113.1	140.0	6.51E+07	12.7	3.0	
160.0	99.0	1.33E+08	9.0	6.2	
226.0	131.0	5.14E+08	11.9	23.9	
320.0	106.0	1.03E+09	9.6	47.9	
452.5	18.0	3.71E+08	1.6	17.2	1
640.0	0.0	0.00E+00	0.0	0.0	1
905.0	0.0	0.00E+00	0.0	0.0	1
1279.8	0.0	0.00E+00	0.0	0.0	1

Don't change   Close

4.6 Deposit Analysis

You have used the Swath Kit to obtain a swath pattern. You are satisfied that it is good representation of what that aircraft sprays under typical meteorological conditions. How do you interpret the pattern? How do you assign a satisfactory lane separation to that aircraft? Do the claims that you have heard for this particular aircraft type match the results you see? The Deposit Analysis part of the Swath Kit enables you to make informed decisions on the aircraft application parameters. The program uses the data you obtained with one run, overlaps it with identical patterns, and presents you with the overlapped simulation, along with statistical parameters that enable you to judge the quality of the information. It is at this stage that all the preparation you have put into obtaining a representation of the spray pattern begins to show rewards!

If a Trial has deposit data you will be able to perform spray run analysis. Choose the **View** menu **Analysis** option or click the Deposit Analysis button. The Analysis Window will be shown. The upper half of the window shows pattern or overlap statistics. The lower half displays the spray pattern or overlap profile.
The underlying data for pattern, overlap or overlap analysis can be obtained by clicking the Data icon.

You can study different aspects of your pattern by selecting options in the Action selection box. Three Actions are available: **Pattern**, **Overlap** and **Analysis**.

4.6.1 Deposit Analysis: Pattern

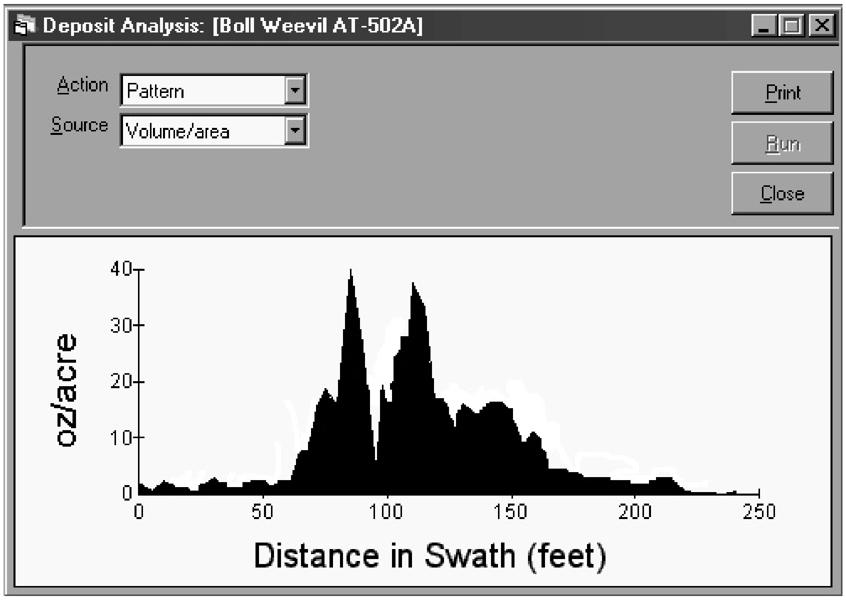
Selecting 'Pattern' in the action box enables a single spray pattern to be displayed (Figure 4.6) . The deposit parameter chosen depends on the setting of the Source control–the program gives you a choice of volume rate, droplet density or % area covered. The units of display depend on the Units setting under the **Options** menu.

Note: The pattern is viewed as if the aircraft "flew into the page", that is, the wing to the pilot's left is on the left of the screen.

Figure 4.6

A view of a spray pattern using volume/area as a source of data.

The two center peaks probably reflect a wing-tip vortex effect.



4.6.2 Deposit Analysis: Overlap

Overlapping is the process of spraying parallel swaths that overlap to form a contiguous pattern of spray across the field. To see the expected field pattern, select the Overlap Action. Overlapping can be performed on any one of the three Sources: volume rate (mass/area), droplets/area or percent area covered. It cannot be performed using Dv0.5.

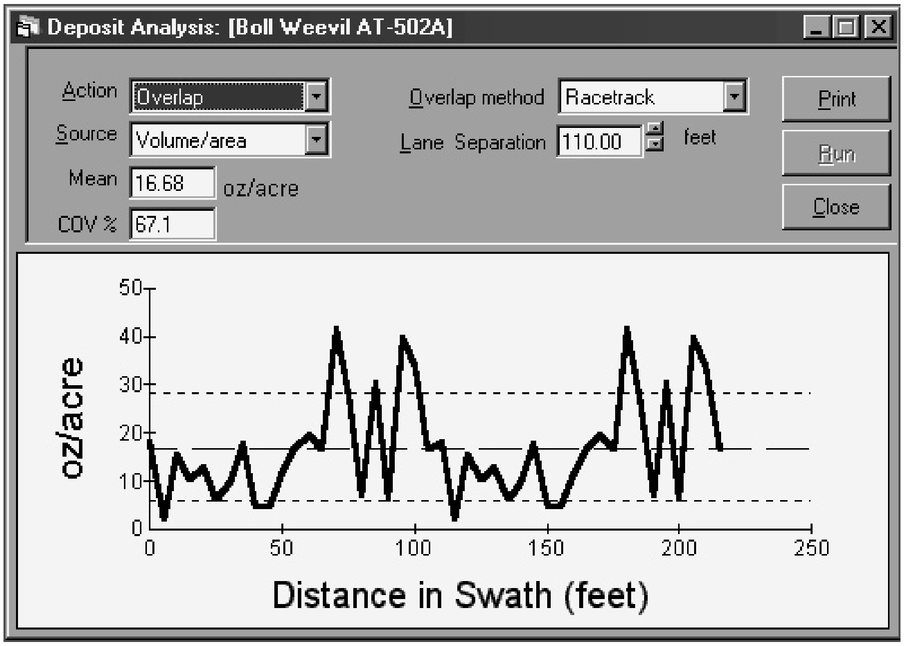
If the Field Spray option (where multiple passes are made on a set of cards) is used, there is no overlap available, as the overlap was already performed in the field for real.

When the Overlap Action is chosen, the Overlap Method and Lane Separation controls are visible. Use the Overlap Method control to switch between Racetrack or To & Fro flight strategies. Choose to fly the aircraft in a racetrack - all sprays in the same direction - if the shape of the resultant pattern is dominated by the effect of the crosswind, not by the aircraft itself. If so, then flying in either direction will still give a pattern predominantly skewed with the wind. Choose to fly the aircraft in a To & Fro or reciprocal fashion - passes in alternating directions. If the shape of the spray pattern is caused primarily by the aircraft, not by a cross wind. If so, then reversing the pattern (mirror image) when flying in opposite directions is valid.
Use the Lane Separation field to increase or decrease the distance between successive spray passes.

For each Lane Separation there is a Mean Deposit and Coefficient of Variation displayed.

Figure 4.7

The same spray pattern shown in figure 5.6 seen in Overlap View. A racetrack flight pattern has been selected. The dashed line represents the mean deposit, and the dotted lines ± one standard deviation. The coefficient of variation is shown in a data box above the pattern.



Note that the Lane Separation can only be determined for whole increments of the cardline separation. That is, if you used a 5 ft. distance between spray cards, then you will only be able to run Lane Separations in 5 ft increments such as 75, 80, 85 etc. If a Lane Separation is manually entered then it will be rounded to the nearest whole unit of the card separation. Click on the up and down spin arrows to increment or decrement the Lane Separation.

Recalculation and display of the overlap pattern is automatic each time the Source or Lane Separation is changed.

The display will show expected field deposit starting at the one aircraft centerline and extending for two Lane Separations. A dashed line shows the mean deposit and dotted lines show the standard deviation. Note: If 100% recovery is achieved (which also means that the aircraft was perfectly calibrated and the spread factor was perfectly correct), the mean deposit measured should equal the amount of material applied per acre.

4.6.3 Deposit Analysis: Analysis

Estimating the desired lane separation can be aided by performing an overlap analysis where the mean deposit and coefficient of variation are displayed for a range of Lane Separations.

When the Analysis Action is chosen you will see the Source options, Overlap Method options and two Lane Separation input boxes. Use the two Lane Separation input fields to enter an upper and lower Lane Separation range. Whereas Pattern and Overlap Windows are refreshed after each parameter is changed, the Analysis window requires you to press Run when the two settings for upper and lower Lane Separation have been entered.

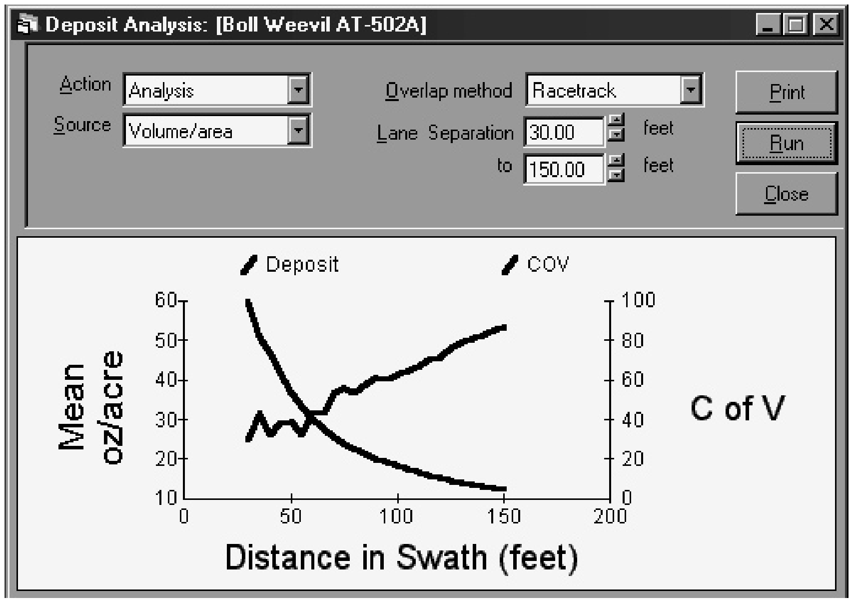
Select Racetrack as the Overlap Method, unless you are certain that the spray trial was performed under zero or close to zero wind conditions. A crosswind generally affects spray movement more than the propeller effects, which serve to slightly skew the spray patter.

Note: the mean deposit in Source units is shown on the left vertical axis. The Coefficient of Variation is shown on the right-hand vertical axis.

Figure 4.8

The data set used in figures 5.6 and 5.7 seen in Analysis View. A range of lane separations from 30 to 150 ft has been chosen.

The descending line shows the mean deposit (left y-axis) and the ascending one shows the Coefficient of Variation (right y-axis). The evenness of the deposit changes as the peaks and valleys of the pattern combine differently with varied distances



4.7 Printing Graphs

Data can be printed directly from the Graph window. You may also use the File Print menu option. First, select the Graph window to be printed then press Print. Printing is directed to the default printer.

The contents of the Analysis window can be printed by pressing the Print button. Note: The analysis window cannot be printed from the File Print option, because of its ‘interactive’ nature–its particular appearance depends on how you set the test lane separation values that you want to study..

4.8 Displaying groups of data

Data from multiple trials can be graphed in one of two ways:

- Open multiple files and display one of the data view windows for each trial; or
- Open multiple trials using the Group option to display multiple trials on the same graph. This option is only available with replicates of the same trial.

To compare trials by displaying deposit information on a single graph you may use the Group option presented when selecting trials to open. To select multiple trials, press the open icon on the main toolbar and move the mouse cursor to the record selection column (far left) and hold the Ctrl key down while clicking on multiple Trials. Once multiple trials have been highlighted, the Group check box will be enabled. Check the Group check box and press Open.

Trials opened as a group will not permit the following views: Weather, Spectrum or Analysis. The deposit window will display multiple deposit patterns to permit comparisons. The display of numerical data when a Group selection has been made will show multiple data sets. The left column of the data display shows the color of the line used on the graph.

Each data set is initially displayed with patterns aligned to the left of the screen. You may choose to rearrange the patterns by shifting each pattern to align the aircraft centerline of each pattern. Using the Align feature allows better comparison of patterns by removing the effect of flight line position. Check the align box on the deposit window.

Checking the 'Average' box displays a plot made up of the avreage of the selected replicates.

4.9 Deleting Trials

Trials may be deleted from the database. Click on the open icon and select one or more trials for deletion by moving the cursor to the left of the screen until the pointer is a right pointing horizontal arrow. Click on each trial to be deleted to select it – the line with the trial data becomes highlighted. Press the delete button to continue the deletion process. You will be asked to confirm whether you want each marked file deleted.

Note: Deletion removes content from the Trial and Deposit information from the database but does not remove weather, Mission or Material Profile used in the trials.

4.10 Printing Trial Data

Trial data may be printed in several ways. Here are the two most commonly used methods.

Printing graphs:
To print a graph of the current trials data, open or go to the desired data view window and press Print.

Printing Underlying Data
To print the numerical data underlying a data view you must either press the Preview button on the toolbar, or use the File Print option from the main menu. Note that the preview button will only allow printing of the underlying data, not the graphs. Using the Preview button will display a preview window from which data can be sent to a printer (Windows default) or to a file.

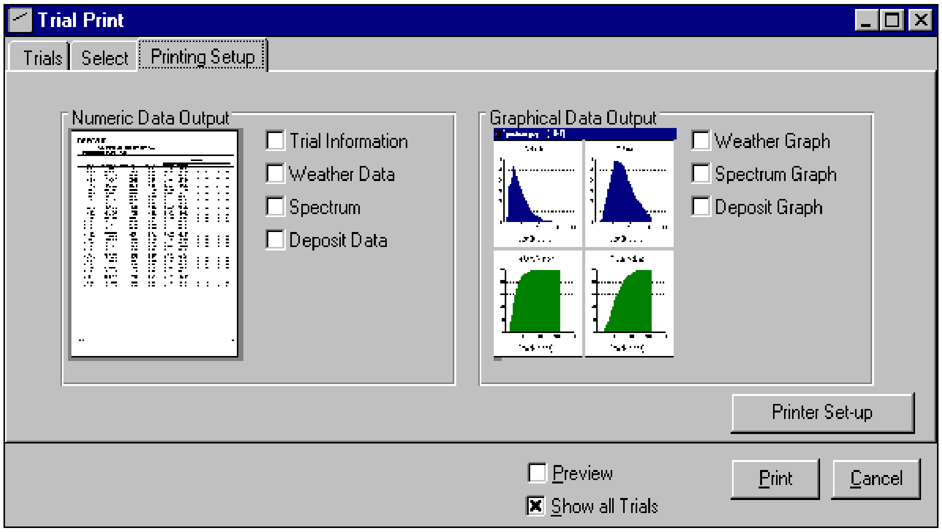
4.11 Print Option

The main menu contains an option File and Print. Printing trial data and graphs is based around the **Trial** Print screen with an additional Printing Setup tab made available to direct the printing operation.

First, click on the Trials tab and select those files to be printed by clicking on the left record margin. Selected trials are marked gray. You may use the filter features on the **Select** tab to narrow down your choices of available data.
From the **Printer Setup** tab, check each option to select the type of data to be printed, and check the **Preview** option if the output should be previewed before printing, or if you are Exporting Data. Note that previewing is not available for graphic data. Note that if preview is chosen you may also print from the preview window. You may also select Printer Setup options from this screen.

Figure 4.9

A Trial print screen..



4.12 Printer Setup

By default, output will be directed to the Windows default printer. To change the output either go to the control panel and change the Windows default, or press Setup in the Trial Print window.

4.13 Exporting Data

Most of the trial data can be exported to many different applications. You may want to do this if you want to further analyze the data with a statistical application, save data in a familiar format like Excel's .xls files, or paste a table into a word-processed document. The Swath Kit program gives you the option of exporting to many different categories including Excel spreadsheets, dBase, Access and FoxPro databases and several word processor and text processor formats.

The data that is exported can be of a predetermined nature or a specific nature. If you have a trial open and select the Deposit Graph (the basic 4-panel figure), you will export a basic table of the trial data. If you have an overlap selected for a specific lane separation, it is the data specific for particular condition that will be exported. To see what data will be exported at any particular time, select the Data Viewer icon in the toolbar.

4.13.1 The Exporting Process

Choose the data you want to export by selecting the appropriate graphic (the main deposit graph, a particular overlap, the droplet spectrum graphic, an analysis or weather data - all these produce separate data documents). Press the preview icon (the magnifying glass). Then press the little lightning flash and you will get a choice of many different data export options, as well the folder where the file will be written. Select the option that you want and press the OK button to export.

Note: Data Export is not the same as Trial Export. Trial exporting enables a part of the trial database to be exported so that it can be imported to another Swath Kit database. The trial data remains in the Swath Kit format throughout this process.

5. Customizing The Swath Kit

5.1 Options

The Swath Kit is designed to be a research tools as well as straightforward system for checking spray patterns. It is also used internationally, where some users may be used to seeing data displayed using the metric system whereas others prefer the US system or a combination of several different systems of units.

The Swath Kit program offers a wide range of customization choices so that the user can tune the system to his or her own needs.

The options menu gives access to program settings. Three tabs are available:
Program Options:
 Units
 Measure - Image Analysis Selection
 Settings

5.2 Options: Units

The Swath Kit for Windows is unit-independent. Data can be entered and displayed in different formats according to the settings given in the **Tools, Option** and **Unit** tab. Units chosen for a session are applied to all trials open in that session.

Units are defined in sets for a combination of parameters: Drops per, Area, Length, Velocity, Flow/ minute, Pressure and Temperature. Figure 5.1 shows a view of the Options:Units window.
..

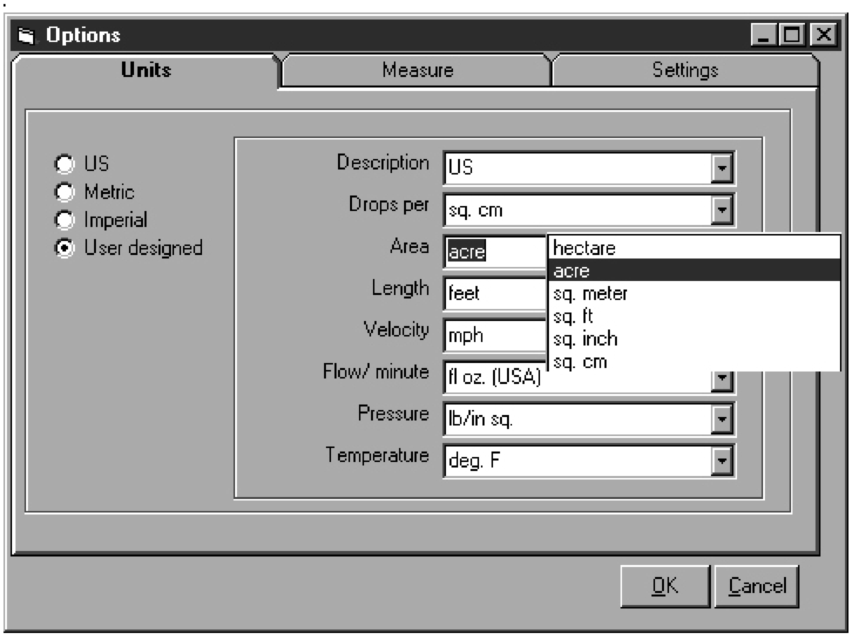


Figure 5.1

Options:Units window showing the principal units available

The options box shows the units available for Area. These choices are only available when the 'User designed' radio button is selected.

The following options can be selected by the user. The selection permits the use of scientifically meaningful units (for example nL/cm^2) to express the volume rate.

Drops Per: choose a small area unit to represent droplet density, e.g. inches or cm sq.
Area: choose an area unit to represent the amount of spray per unit area, e.g. oz per Ha (Yes–feel free to mix and match US and metric units!)
Length: choose a unit to represent parameters such as aircraft height and card separation.
Velocity: choose a unit to represent aircraft and wind speed.
Flow/minute: choose a unit that represents the flow per minute from the aircraft or atomizer.
Pressure: choose for boom pressure.
Temperature: choose for air temperature

There are three predefined sets of units – US, Metric and Imperial – that can be selected by clicking the respective radio button. You may also define any number of additional sets by clicking the user defined radio button, entering a descriptive title in the Description field then selecting a unit for each parameter from the drop down lists for each parameter described above. Once defined and saved you may recall user-defined unit combinations using the drop down list for Description.

When units are changed any data being displayed will be automatically redisplayed under new units.

5.3 Options: Measure

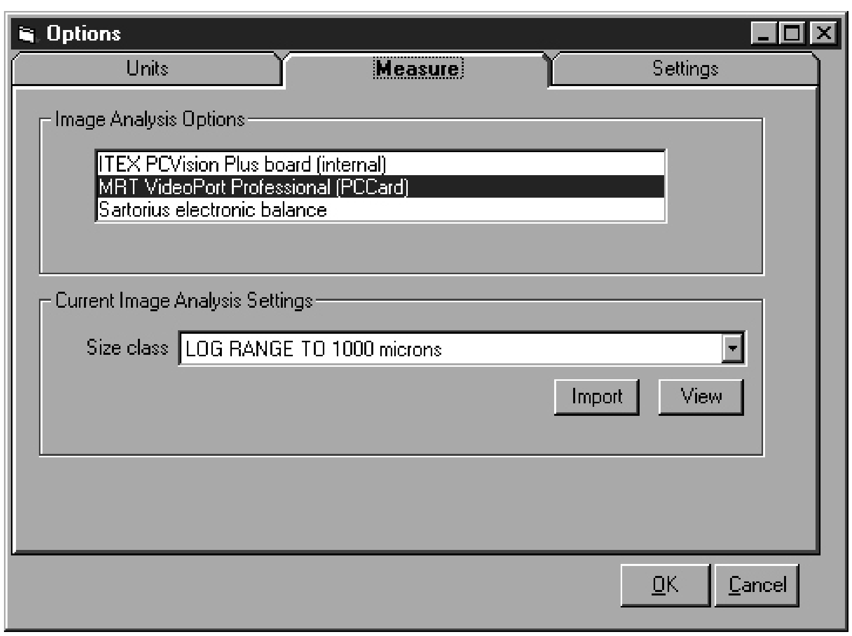
The specific configuration for image analysis is stored with the specific image analysis tool. More than one tool is available to provide deposit data for SKWin, but at time of writing only the MRT Videoport professional PC Card is the imaging option and the Sartorius balance is the only dry material data input option.

Select the Tools and Options menu, then select the Measure tab. Using the radio buttons, select the appropriate type of image analysis hardware to ensure the correct working of the system (Figure 5.2).

Figure 5.2

Options:Measure window showing the hardware options for image analysis and solid weight data input.

Different bin size class series can be selected in this window. Importation of bin size files can be done by pressing the 'Import' button



Choose a size class carefully to ensure that the expected range of droplet sizes can be accommodated by the range of size bins. If you are uncertain, select the Default: Root-two progression of 10 to 7239.7 um option that can accept most agricultural droplet sizes. To view the size bins in a size class selection press the View button.

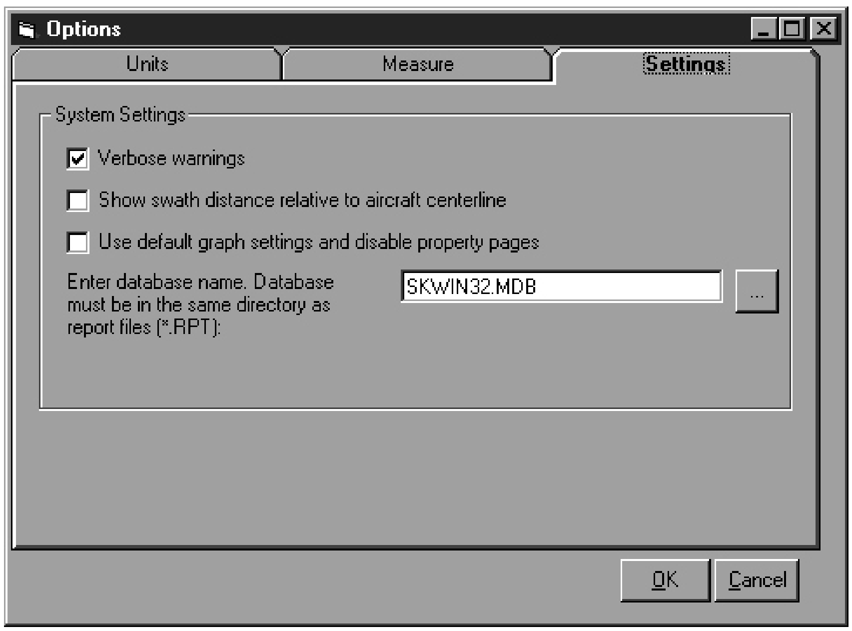
New bin size class files can be imported when the 'Import' button is clicked. The structure of the text files is shown in Section 3.3.2.

5.4 Options: Settings

This list of options enables the user to change the way the system messages appear, the way that graphs are displayed and the main database used to store trial data. The Options:Settings window is shown in Figure 6.3

Figure 6.3

Options:Settings window showing user-selected settings for Swath Kit messages, graphic display options and database file name for storage of trial data–(The default file name is shown).



Verbose Warnings: Use this option to have SKWin give more prompts when problems occur or where extra caution is required before making an action.

Centerline Correction: Data for deposit is displayed with distance across the swath as the horizontal, axis. By default, this is displayed using card number and card separation to calculate a distance from the left hand of the sampling line; that is, card zero is to the left of the pilot.

However, you may also display deposit using the Centerline Correction option where the X-axis is marked with 0 (zero) at the point where the aircraft flew over, and cards to the left denoted as negative distance values, and cards to the right as positive distance values. The two types of display obtained are shown in figures 5.4a and 5.4b.

Figure 5.4a

No centerline correct-ion. Numbering starts from the first card on the left of the card line (card 0). The spacing of the cards is used to calculate distance units.

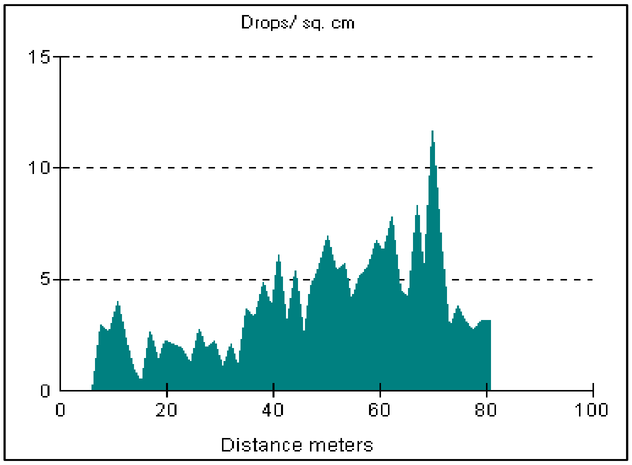
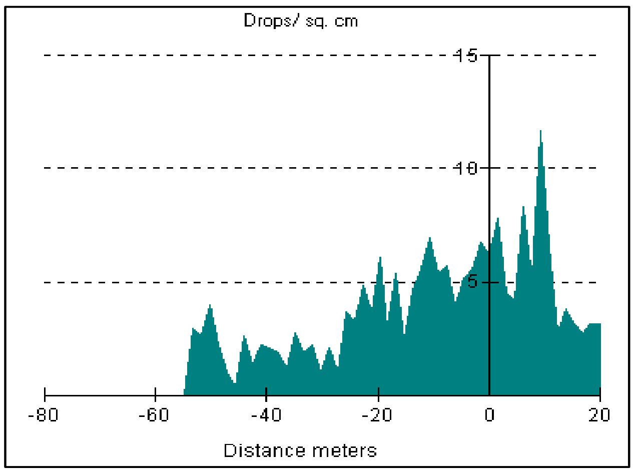


Figure 5.4b

The same pattern shown in figure 6.4a with centerline corr-ection. The vertical line marked zero represents where the aircraft flew over the card line. Distance to the left of the centerline increases negatively.



Default Graph Settings and Disable Property Pages:
There is a wide range of graph display options available to the Swath Kit user. To simplify operational use, Droplet Technologies has set a default display setting to the all the graphic displays. However, if the Default Graph Settings box is unchecked, many display options become available (Figure 5.5).

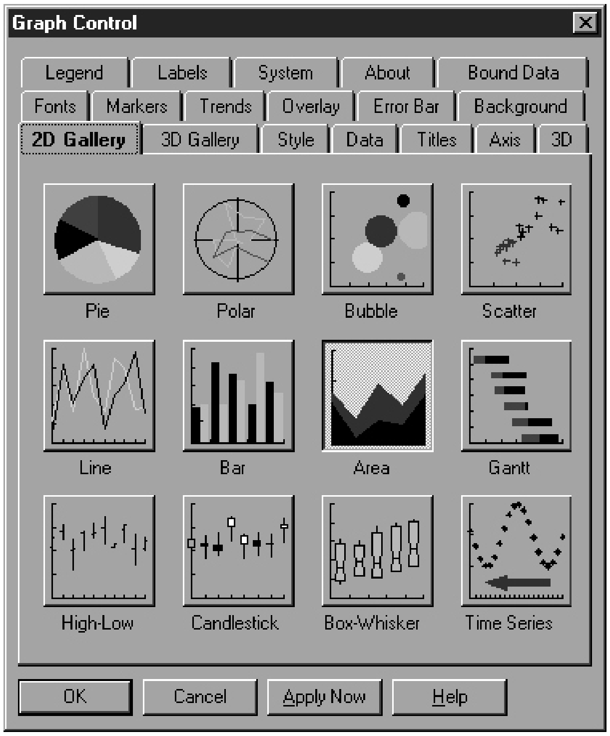
The options become available when the right mouse button is clicked anywhere in the graph window that you wish to modify. Statistical modifications are also available with this option. The graphical system will ask whether you want to change the defaults – answer 'yes' if you want your changes to remain in subsequent graphical use.

Four-panel displays can be individually modified so that each panel shows a different style of graph.

Figure 5.5

Graph Control options.

Use the tabs in the GC screen to select the type of graphic display you require. Statistical trends can also be displayed. Note that the nature of the data means that not all the graph options are available.



5.5 Using Different Databases for Storing Trials

Users who do many trials with the Swath Kit find that it is worthwhile to store trial data in different files, rather than let a very large amount of trial data accumulate in the default database (skwin32.mdb). In order to write trial data to a different database, it must already exist in the default data directory where the RPT files are present.

To create a file you must first export existing trial data to it (one trial is sufficient). See section 6.3 below for details on exporting trials.

5.6 Using Different Focal Length Lenses

5.6.1 General

The Swath Kit can be used for measuring different types of sprayed card. The most commonly used application is insecticide spray, where a resolution of around 20 μm per pixel gives a horizontal span of coverage of around 1 cm for each field that is read on a card. If herbicides are being used, then typically the droplets are much bigger, and less resolution is required. This enables much larger areas of the card to be read with each field; a horizontal distance of 6 cm is typical. A number of users require an intermediate setting, where relatively small droplet stains can still be counted, but stains smaller than 80 μm are rarely registered by the image analysis system.

5.6.2 Lenses and Extension Tubes

The default lens has a focal length of 50 mm. In order to be able to read close images, an extension tube of around 25 mm is placed between the lens and the camera. This arrangement gives a horizontal image which covers just over 1 cm of a card, with a resolution of around 20 μm/pixel.

In order to increase the area covered by each field (field of view) of the lens, the focal length of the lens has to be decreased. A wide-angle 25 mm lens gives an area with a horizontal dimension of around 2.5 cm, with a resolution of around 50 μm/pixel. This lens requires an extension tube of 5 mm to be able to focus closely, although a 3 mm extension may increase the field of view of the same lens. (Note: CS mount lenses require an extra 5 mm over standard C mount, i.e. a total extension of 10 mm).

To increase the field of view still further, a wide-angle lens with a focal length of 12.5 mm is used. This lens requires only a 1mm spacer between the lens and the camera (6 mm in CS mounts). It gives a horizontal image of around 6 cm, with a resolution of around 120 μm/pixel.

5.6.3 Face Plates on the Blue Box Image Analyzer

When reading cards, it is important to keep them well focused so that the best possible image fidelity is obtained. For this reason, when high resolutions are used (20 μm/pixel and better), the plate against which the card is read has a small opening. This keeps the card from bending towards the lens and allowing the image to be out of focus.

With wider-angle lenses (smaller focal lengths), the depth of field (the positions at which an image stays in focus when moved closer or further from the lens) increases, and focus becomes less critical. Therefore for 12.5 and 25 cm lenses the same face plate is used. Be careful, however with the 25 mm lens that you do not distort the card too much when taking a reading.

5.6.4 Changing lenses and Focusing

Use the following procedure when changing from the default (50 mm) lens to a wide angle lens:

1. Using a hex wrench, remove the 4 cap screws which hold the face plate onto the front of the Blue Box. Exchange the small aperture face plate with the large aperture one, and re-fasten with the screws. Make sure that the face plate is flush against the front of the Blue Box.

2. Remove the two upper screws at the back of the Blue Box, and remove the top cover.

3. Grasp the lens, and turn it counter-clockwise to unscrew it from the camera. The extension tube may or may not come off with the lens. If not, remove the tube after you have removed the lens.

   To fit the 25 mm lens, install a 5 mm extension ring (10 mm with CS mounts) onto the lens, and screw the combination onto the camera (Note: make sure you don't cross-thread the lens/extension tube. Very little turning force should be required).

To fit the 12.5 mm lens, install a 1 mm spacer on the lens mount (5 mm + 1mm on CS mouns), and screw the lens into the camera. For either lens, tighten sufficiently so that turning of either the focus ring or aperture ring does not cause the lens to unscrew from the camera.

4. At this stage the image will have to be focussed. Place an image with fine print in front of the face plate. It may be easier to attach it with tape, but make sure that the image is not bent away from or towards the camera. Connect the Blue Box to the laptop computer, and open up a test file in the Swath Kit. Select the Measure tab, and adjust the Image Analysis Settings screen so that the threshold is reduced to zero. This will result in a 'native' video image on the computer screen, with no colored binarized overlay.

5. To focus a wide angle lens as accurately as possible, it is necessary to open the aperture as wide as possible (this decreases the depth of field). However, with the lights on, the image will 'wash out' i.e. turn to all-white as soon as you open out the lens. It is therefore necessary to switch off the light, but keep the camera switched on.

   To do this, grasp one of the lights carefully with a clean cloth (careful , it may be hot!), and pull it gently upwards. When it comes out, both lights will go out.

6. Move the blue box to a fairly dim area where you can still get a sharp image with the lens fully open. If you cannot get a focused image by turning the focusing of the lens alone, you will have to move the camera forwards or backwards in relation to the front of the faceplate.

   To loosen the camera, loosen the 4 nuts that hold the top of the fastening plate which keeps the camera positioned. You will not have to loosen them much for the camera to be able to move. Once free, move the camera until you get a sharp image with the focusing ring somewhere in the middle of its focusing range. Do not focus with the lens set on full-close or full-distant settings. You will not then be able to finely focus the lens with the ring, but will have to move the camera again.

   Once you have found a good position for the camera, tighten the nuts so that the camera is once again immobilized. ***Do not over-tighten!*** You may damage the camera.

7. Replace the fluorescent light, and set a smaller aperture which produces a good image.

6. Importing and Exporting Data

Some of the information contained in the Swath Kit databases can be freely added to and modified by the user. Other information can only be added by importing specific files from Droplet Technologies. The latter files deal with Aircraft and Atomizers. The reason why these cannot be edited freely by users is that subsequent swapping of experimental trial data between users would become impossible as the same named aircraft or atomizer could refer to differently performing units. The user is of course free to adapt such existing equipment in any way by setting up custom aircraft configurations.

If any aircraft or atomizers are not covered in the database, users are invited to contact Droplet Technologies so that these units can be added to the databases. New additions will be posted on the Droplet Technologies web site (www.droptech.com).

This section deals with importing aircraft and atomizers as well as methods of importing and exporting trial data that can be used by the Swath Kit, and other application programs.

6.1 Importing Atomizers

The Swath Kit for Windows database is supplied with numerous nozzles, each with details about the relationship between flow rate and pressure and the limits of use. As more nozzles are made available it will be necessary to add to this database by importing new or updated information. The information to be imported must be supplied from a single source to ensure that all Swath Kit users can exchange information correctly; each atomizer is given a globally unique identifier that must come from a single source. While these files will be ASCII text files it is strongly recommended that you don't make direct changes yourself.

Data will be provided either through e-mail, through our web site (www.droptech.com) or supplied on a diskette through the mail.

The atomizer file name will use the following convention:

MMDDYYvv.ATZ

Where MMDDYY will be the month, day and year of the particular update, and vv will be a version number. All files will end with the ATZ extension.
Once the file is retrieved, use the Tools | Import | Atomizers menu, select the appropriate filename and new data will be added to the Swath Kit's data base.
If you wish to request specific nozzles be added, contact us and provide the following information about the atomizer:

Manufacturer, e.g. Spraying Systems
Atomizer Name, e.g. 80 deg. flat fan
Restrictor, e.g. 02
Minimum design pressure, e.g. 20 psi
Maximum design pressure, e.g. 80 psi
At least 3 pairs of data showing the relationship between flow rate and pressure.

6.2 Importing Aircraft

The Swath Kit for Windows database is supplied with numerous aircraft, each with details about the aircraft's design and the limits of use. As more aircraft are made available it will be necessary to add to this database by importing new or updated information. The information to be imported must be supplied from a single source to ensure that all Swath Kit users can exchange information correctly; each aircraft is given a globally unique identifier that must come from a single source. While these files will be ASCII text files, it is strongly recommended that you don't make direct changes.

Data will be provided either through e-mail, through our web site or supplied on a diskette through the mail.

The aircraft file name will use the following convention:

MMDDYYvv.ACT

Where MMDDYY will be the month, day and year of the particular update, and vv will be a version number. All files will end with the ACT extension.

Once the file is retrieved, use the Tools | Import | Aircraft menu, select the appropriate filename and new data will be added to the Swath Kit's data base.

6.3 Exporting Trials

Trial data may be exported from the main database, either to save disk space or to provide a subset of data to exchange with other Swath Kit users. Exported Trial data include all relevant database tables for the chosen trial(s) to enable an exchange of Trial results between Swath Kit users.

NOTE: This is not the same as Exporting Data where individual trial data points are output to disk in a standard file format for other applications (spreadsheets, databases and text editors).

The export provides all user-supplied information about a trial. However, if the exported Trial references core data (atomizers or aircraft) that have not yet been updated on the recipients system then data cannot be re-imported to a new database. Always ensure the aircraft and atomizer databases are kept up to date (see Importing Atomizers and Importing Aircraft).

To export Trials, simply choose the Tools | Export | Trials option from the menu and select a new database name; by default the extension will be MDB. Next, select the Trials you wish to export by holding down the Ctrl key and clicking the record selector column (on the far left) to highlight Trials.

The resulting single database file, for example BTTRIALS.MDB, may be archived or distributed to other users of the Swath Kit for Windows. Data are not automatically deleted from you system. You may manually delete Trials after the export (see Deleting Trials).

To retrieve data that has been exported see Importing Trials (below).

6.4 Importing Trials

Select Tools | Import | Trials menu option. Select the filename of the database containing your Trial data to import. Information will be retrieved and inserted into the current Swath Kit for Windows database.

7. Miscellaneous Topics

7.1 Image Analysis Limitations

There are limitations to the kind of spraying for which the Swath Kit can be used. Because flat cards are used to catch droplets, the system should not generally be used with very fine droplets with a $D_{V0.5}$ less than 80μm. Very large droplets– greater than 3,000μm–can be read accurately with the system, as long as wide angle lenses are used, and an alternative bin size-class file is used (Section 3.3.2).

As application rates get higher, more and more droplet stains will overlap giving errors. The error in reading deposit from overlapping droplets increases as a function of spray volume and droplet size and should be considered a factor for applications of 2.5 gallons/acre (25 liters/ha) or more. Greater application rates can be used, with the 'area covered' parameter as the source of swath data. However, no droplet size, number or volume data can be accurately obtained because of the extent of overlapping..

A maximum of 200 cards can be processed for any single trial.

7.2 Limitations with Aqueous Sprays

When an aqueous solution of a non-volatile material evaporates, the concentration of the non-volatile material in the solution increases. The same process is going on in droplets of aqueous spray mixtures during their sedimentation in the atmosphere.

When editing a Material in the Material Database, the user has an option of entering the AI (active ingredient) concentration of the original tank mix. The Swath Kit has no way of determining how much evaporation has taken place from the droplets that have sedimented on the target cards. It therefore assumes that the AI concentration is the same as the original tank mix, and does not allow for the concentrating that has taken place. Therefore the units on the Y-axis will be under-estimates of the material recovered.

As a principle, it is better to use volume units to express the recovery. Sure, you may get an application rate of 1 gallon/acre producing one of 0.5 gallons/acre, but that would be a reflection of what occurred. If all the deposit was caught, that 0.5 gallon would have double the concentration of active ingredient.

7.3 Data Files used by Swath Kit for Windows

The Swath Kit for Windows uses the following data file types:

Main database file
Named SKWIN32.MDB and resides in a data directory beneath the application directory.

The second data file is the weather raw data spool file, *.SPL. These may be stored in the data subdirectory until imported into the database but they will not visible to the Swath Kit program until imported and attached to a specific trial.

Typical directory layout:

C:\Program Files\Droptech\Swath Kit	Application Directory
C:\Program Files\Droptech\Swath Kit\data	Data File Directory

Note: You may occasionally find temporary files in the data directory with the SPR extension; e.g. RECALC.SPR or SWATHIA.SPR. These are used to hold raw droplet data, either during the export and import to an image analysis module, or during droplet statistic recalculation. They may be deleted while the Swath Kit is NOT running if space is required.

7.4 Spread Factors

7.4.1 What is a Spread Factor?

When processing an image of a card with droplets, the computer program only has a series of droplet stains on which to base its calculations. The stains were made by droplets which spread to some degree after they hit the surface of the target card. If the relationship between droplet size and stain size is known for a particular material, the program can reconstruct the droplet spectrum, and give meaningful data on droplet size, and spray volume recovered. The equation which is used in this calculation is called the spread factor. It is generally given in the form of a polynomial, where $\text{drop} = ß0 + ß1 \times \text{stain} + ß2 \times \text{stain}^2$, where ß0, ß1 and ß2 are constants, and the stain and drop data are presented as diameters.

Any errors in calculation of droplet sizes and total volume recovered from a spray swath are most likely to be caused by errors in the spread factor. The most likely source of error in determining spread factors of aqueous formulations (those ones most commonly used in forestry in the northeast US) occurs in the method that is used to obtain them.

7.4.2 Spread Factor Determination

Spread factors are typically determined in the laboratory using droplet fall distances of 10 feet, under temperatures and humidities found in a lab environment. The changes to the formulation by evaporation are usually minimal under such conditions. Contrast that to the same droplets falling 50 feet, in hot and dry conditions, losing much of their water content during descent. Clearly the dried-out concentrated droplets would be less likely to spread on a Kromekote card than those produced under lab conditions. If your weather conditions were such that a large part of the aqueous content of your spray was lost to evaporation, and you use the laboratory spread factor, your apparent volume recovery will be very small. That is because the lab spread factor assumes a large expansion of droplet material occurred after deposition, and calculates a much smaller apparent droplet diameter.

To avoid such errors, use a field spread factor determined under typical spray conditions. Where this is not possible, use a generic field spread factor for your spray material type, or a field spread factor of a related material. This will give more accurate information than a lab spread factor specifically for your material. For non-evaporating materials such as ULV formulations and oil-based formulations, there is little change in their composition during descent. Consequently the laboratory method is still valid for these materials.

What are the warning signs that your spread factor is not correct? In cases where you have caught most of your spray swath on your cards, but the program tells you that your application rate is only a few percent of that applied. Alternatively, the program reports an application rate that would correspond to a recovery that is quite a bit greater than 100 percent. In such situations, reprocess the data by using a different spread factor.

7.4.3 I have no Spread Factor – What do I do?

A work-around the problem of not having a spread factor is to do a bit of guesstimating. You will definitely not win the Nobel Prize for this, but your data may make sense. Choose a day when you are sure that you can catch most of your deposit – typically that means low wind conditions. Spray a couple of sets of cards and read them using an estimated spread factor. Adjust the spread factor (it is easier to use a linear one, where just the slope, ß1coefficient is changed) until you get a 90% recovery. Take the mean of the two runs, and use this spread factor for that specific spray material *under the same spray conditions*. The non-scientific part of this method is the assumption that you have caught 90% of your deposit.

8. Field Trials

8.1 Field Equipment Preparation

The objective of aircraft spray characterization is to visualize the swath pattern of the aircraft in order to:

1. Establish whether an even pattern exists across the swath,
2. To make sure all equipment is functioning properly,
3. Determine that an effective dose is delivered across the assigned lane separation,
4. Analyze the droplet size distribution.

The spray pattern characterization may be performed in a research capacity, for example when being used to test a new type of spraying, or a new nozzle, or it may be a simple check of the aircraft to ensure that it conforms to a government contract. The type of test will determine how rigid the testing will be. A simple confirmation of an existing aircraft/spray system combination, for example at the start of a new spray season will be performed with less rigidity than establishing the lane separation for a new aircraft type which will be used by all applicators bidding on a state forestry contract with that type of aircraft

When performing a swath pattern assessment, you should already have established a target lane-separation for the aircraft and calibrated the aircraft on the basis of that value to give the desired dose per area. Before going to the characterization site, make sure you have the items listed below and all equipment is functioning properly.

There are several questions to be considered when conducting a spray characterization trial:

- "How many spray runs should be used in order to receive a good representation of the spray pattern from the aircraft?",
- "If I use more than one card line, what should be the distance between each card line?",
- "How wide should the collectors be spaced to get an adequate measurement of the spray pattern?"

The swath pattern obtained from one card line should not be considered sufficient to establish the true pattern. A minimum of two lines spaced 100 feet apart should be established per independent run. For single-engine aircraft, 400-foot lines are adequate when a flying height of 50 feet is used. For multi-engine aircraft, the lines should be increased to 600 or 800 feet or further if a 100-foot flying height and large multi-engine aircraft are being tested.

Collectors should be placed in a straight line at 5-foot intervals for small aircraft in order to obtain a good resolution of the pattern. A 10 foot spacing gives a coarser estimate of the pattern but is good for the wide patterns made by larger aircraft. The Swath Kit assumes that all cards are evenly spaced, so a widely spaced card distribution on the outside of the line and a narrowly spaced distribution in the center is not recommended.

Essential Items:

Collector Stands.
Nylon string marked in 5 foot (or required spacing) increments.
Spray Cards.
Compass
Tracer.
Card Boxes.
Flags
Radios.
Protective clothing

Recommended Items:

Radar Gun.
Smoke Bombs
Spray bottle
Cardline markers

8.1.1 Collector Stands.

Have an adequate supply of collector stands. The collectors should hold the cards at least 6 inches from the ground. In areas with tall grass, the collector stands should hold the cards above the grass line. Vertically oriented collectors should be used for small and horizontally drifting droplets, whereas, horizontally oriented collectors should be used for larger, low-wind, and vertically falling droplets.

8.1.2 Nylon string marked in desired increments.

Each increment should be marked (e.g. 0 through 90) with an indelible pen on a piece of colored nylon ribbon to coincide with card numbers (or card distance). It is handy to have the rope rolled onto a spool for easy release and retrieval. If three card lines are used during the characterization, have three strings prepared.

8.1.3 Spray Cards.

Kromekote R paper-has been used for many years. It is commercially available (See Equipment and Supply Sources). Ask for Mead Mark 1, 10 point cover stock. It is advisable to use papers that are glossy on both sides to prevent moisture from penetrating and bending the non-glossy side. A small-sized target is a more effective collector of small drops than a larger sized collector; therefore, 2” x 3” Kromekote” cards are recommended over the larger 5” x 6” cards. Since spread factors will vary depending on quality of Kromekote paper, it is necessary to use only one supplier for spray cards. Pre-label these cards with an indelible pen. Cards should be labeled with spray run number and card number.

The swath pattern obtained after one run should not be considered as sufficient to establish the pattern. A minimum of two independent runs should therefore be made. It’s worth the time and effort to pre-label sets (3 card lines x 3 replicates) of cards for every configuration to be tested.

8.1.4 Tracer.

A visible dye must be added to the spray solution. Typically a 0.5% solution of a powdered food dye such as FD & C Blue #1, or Red #40 or Black Shade R will be sufficient to dye water (See Equipment and Supply Sources). This represents about 2 lbs per 50 gallons (1kg in 200L). Adjust the quantity so that droplet stains have sufficient contrast against the white background of spray cards as seen by the image analyzer. Opaque spray mixtures such as biological insecticides generally require smaller amounts of tracer than clear mixtures. Pre-measure dye into plastic bags (powder) or plastic bottles (liquid) in units or subunits required for each tank load.

CONSULT THE MSDS SHEET OF THE TRACER BEING USED TO ESTABLISH PRODUCT SAFETY. ENSURE NO NON-TARGET SURFACES ARE GOING TO BE SPRAYED THAT MAY BE DAMAGED OR DISFIGURED BY THE TRACER.

8.1.5 Sensitive Cards

Water-sensitive or oil-sensitive cards can be used as an alternative to Kromekote cards. This avoids the need to add tracers, although these collectors have their limitations. For example, water-sensitive cards cannot be used in highly humid environments, as they show the presence of moisture before they are sprayed. Oil sensitive cards do not show the presence of small droplets, and the stains are not permanent, so they have to be read immediately after spraying.

8.1.6 Card Boxes.

Slotted boxes for holding glass microscope slides are recommended for use to hold sprayed cards until data analysis. Many spray formulations, especially those containing oils, do not readily dry, so, cards must be kept separate to avoid cross contamination and smearing of the deposit. Since the card boxes are inexpensive, use one card box per card line. Each box will hold 100 cards. When picking up cards after a spray run, touch only the edges of the cards and handle them as little as possible. Do not double up cards by placing them back to back in the boxes.

8.1.7 Weather Equipment.

When weather cannot be monitored using the Swath Kit, please keep notes of weather for each spray run by using hand-held instruments. Equipment for monitoring weather: a sling psychrometer (and distilled water) for measuring wet and dry bulb temperatures at 10 minute intervals, and at the time of aircraft over-flight; a wind anemometer (e.g. Davis Turbo Meter); a good sighting compass for determining wind direction. Good weather information is critical; without it, data output from the Swath Kit can be easily misinterpreted and even useless.

8.1.8 Flags

Most agricultural aircraft are fitted with DGPS tracking guidance systems. However, at times traditional methods may have to be used. Use a minimum of two flags for aligning the pilot over the card line. White and blaze orange are good colors.

8.1.9 Radios.

Have freshly charged batteries on hand or a good supply of disposable dry cell batteries. Be sure to establish the correct frequency with the pilot. Have one person in overall charge to call in the pilot, or abort the run if things don’t look good. It is a good idea for the person who monitors the weather sensors to also be in communication with the team.

8.1.10 Protective clothing

Use appropriate safety equipment for the spray material being applied. Loaders and handlers of pesticides should be furnished with disposable protective gloves and coveralls, and goggles accordingly.

REFER TO THE MSDS AND LABELING OF ANY DYE OR PESTICIDE TO CONFIRM PRODUCT-SPECIFIC PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS.

8.1.11 Smoke Bombs

Use 3- to 4- minute duration smoke bombs to judge the direction and turbulence of the wind. A smoke bomb fits into the end of extending tree pruning poles and the smoke can be released 20 feet in the air. Releasing a smoke bomb 20 feet in the air will help reveal turbulence or inversions. Smoke bombs can be a fire hazard, so precaution needs to be taken when they are used in grassy areas.

8.1.12 Spray bottle

It is important that a good contrast exist between the droplet stains and the white card surface. A simple test with a hand-held spray bottle can be used to spray test cards, which will then be able to reveal whether or not sufficient tracer has been added. An important rule to remember "you can never have too much dye!"

8.1.13 Cardline markers

18 wooden pegs labeled with direction every 20 degrees around the circumference of a circle enable rapid orientation of the card string to be made under conditions of rapidly changing wind direction.

Make sure you have a compass for orienting the card line.

8.1.14 Miscellaneous supplies

Miscellaneous supplies, such as pens and notebooks, are needed. Make plenty of notes about weather conditions at application time and on observation of the way the spray cloud settled out. These comments are valuable evidence you want to try to interpret the shape and width of the patterns observed. Notebook use also encourages observations of possible factors influencing spray patterns and the resulting effects. Other extras include permanent markers and extra blank spray cards.

- A dictating tape-recorder for keeping field notes.
- Swath Kit manual.
- Tarp for protecting computer.

8.1.15 Swath Kit Preparation

Before leaving the office, make sure all equipment is functioning. It is a good idea to set up the Kit and test the image analyzer with spray cards sprayed with the same tank mix you will be using for spraying. Test the weather station to ensure proper readings are received. Use procedures described in the Swath Kit manual if the station is out of calibration.

Obtain the spread factor that will be used to read cards from a knowledgeable source. If no suitable spread factor exists, use a similar material's spread factor. Remember that spread factors can be modified after the cards have been read, without having to re-read any of the cards themselves.

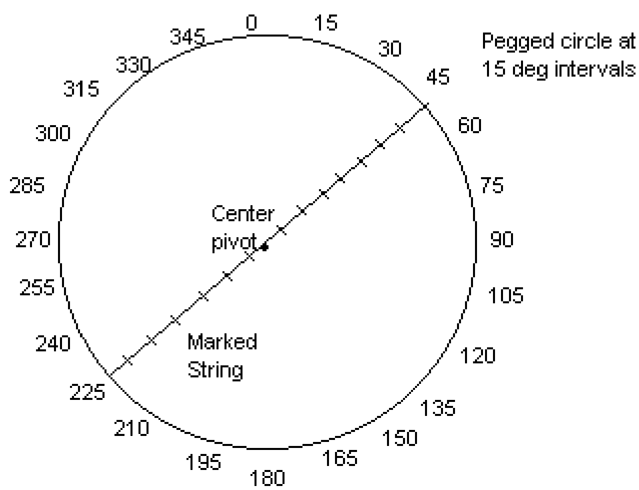
8.1.16 Pre-flight Procedures

When performing a number of trials at the same location on different days, it is worthwhile to do some site preparation. Lay out a compass rose 200 feet in diameter, using wooden stakes labeled with direction every 15 or 20 degrees around the circumference of the rose (figure 8.1). On the morning of spray, the middle of the pre-marked nylon string is attached to a wooden stake in the center of the rose. With one person on either end of the string, new card line directions can be matched to the current wind quickly by simply picking up the ends of the string and walking to the appropriately marked peg in the compass rose. Without this technique, it would be hard to keep pace with new card line layouts to match the quickly changing wind directions that often plague a spray trial. Card line layout in the early morning can be hectic because of constantly shifting wind directions. Sometimes, waiting until the sun is up over the horizon allows time for a wind direction to settle. The figure below shows such a compass rose layout.

Brief the pilot on the radio frequency to be used, the procedure for flight such as spray switch-on and switch-off, and aborting spray runs. Spray switch-on should be made 200 feet away from the first card line when flying into wind at 50 feet. Switch-off should be made at 500 feet past the last card line in low wind conditions, but should b e extended according to the strength of the wind. As a rough guide, in 9 mph winds, the aircraft should fly about 1,500 feet past the card lines. In stronger winds, should you be characterizing the aircraft?

Figure 8.1

Compass rose layout for trials held over several days allows quick orientation of cardlines in response to changing wind direction. Radius for circle is 100 feet.



8.2 Spray Trial Procedures

8.2.1 Personnel

The number of people required to run a spray trial project depends largely on the number of runs that have to be performed. There will always be a need for people to pick up sprayed cards and lay out fresh ones. However we have found that there should be one project coordinator who makes the decisions on whether to spray or not, how to react to changing weather conditions and who calls in the aircraft for spray runs. This person should be informed about all aspects of the job, especially about the wind direction and strength, so that he/she can make the best possible decisions. If a limited number of hand-held radios exist, make sure that p.c. has one so that he/she can talk to the pilot.

8.2.2 Setting-up

As a first action in the test area, the weather station should be set up to start monitoring weather. Check that the data logging computer clock is coordinated with your own watch! As you record the time of each pass, it should correlate directly with the times that the weather system records. The weather station should be located close to the card line, but not so close that it gets sprayed on each run. Make sure the weather stand is not near any buildings or objects that could inhibit weather readings, especially those associated with wind. Always anchor the weather stand with guy lines and tent pegs provided. This extra precaution keeps the weather stand from being tipped over by field crews and clumsy Swath Kit operators! Let the Kit run for at least 5 minutes so that the average wind direction can be determined for the initial period. This can then be used to determine the card line direction. Bear in mind that as the sun rises and heats up the ground, the wind direction may suddenly vary. The weather station should be constantly monitored for any sudden shifts in wind direction.

8.2.3 Weather Considerations

When weather cannot be monitored by the Swath Kit, you are strongly advised keep a record of weather parameters for each spray run by using hand held instruments. Define the weather limits acceptable for the spray trial, in terms of wind speed and direction, and temperature and humidity considerations for the material being sprayed. The higher the proportion of water in the spray and the smaller the droplet size, the more you should be concerned about high temperatures and low relative humidities.

The orientation of the card lines should be perpendicular to the wind direction unless distinct crosswind effects are being studied. It is usual to designate the first card to correspond to the left side of the aircraft from the pilot's point of view. If shifting winds resulted in a reversal of the numbering system (high numbered cards on the left), make a note of this in the "Note Pad" section of the information file. Make sure the cards are read in reverse order when they are image analyzed.. Always have a notebook handy for recording the time of spray, flight number, and any peculiarities about the run or spray pattern. It is difficult to over-emphasize the importance of good notes made during and after a characterization trial. So many things can change at the last minute, and only your notes will tell you why something in the pattern is not quite as it should be.

8.2.4 Aircraft Spray Height

When spraying at agricultural crop height, it is no problem to get the pilot to fly a specified distance above the ground. The heights used in forestry spraying, typically 50 – 100 feet, require some preparation.

One method is to use 2 helium filled balloons raised to the desired height at each end of the card line. For accurate balloon heights, leaning balloons due to slight winds should be measured by a inclinometer at right angles to the direction of lean to correct for height errors. Of course the height problem does not present itself if the aircraft is fitted with a radar altimeter.

8.2.5 First Run

If the aircraft is fitted with a DGPS system, get the pilot to fly over the required position over the card line to set his A–B line. You can position flaggers 400 feet on either side of the card line, perpendicular with the designated center cards for directing the pilot while he performs his first run, as usually there is no reference field boundary that the pilot normally uses to keep straight when setting an A–B line.

It is a good idea for the pilot to make one dry run before spraying. This will help alleviate any problems with radio communication, spray height, aircraft speed, or position of flaggers. If no problems occur with the dry run, and the project coordinator is happy with the wind direction, he can tell the pilot that the next over-flight will be the first wet run.

After each run, record the following in your notebook (later to be entered at the Swath Kit Trial tab):

- Time of over flight of card line
- Center card number
- Aircraft speed
- aircraft height

If rotary atomizers are used, then tachometer (rpm) data for as many units as possible should be recorded on the Mission tab

8.2.6 Notepad

When you are transcribing your field notes into the computer, make use of the "Note Pad" tab of the Trial data. Record anything that did not look right (i.e. spray cut off too early, flew too high over the card line...).

8.2.7 Standard Operating Procedures

If spraying from 50 feet or higher, wait at least 5 minutes after the run before picking up the cards. It can take this much time for the small droplets to settle out and allows the droplets time to dry on the cards. During this time, do not walk around or upwind of the cards.

To get a robust estimate of a spray pattern for a given aircraft setup do three replicates; each replicate should be as close in time as possible. This helps eliminate any pattern differences that could be attributed to changes in weather conditions.

If time permits, the cards can be read and analyzed between spray runs so that problems in a spray pattern such as a peak or valley can be detected. If necessary, adjustments can be made to create an even pattern and the configuration can be tested over cards again. Keep all spray cards after they have been read until the final report has been written. You never know when you might need to re-read just a few cards or a complete card line.

8.2.8 Wind Direction

Because the technique of aerial application involves the application of material in the form of droplets, the wind speed and direction will always be a major consideration when spray deposits are analyzed.

Aircraft spray patterns can be studied in reference to cross winds or head winds. Spray cards can also be sprayed like a field in a real-life mission with several runs, offset by the chosen lane separation. In Swath Kit terms this is known as a "field application" instead of a single spray run. Thus there are 4 possible options of spraying a field trial. These options are entered into the Trial Screen under the Trial tab and Flight field.

1. **Into wind - centered.** This is option used when the spray line is arranged perpendicular to the wind, and the aircraft flies over the center card.

2. **Into wind - offset**. This option is used when the wind is no longer perpendicular to the spray line but may be up to 45 degrees off to the left or right. Under such conditions, the aircraft still flies perpendicularly to the card line, but is offset into wind.

3. **Crosswind.** This option is used when the card line is set up parallel with the wind, and the aircraft flies perpendicular to the upwind end.

4. **Field Application.** This option is used when several swaths are applied to a card line.

9. Newer Options: Drift, Manual Entry & Solid Analysis

Since the release of Swath Kit Version 3, several options have been added to the Swath Kit as a result of users' requests. These are:

- The use of vertical collectors to measure drifting spray fractions.
- The ability to manually enter results obtained from a different source data so that the analysis engine of the Swath Kit can be used.
- An option to interface the Swath Kit to a Sartorius balance for measurement of solids collected using a two-dimensional collector array. This option has not been tested by the user who requested it, and as yet, is only available for one balance manufacturer. Because of the limited feedback, it is being offered on an as-is basis. Further development could be possible, if sufficient users demand it.

9.1 Drift Analysis

9.1.1 Procedural Changes from Card Line Analysis

The drift fraction sampling option enables users to place cards aligned vertically on a pole or other vertical collector, and measure them to estimate the droplets which are drifting horizontally. It should be noted that the catch efficiency of the drifting droplets will vary according to their size, the width of the collector and the speed of the wind.

A uniform spacing of collectors should be used. The spacing used is entered in the Trial tab of the Trial screen. There are two text boxes that indicate card spacing – on the left is the usual ground card spacing and on the right is the drift collector spacing. Enter the spacing data as appropriate.

You may enter data for up to three vertical collectors. The data for each card line is entered separately by selecting the appropriate line from the drop-down list box in the Measure tabbed screen (Figure 9.2 below). The default option is the standard horizontal collecting line.

Once the cards have been read, the results can be viewed by selecting the green vertical sampling icon on the main Swath Kit toolbar (Figure 9.1).

Figure 9.1

Icon for vertical collector deposit graph.

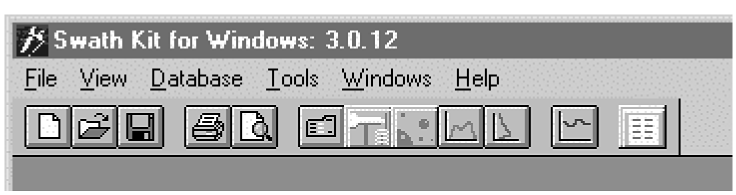


Figure 9.2

Measure Screen, after 'measure' button is depressed. Note the drop-down list box for selecting whether the horizontal cardline is read (default) or one of the three vertical collector lines.

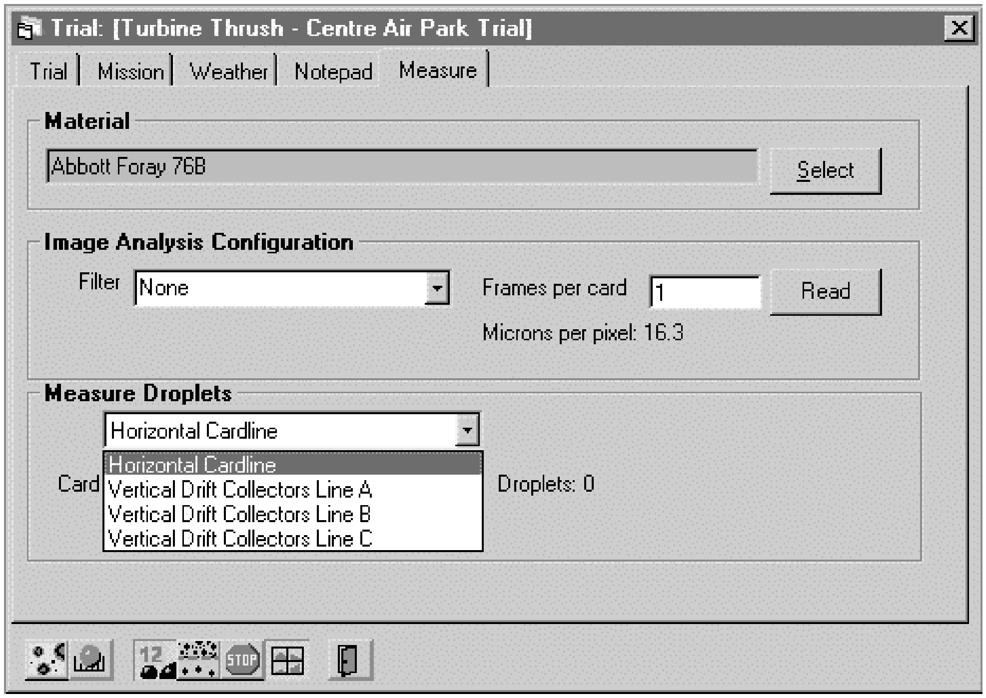
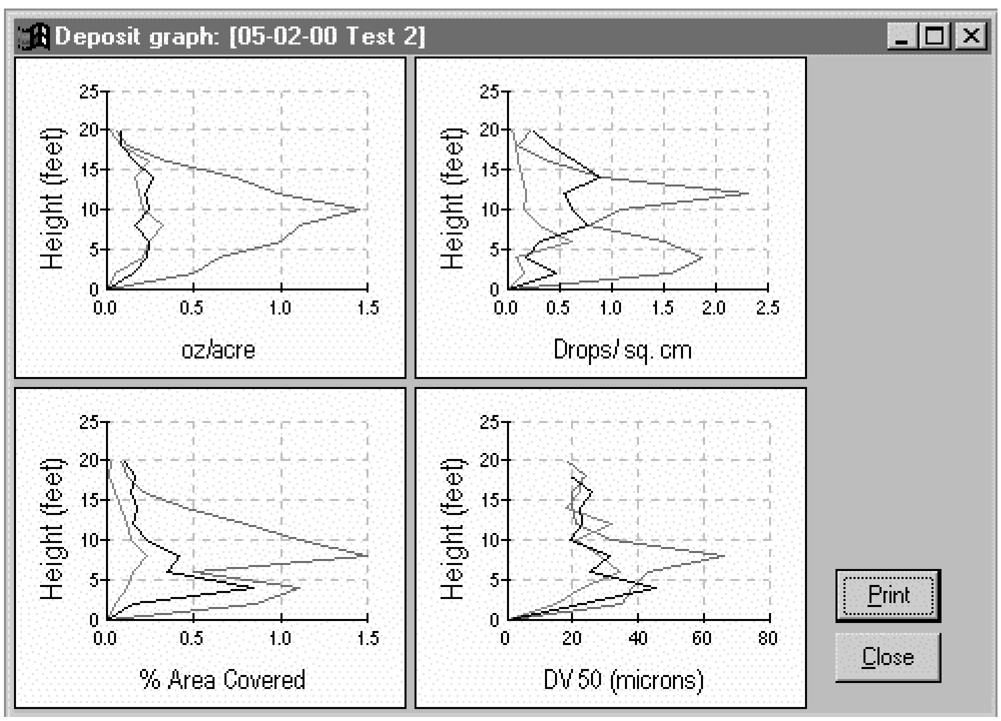


Figure 9.3

Deposit graph of vertical collector results. The data plots are color-coded to identify the individual vertical collector lines.



9.1.2 Vertical Collector Result Interpretation

The deposit graphs (Figure 9.3) show an identical series of graphs used to illustrate horizontal collector card lines. If weather data are available, drift and deposition models such as AgDRIFT and AGDISP (USDA Forest Service and Continuum Dynamics Inc, Princeton, NJ) can be run using the weather and trial data, to compare actual measurements with predicted measurements. Collection of drifting droplets and drift interpretation is not a routine activity and pertains more to the research side of aerial application.

9.2 Exporting Individual Stain Data Files with Filer32

The Swath Kit was designed for a wide range of users of different technical expertise. Therefore many of the calculations and modeling processes are intentionally hidden from the user, so that she/he is not confused or dissuaded from using the many data analysis options of the Swath Kit.

Some users working at the research level need to get right to the heart of the data and use powerful statistical programs such as SAS to do the number crunching on deposit data. Droplet Technologies provides a utility that enables you to extract stain diameter data for processing. Note that the Swath Kit stores deposit data as stain sizes (not droplet sizes). Droplet sizes are calculated by the Swath Kit program by applying spread factors ‘on the fly’. The utility program, Filer32.exe, is included on the installation CD and is available on the download portion of our web site www.droptech.com.

9.2.1 Procedure

Because this program represents a ‘work-around’, its use is not integrated into the menu system of the Swath Kit. Follow the procedure described below in detail.

Filer32 uses a temporary file that the Swath Kit program generates (for its own purpose) when details of a trial are changed. The name of the generated file is always recalc.spr. After processing with Filer32, you can save the file as a comma-delimited text file, which you can open in a spreadsheet or use as an input file for statistical programs. The name of the saved file will always be recalc.txt.

You can see from the last paragraph that a great deal of confusion can arise with files named identically. It is up to the user to work with Windows Explorer and rename the text files as soon as they are created.

Here is the procedure, step by step:

1. Open the trial whose deposit data you require.

2. Go to the Measure tab. Change the filter setting (it doesn’t matter what you change it to – just change it to something different from what it was before). Close the trial (say NO when the program asks you whether you want to save the changed trial). If you have other trial data you want to extract, keep the Swath Kit program open.

3. Run Filer32. (It’s easier if you have a shortcut icon on your desk). Press the Open button. You have a choice of types of files, but the default is SKWin raw droplet data (*.SPR) so you shouldn’t have to select the file type,

   You will have a choice of two files (if you don’t see the files go to the Swath Kit/data folder) Recalc.spr and SwathIA.spr. Double click on Recalc.spr – this is the file you want.

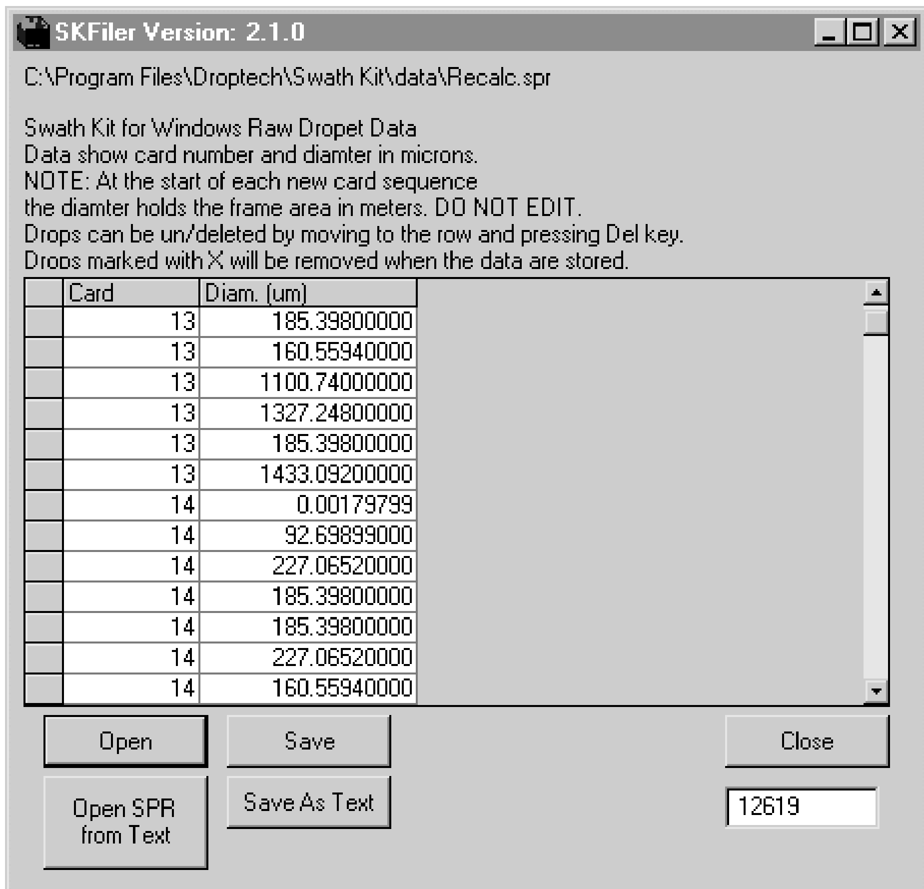
You will see two columns of data – Card and Diam (μm). Note: you may have to expand the column of the diameter data by clicking on the right hand side of the column header, and moving it left.

4. Each measured stain has a record. The card number is self-explanatory. The Diam field refers to the **diameter of the stain.** Whatever the shape of the stain, an algorithm calculates the stain based on it being perfectly round. This is the raw data – it is not affected by what the filter setting is, or what spread factor you have selected. You will have to apply your own spread factor in any data analysis.

5. At the start of each new card data sequence, there is a number that indicates the frame area (in square meters). Do not delete that record!

Figure 9.4:

SKFiler32.exe window showing the stain diameter of every stain measured in a trial. Note that the first record of a new card shows the frame area in meters.



9.3 Manual Data Entry

Situations arise when you would like to plot and analyze a data set of a swath pattern parameter that was not obtained with the Swath Kit. A typical example may be a series of values of a colored tracer dye that was washed off from samplers placed adjacent to a line of target cards used for droplet deposition. The data may be dye concentrations obtained from a spectrophotometer.

Such data can be entered into a Swath Kit manually, using a data table. Although it is possible to enter droplet size percentile data, typically this is not available from other lab analyzers; no matter, there is no need to fill out all the fields in a data table.

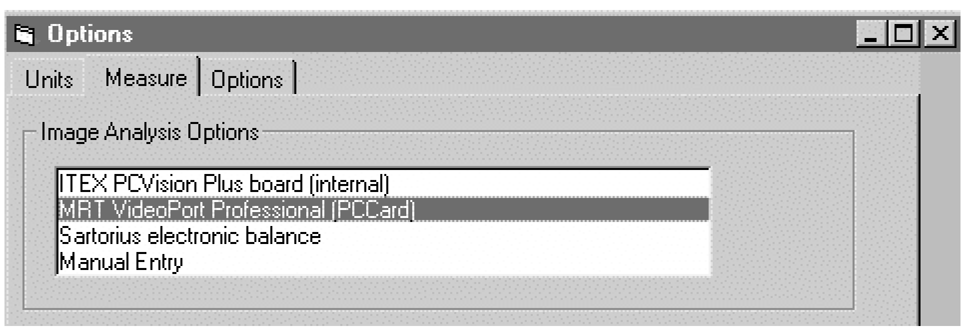
Note: A new trial must be created for a manual entry data set. It is not possible to mix image analysis-generated data with manually entered data. This applies to replicates too; you cannot create a trial, read a set of cards with the Blue Box, hit the replicate button and manually enter the data in the new replicate.

9.3.1 Manual Data Entry Procedures

Once you create a new Trial and add a Mission (you may use the same Mission that you used for image analysis of cards using the Blue Box), go to Tools | Options and select the Measure tab. There is a drop-down list in the box titled 'Image Analysis Options' itemizing the different hardware devices that it is possible to use for data input. Select the 'Manual Entry' option and click OK (Figure 9.5). This will configure the Swath Kit program not to use the image analyzer when you press the Measure button on the Measure tabbed screen (as you do in normal image analysis). Instead, you will be presented with a data table that you can use to manually enter data (Figure 9.6).

Figure 9.5

Selecting the Manual Entry option from the Tools | Options menu.

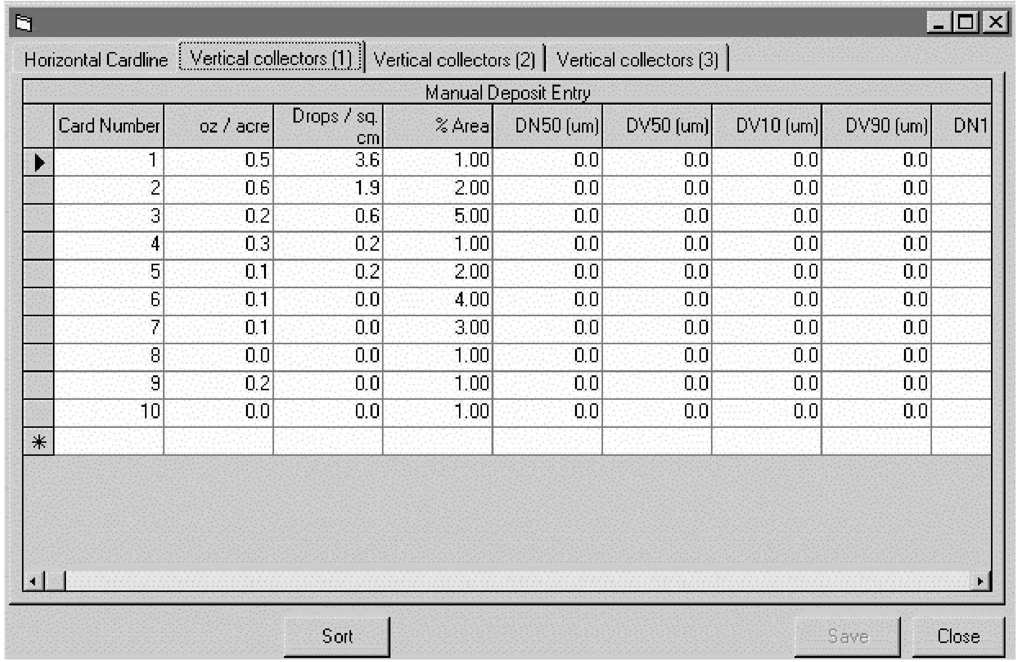


Once you have entered the data manually, the full analysis options of the Swath Kit are available for the parameters entered. You should normalize the data values so that they make sense. E.g. you may have tracer wash-off data in mg/mL. You can calculate the total volume of material per unit area (e.g. gallons per acre) by using a coefficient calculated from the dye concentration in the tank mix and the area of the sampling target.

Figure 9.6

Manual data entry table. Select the appropriate sampling cardline from the tabs at the top of the table.

All of the fields can hold data, although it is not necessary to fill all the boxes. The card numbering should be sequential.



	Card Number	oz / acre	Drops / sq. cm	% Area	DN50 (um)	DV50 (um)	DV10 (um)	DV90 (um)	DN1
▶	1	0.5	3.6	1.00	0.0	0.0	0.0	0.0	
	2	0.6	1.9	2.00	0.0	0.0	0.0	0.0	
	3	0.2	0.6	5.00	0.0	0.0	0.0	0.0	
	4	0.3	0.2	1.00	0.0	0.0	0.0	0.0	
	5	0.1	0.2	2.00	0.0	0.0	0.0	0.0	
	6	0.1	0.0	4.00	0.0	0.0	0.0	0.0	
	7	0.1	0.0	3.00	0.0	0.0	0.0	0.0	
	8	0.0	0.0	1.00	0.0	0.0	0.0	0.0	
	9	0.2	0.0	1.00	0.0	0.0	0.0	0.0	
	10	0.0	0.0	1.00	0.0	0.0	0.0	0.0	
*									

9.4 Dry Material Pattern Analysis

One of the original Swath Kit users expressed a need to use the Swath Kit for analyzing results from collectors of dry materials. Instead of using a one-dimensional card line, a two-dimensional array of several lines was used to sample the dry material. The results can be presented as an x,y,z 3-dimensional graph where the z-dimension represents the distribution of material/unit area.

Direct data entry from the serial port of a Sartorius electronic balance was enabled. At time of writing (April 2001), DT has had no feedback from the user on how effectively the dry material option works in the Swath Kit. These instructions are presented with the proviso that they are untested and as yet only supply one manufacturer of balances. However, we at DT believe that the system can be developed further to accommodate other hardware if users have this requirement.

9.4.1 Dry Material Set-up Procedures

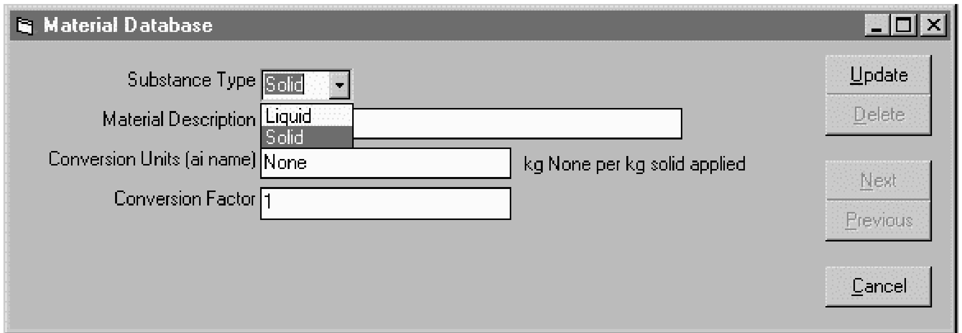
In order to configure the Swath Kit for dry material collection, it is necessary to tell the program that data will be coming from a serial port on an electronic balance instead of an image analyzer and to create a dry material in the material database.

To select the correct hardware, go to Tools | Options on the main menu and select the Measure tab. There is a drop-down list in the box titled ‘Image Analysis Options’ itemizing the different hardware devices that it is possible to use for data input (figure 11.4, above). Select the appropriate balance from the list (at time of writing, April 2001, only the Sartorius balance is available).

To add a material to the database option on the main menu, select Material, New (Figure 11.6). The top list box labeled ‘Substance Type’ gives you the option of selecting a liquid (default) or solid material. Selecting a solid material removes the spread factor parameter table, and changes the Conversion Units box to ‘None per Kilogram’. Enter a Material Description, the units you want to use (for example pounds) and enter the Conversion Factor as 2.205 (the number of pounds in a kilogram). This is similar to the principle used with liquids, where the standard units are liters. The Swath Kit records mass data in either kg or L, and you have to indicate in what units you want the final data displayed. This is what the 'Conversion Factor' is. It is a simple coefficient (multiplier for the non-technical) to convert kg to your units of choice.

Figure 9.7

Adding a new solid material requires that you specify 'Solid' in the Substance Type drop-down list.

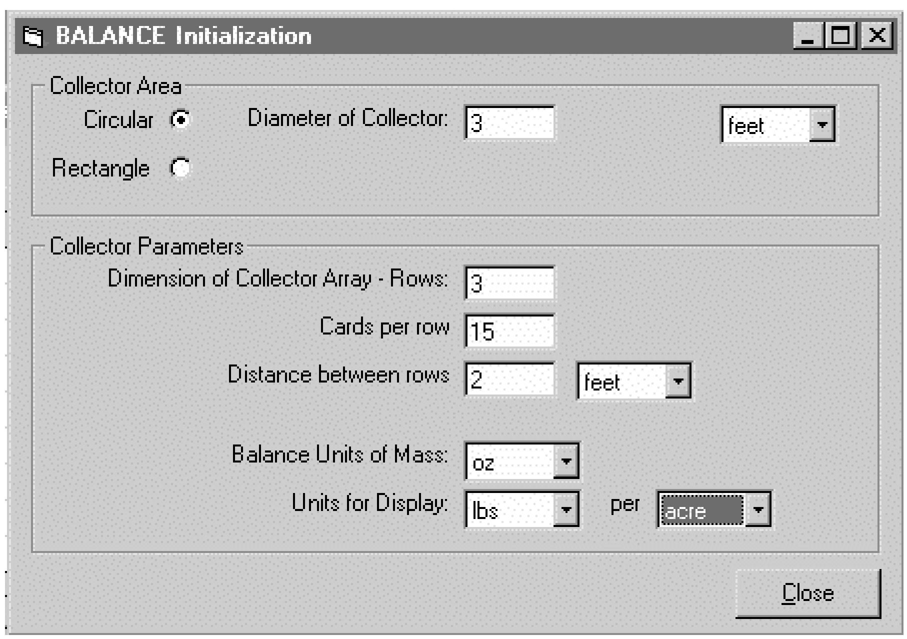


9.4.2 Balance Initialization

When you press the Measure button in the Measure tab, the program presents a Balance Initialization screen (Figure 9.8). This is where you set up the size of collectors (which enables the Swath Kit to calculate mass/acre or ha) their arrangement (rows and columns) and spacing. It is also necessary to enter the units of measure being output by the balance and the units for the display. Use the drop-down lists in the appropriate boxes.

Figure 9.8

Balance Initialization screen. This is where you tell the Swath Kit the collector arrangement and size, and the units used by the balance and the units required for display.



9.4.3 Data Entry

Once you have initialized the balance, the program display s the data entry screen (Figure 9.9). A table based on the collector array (rows and columns) is displayed along with box showing t the raw input from the balance. A separate tab enables you to put a value for the Tare – which subtracts the weight of the container that you use for measuring your material. Most electronic balances enable this to be done automatically alleviating the need to use this option.

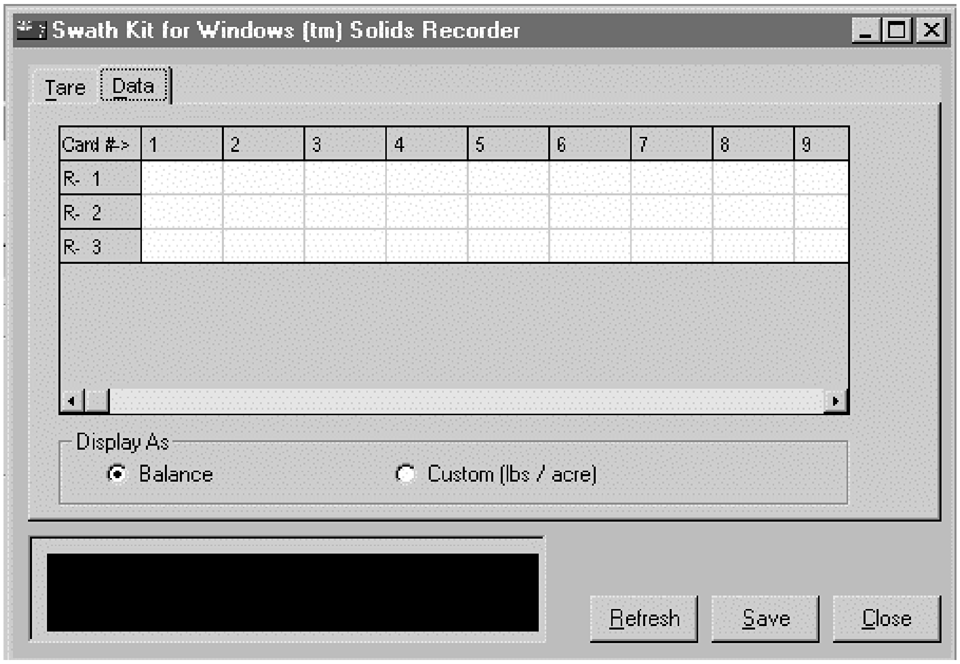


Figure 9.9

Data entry screen for dry material.

9.5 Registering the Swath Kit Program

When the Swath Kit program was released, we allowed users a 10-day trial period before they had to get a registration key. We now allow all users to install the Swath Kit software in as many computers as needed. The registration wizard is provided in the Swath Kit CD.

To make the installation permanent, run Regwizard (in the Registration folder on the CD). Note that the regiwizard.exe program must be in the same folder as the license.dat file.

Hen running an unregistered version of the Swath Kit, you will get a registration screen that will give you Registration Number. Enter this number into Regwizard and it will produce an unlock key. Enter this unlock key to make your installations permanent. Make sure that you quit the Swath Kit program completely after using the unlock key.

This procedure gives you the freedom to install the Swath Kit (and Met Kit) on any number of computers.

10. Glossary

Actions

When in the Analysis window you can perform three different displays with the deposit data: Pattern, which simply displays the shape of a single flight line; Overlap, that displays the expected shape of the field deposit from multiple overlapped flight lines; and Analysis, that will display the average deposit and its variation from a range of lane separations.

Active ingredient units

The Swath Kit measures volume of spray per card area. To convert this to meaningful active ingredient units you must provide the relationship between liters of spray to your active ingredient, e.g. lb. AI per liter of spray. This relationship is stored with the Material.

Aircraft database

A predefined series of common agricultural aircraft types that can be selected for aircraft trials. The database contains detailed information about aircraft type and characteristics. Not editable by the user.

Aircraft Type

A combination of aircraft manufacturer and model. If the exact specification is not available pick the nearest model and engine type.

Application Rate

The volume of a spray material applied per unit of area - typically presented as gallons/acre or liters/ha. Used interchangeably with its synonym, Volume Rate.

Atomizer databases

The atomizer database contains descriptions of many common agricultural nozzles and describes their flow rate as a function of pressure. Not editable by the user.

Atomizer type

A combination of the atomizer manufacture, atomizer class (e.g. flat fan, hollow cone etc.) and the restrictor size. Atomizer type is selected from a list of available atomizers. If the specific atomizer is unavailable you should choose a similar type. Note that the Atomizer Assistant can’t give correct suggestions unless the correct atomizer is selected.

Calibration Assistant

An ‘expert system’ programmed helper who suggests the nozzle type and number required for a particular spray task.
Cardline Conditions
The orientation is the bearing of the direction of the cardline. Note that either the bearing or its reciprocal can be used (e.g. 280 degrees or 100 degrees).
The center refers to the card over which the aircraft flew.

The spacing is the card spacing given in the units referred to by the label near the box (usually ft or m).

Centerline

This tags the card that the aircraft over-flew during the spray pass. Watch carefully as the aircraft over-flies the line so that you see exactly which card was over-flown. This data is used in the overlapped spray simulation to position the spray passes so accurate estimation is required.

Characterization

A commonly used expression for capturing and measuring the characteristics of an aircraft's spray pattern. A characterization usually involves an assessment of spray distribution across the swath and a droplet spectrum analysis. Also known as 'Spray Pattern Analysis'

Coefficient of variation

Coefficient of Variation is a dimensionless measure of variation, as a percentage. It is calculated from the Standard Deviation divided by the mean. This should be used as a yardstick of how even or uniform an overlapped spray pattern is. For aerial application, a number of 30% is reasonable. Remember, any fool can spray a 1000' foot swath with a Piper Pawnee just by increasing the flowrate so that the mean deposit over the area is correct, but you certainly wouldn't be happy with the variation of deposit in the overlapped swaths!

Custom Aircraft

A named aircraft profile consisting of:
A specific aircraft type
A nozzle location listing
An N number
A pump type
These parameters are stored together as a Custom Aircraft using a descriptive title, for example: 'Billy's Ag Truck D6-45: Cotton Contract'

Date/Time

The time at which the aircraft flew over the cards. This is important because it serves as the link into the weather database. Press the Data/Time button to edit this field and ensure accurate format. If a date and time are already entered then you will be able to edit these data. If the field is blank then the current time will be displayed in the edit box.

Use the format 06:34:19 01-Jan-98 (hours:minutes:seconds day-month-year)

$D_{V0.5}$ & $D_{N0.5}$

See NMD & VMD

Flight Conditions

Aircraft airspeed, and height above ground in the appropriate units.
Flying height should be obtained from the aircraft or from photography of the aircraft as it passes over the card line. If the aircraft altimeter is used, ensure the elevation of the test site is measured by first taking the altitude of the airfield or test site before take-off using the aircraft altimeter, and then subtracting this elevation from the altimeter reading during the spray run.

Flying speed can be determined either from the aircraft or from a radar speed-gun. However, be aware that the aircraft air speed indicator (ASI) is measuring the indicated air speed (IAS) of the aircraft, not the ground speed (GS). Thus, an aircraft flying at an ASI reading of 100 MPH into a 10 MPH head-wind is only actually traveling at 90 MPH relative to the ground.

Flight Direction

Intowind - Offset from Centerline: Usually you will fly the aircraft at right-angles to the cardline. If the wind is not exactly in-line with the flight direction, you can offset the flight line to the upwind side of the center card (card 50 out of 101 cards) to allow the whole spray pattern to be caught. This technique is the most commonly used, especially if the wind is predictable.

Intowind - Over the Centerline: An alternative technique, which ensures spray patterns are always flown into wind, is to fly the aircraft over the centerline but always fly it directly in-line with the average wind direction. This means that the flight line of the aircraft will not necessarily be at right-angles to the cardline. When this technique is used then distances between the droplet collectors needs to be adjusted. Actually, for reasons of simple geometry, they are closer together than you originally laid them out. The Swath Kit will adjust these measurements for you if you choose this option. A small window will appear after you have measured the weather when you can accept or reject these changes.

Crosswind: Fly at right angles to the wind and cardline, and orient the cardline to be parallel with the wind. You will need to fly over the upwind end of the cardline; remember to adjust the centerline card in the Information File.

Field Application over target area: Use this option if you made a field application with overlapped spray passes, not a single spray pass, over the cardline. When you choose Pattern in the Analyze Spray Pattern part of the program, the Swath Kit will work out a coefficient of variation as well as an average deposit. No overlap simulations are permitted because the data already represent the deposit from an overlapped application.

Flowrate

The amount of spray per atomizer/aircraft per minute. For example: 12.3 fl. oz/minute per atomizer.

Lane Separation

The successive distance that a pilot offsets a spray aircraft when spraying an area. Note that Swath Width is sometimes mistakenly used to define lane separation.

Location

Enter a name of the place where the trials were held.

Material

Each spray solution is described in the Material database by its spread factor and conversion ratio between liters of spray to active ingredient units. Choose a material prior to measuring deposit.

Mission

A saved profile of a specific aircraft, fitted with a boom with measured atomizer mounting points, and specific atomizers. The *mission* profile is used for construction of individual trial profiles.
Example: ‘Cotton Contract: Billy’s Ag Truck D6-45’

Mission description

A descriptive term used to describe or name the spray mission. Since the spray mission includes both aircraft and spray parameters, try and make the Mission Description include these elements too. For example: “GYPSYMOTH: 1 gal/A: Bt Micronairs”

Module

A pre-defined item of information such as an aircraft or mission.
Examples: A mission profile is a module which can be used many times for different trials.

NMD (Number Median Diameter)

Also written as $D_{N0.5}$. The droplet size (usually in μm) in a population of droplets that has an equal numbers of droplets that are both greater and lesser than that droplet size. See VMD

N-Number

This is the ICAO registration of an aircraft. In the US all registrations stat with the letter ‘N’ followed by a number. In the rest of the world, registrations are all letters, with a country code at the start. Up to 8 characters may be entered, numbers or letters.

Overlap Method

An aircraft can fly the field in two ways: Racetrack, where the aircraft flies successive spray passes in the same direction; or, To & Fro where the direction of flight is alternated for successive runs. Use the Overlap Method control to select the flight Overlap Method.

Pixel

A pixel is a picture element and is the smallest resolution of the image. The size of each picture element is determined by the magnification provided by the camera lens. The size of the measured image depends on the number of pixels horizontally and vertically. The Swath Kit uses either 640 (H) x 512(V) or 640 x 480 pixel resolution.

Pressure

Pressure refers to the in-line boom pressure. A single measurement is typically used to represent the entire boom and nozzles. However, actual pressure at each nozzle will differ slightly depending on distance from pressure gauge and plumbing.

Pump type

Choose from three options: Engine driven, Windmill or Electric. This information is used correctly print out calibration instructions.

Racetrack

The aircraft is flown in the same direction for each spray run.

Replicate

A repeat of a trial. The repeat is performed with the same spray equipment set-up, in as similar a manner as possible (e.g.: spray height, wind direction).

Source

Deposit can be displayed using one of three parameters: active ingredient per unit area, droplet number per unit area, and percent coverage. The Dv0.5 is not available because it cannot be used in overlap analysis. Use the Source option to select which deposit parameter to work with.

Spray Pattern Analysis

See Characterization

Spray volume

The volume of spray mixture applied per unit area. For example, 10 gallons per acre. This does not relate to the amount of pesticide, just the total carrier volume. a.k.a. Application Rate.

Spread Factor

An equation which calculates droplet diameters from stain diameters. For the Swath Kit for Windows, it takes the form of a polynomial,
Droplet Diameter = ß0 + (ß1 x Stain Diameter) + (ß2 x Stain Diameter^2)
(where ß0, ß1 and ß2 are constants).

Swath Width

A term with many meanings. Often used mistakenly in place of lane separation, but best used to define the entire width of the swath from edge to edge. Also known as pattern width.

Target Airspeed

The expected forward ground speed of the aircraft. This is needed to permit calculation of the flow per minute from the aircraft (based on forward speed, lane separation and desired spray volume). flow per minute per aircraft is a crucial piece of information for choosing the correct size nozzle.

Toolbar

The toolbar is a series of buttons to launch actions. It also informs you of the available information for a trial. If data (weather, spectrum or deposit) are missing then the data view button requiring that data will be disabled (as will the menu option).

Trial

A trial is an individual characterization run of a spray aircraft. A trial is built up from a mission profile that contains a description of the trial's spray goal, a custom aircraft and an atomizer. Added to this are trial-specific information and data that relate only to a single trial, for example, the aircraft measured speed, the weather or the spay deposit.

Trial location

A simple textual description of where the spray trial is being held. Additional description may be added to the Notepad.
Trial Names
A trial name can consist of up to 64 letters numbers and spaces. Use names which will be easily recognizable. The same trial name can be used for several replicates, which differ from each other only by their replicate number.
Example: Gypsy Moth 96: Ag Cat/Bt/Micronairs/45 deg.

To & Fro

The aircraft is flown in alternating directions to and fro for successive spray runs. Use the space to show options. Place the cursor on the field you want then press [Enter]. Choosing the correct option is important because the Swath Kit needs to know how you intend to fly in order to make correct warnings about the appropriate wind direction.

Update

Update the database with newly entered information. When enabled, data in a trial have changed and should be saved.

VMD (Volume Median Diameter)

Also written as $D_{V0.5}$ The droplet size in a population of droplets where equal volumes are made up of droplets that are both greater than the VMD and less than the VMD. See NMD.

Volume Rate

Another name for Application Rate. The volume of a spray material applied per unit of area - typically presented as gallons/acre or liters/ha
The spool file consists of an ASCII format file with 6 columns: Date, Time, Wind speed, Direction, Temperature and Humidity. All units are SI.