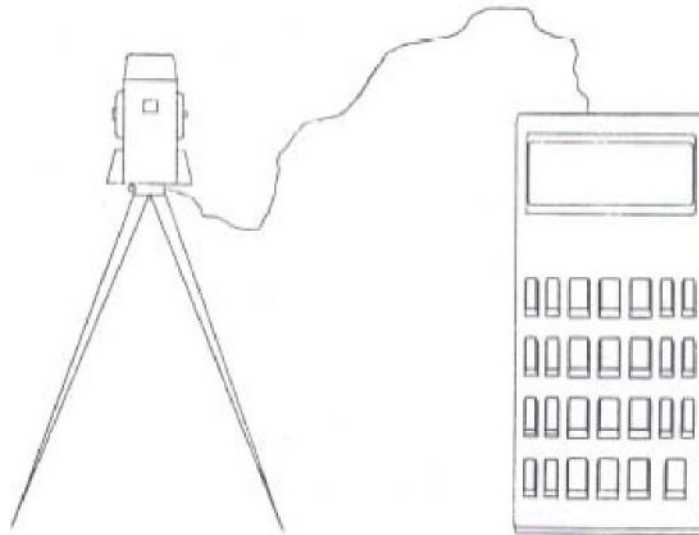


**ELECTRONIC FIELD BOOK SYSTEM  
EFB  
USER'S HANDBOOK**



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## **(1) INTRODUCTION**

Florida Department of Transportation Electronic Field Book system (**EFB**) is designed to meet the specialized operational requirements for highway route surveying.

The Electronic Field Book is a system of:

- X Surveying Instrument(s) (usually Total Stations)
- X Software
- X Computer Platform(s)

The computer platform for field operations is a rugged, hand-held Personal Computer (PC) operating under a Disk Operating System (DOS).

The computer platform for office operations is a desk top PC, operating under DOS. Files may be transferred to any other operating system as desired.

The software is designed to be simple and consistent with current field practice. The software-hardware combinations are also device (field computer, total station) independent. The goal of the system is to provide both an automatic and manual field book for the gathering of conventional survey data, in a format that may be easily and efficiently used in the highway design process. The software also uses state-of-the-art methodology and data processing techniques to improve the accuracy of results delivered to the designer or mapper. The EFB permits uniformity and efficiency in the data gathering process, while not sacrificing the flexibility of the manuscript field book.

This documentation is intended to describe the operation of the Electronic Field Book system on the hand-held computer for field operations. The documentation serves as a description of software operation that is common to all supported hand-held computer hardware and the field operation of the system.

Processing the data collected is explained in separate publications.

## **(2) BASIC CONCEPTS**

As with any computer, the EFB cannot make intuitive decisions about the environment in which it operates. Therefore, the surveyor "guides" the EFB through the survey tasks by structuring his data in screens designed for specific types of data, which are then recorded in chronological order, thus producing the complete record of field operations. The data are placed in the screens by responding to prompts, and the screens are selected through the use of menus.

The menus, which open specific data screens, are the means by which the EFB is guided through a job.

(a) **Point Naming**

Point names used by the Department will adhere to the abbreviations found in Appendix C - Standard Abbreviations found in this document.

For EFB a system of alphanumeric point names consisting of two parts was developed:

- the alphanumeric **prefix** designated by the surveyor
- a numeric **suffix** assigned by the system.

Users will select an alphanumeric prefix of up to seven characters. The numeric suffix, serial in nature, will be assigned by the system. The suffix will be from one to seven characters, depending on the length of prefix chosen by the user. The length of the prefix and suffix combined will not exceed eight characters. Many thousands of points of the same alpha name, each differentiated by a unique numeric suffix can be accepted by such a system.

A point previously observed or occupied may be used at a later time in the survey by simply typing in the complete point name designation of the object (prefix and suffix) as it was earlier designated.

Some examples of point names are:

PAVT5  
TREE16  
FH27  
MH2  
FL88  
RR92  
DR16

Notice that in each case the numeric suffix is attached to the prefix to make the *complete* point name! A prefix of seven alphanumeric characters is the maximum that is allowed to be assigned by the surveyor. In such a case where seven characters are chosen as a prefix, the point name has only nine possible suffixes (i.e. JOHNSON1 through JOHNSON9). Although using long prefixes is allowed, it is inadvisable to do so since it limits the total number of point names that can be used in a project, and can often be cumbersome to type on a limited keyboard.

The following will illustrate the magnitude of point names available with such a point designation system:

A1....A9999999  
AA1 . AA999999  
AAA1AAA99999  
AAAA1AAAA9999  
AAAAA1AAAAA999  
AAAAAA1AAAAAA99  
AAAAAAA1AAAAAAA9

'A' represents a possible alphanumeric character (A through Z).

You can see from the previous example that the total number of point names available is very large. Since this also provides flexibility, and the opportunity for meaningful abbreviations, the surveyor should use the simplest prefix in the point naming that is meaningful to him. He would select a prefixes that will be easily remembered and will intuitively suggest the objects observed in the field.

(b) **Reference Naming** - (B: field of Setup, HVD Obs and SOR Obs screens)

In many instances, it becomes necessary to communicate the *OFFICIAL* designation of an object. This is especially true when using the results of previous surveys and their monumentation, such as the National Geodetic Reference System (NGRS). Points monumented by the United States Coast and Geodetic Survey, National Geodetic Survey, U.S. Army Corps of Engineers, Departments of Transportation, or other organizations are often designated with a name, stamped on the monument. The EFB has the capability to use these designations, but they are used as *reference* to the point name. Another, and perhaps more important use of reference names is to indicate to the segment manager which points potentially contain control information.

The *reference name* is used for communicating the stamping, or "official" designation of a mark or object for others who may subsequently tie to the object. The reference name is the way to associate common points between all other data sources, and past or future surveys. The reference name is also the means by which the segment manager knows that points potentially contain control information; coordinates or azimuths. When the data are brought back into the office, CAiCE will interrogate the incoming data, looking for reference names. If a reference name is found, it will attempt to find control coordinate or azimuth data for that point in a control database set up by the user. If the reference name found in the field data

does not have control information in the control database, the user will have the opportunity to add some control information to the control database for that given name.

An example of a reference name would be the stamping on an NGS horizontal control station. The surveyor notes the designation (stamping) of that mark with a reference name. The surveyor must also assign a point name for use by the EFB for the NGS station.

Any monumentation set while collecting data having a particular stamping or designation of importance would also be given a reference name (that of the designation), since others may use that monumentation at some later date, and will need to be able to "reference" back to work performed establishing it (ie. it's coordinates). This is the manner in which the surveyor may update his control database, once the processing of the data is completed.

The Reference Name should be entered into the B: field the first time that the point is utilized in that particular segment. If it is a point to be used to establish new Control it will be preceded with a period (.). If it is existing known control that has already been entered into the data base from a previous segment, enter the name reference only without the period. The Reference name will have the county designation, date, series and number of BLC, for example 8691A01. If NGS or other control, enter the stamping on the mark as found in the field.

Reference names are keyed in exactly as they are stamped. Reference names are limited to 16 alphanumeric characters however, and may contain special characters such as dashes (-), spaces (a space used in a reference name will be printed as an underbar), and periods (.). In some instances, a reference name may exceed 18 characters as stamped on the monument. In this instance, the user must abbreviate in some way. Most data screens support some form of comments, and notes to this effect may be placed there.

An example of a reference name that might be keyed is:

LOGAN\_TOWER\_1934 **Note: The underbar ( \_ ) is printed when a space is input in the reference name field on the data screens.**

060-92-A05

**Note: The period (.) indicates this point will be added to the Control Database.**

WARNING: It is extremely important for the field surveyor to use the reference name capability for designating which points are control and their identity, and to carefully key in reference names to avoid misspelling. If the field surveyor is careless in typing, the ability to automatically create control files for the project during processing will be lost, and he may not be able to even perform important processing steps!

The warning above alluded to a case where the surveyor neglects to use reference names at all. This is a bad decision since the CAiCE processor relies on being able to "reference" control, for which the reference name was provided. If you are establishing control for the first time, and cannot decide on a reference name, it is a good idea to type the survey point name as the reference name.

(c) **Planimetric Information**

1. **Geometry - The geometric use of a point, when that point is part of a multi-point object.**

Many objects may be designated with a single point, such as a telephone pole, or a valve cover. When larger objects are to be designated, such as the edge of pavement along a length of highway, *many points* are often used. When an observation is made to locate an object, the EFB requires that information about that object be input to indicate the object's **potential** relationship in multiple-point configurations called chains. The information required is what is known as the *geometry* of the point.

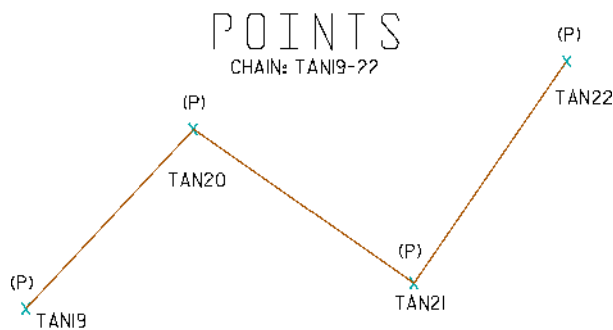
For all practical purposes, there are simply three geometric elements that exist that are of significance in field surveying; individual points, lines, and curves. The geometric relationship between points becomes important when we begin to associate many points together, such as our edge of pavement example previously. When we speak in these terms, the geometric elements (more than one point) that concern us are lines and curves, since "a point is a point". The surveyor will attach geometric relationship information to every object (point) he locates using the EFB.

For EFB surveying, all geometry attached to a point is one of two types:

Point (**P**) - a single location for an object wholly defined by one unique set of coordinates, or the intersection point of straight lines (tangents) in a line string.

Curve (**C**) - a point on a *circular* arc, or a point on a *smooth* curve (spline) passing through a series of non-linear points.

A point geometry, **P**, indicates that the point in question will never be used in a curve. To explain this a bit further, we need to have an object in mind, such as a tree. A tree will seldom be used as part of a curve, therefore the geometry for the location of that tree should be *P*, for point. Points connected together (a *chain*) may also have been given the geometry type of *P* for point. This is true, for example, when the surveyor connects the points representing poles supporting a power line. The location of the poles are given a *P* geometry, since they all lie as points-of-intersection (PI's) of the wire span.



A curve geometry, **C**, indicates that the point in question is part of a curve. The *C* geometry would be used to indicate any point lying on a curve. More importantly, the curve geometry is used for points to indicate critical places of curvature, such as the PC's, POC's, PT's, etc.

Identifying the geometry of the points located in the field is therefore minimized to simply **P**, for point, or **C**, for curve. The geometry of points eases construction of complicated elements as we will see later.

## 2. Types of curves



To simplify the EFB, only two types of curves are supported in the EFB. The first type of curve defined for the EFB is the **circular arc** which is a curve with a constant radius. When surveying a circular arc, it is only necessary to locate points actually on the curvature of the arc. The radius, and other geometric elements of the arc are solved from the relationship of the points surveyed.

The second type of curve is what is known as a **smooth curve**. A smooth curve *best fits* a curve passing through points defining the curve itself. A good example of an object that may be located with the smooth curve is a stream. There is no defined geometry for a stream, but the meandering of the stream can be shown to pass through survey locations modeled by the smooth curve.

To present how the circular arc, and the smooth curve are defined in the field, a few simple rules should be kept in mind when deciding how observations are to be taken:

X     **Three (3) curve points in sequence define a circular arc (PC, POC, PT)**

A special case of a circular arc may be defined in the field by a single curve point, provided the back and ahead tangents are properly defined by *P* points.

X     **A smooth curve is defined by four or more curve points in a**

The EFB user is responsible for indicating the geometry of every point he observes or occupies. As mentioned, there are only two choices:

X     The observed point is a **P-Point** location (i.e. a tree, fire hydrant, PI of two intersecting lines, etc.)

X     The observed point, **C-Point**, is on a circular arc or spline curve (i.e. edge of a meandering stream, a horizontal curve in the road, etc.)

It is possible that the assigned geometry of a point has no meaning. Such is the case when a tree, for instance, is accidentally given a *C* geometry type. The system does not care whether a single location for an object is *P* or *C*. When locations are tied together, it becomes very important that the surveyor correctly define the geometry. The *tying* of points together is how

the geometrics of line work will be expressed, which is known as the chain.

3. **Chains - A named (chain name) series of points that have been previously located and their geometry (P -or- C) for each point in the series is defined.**

Geometry of points is important when points are associated together to describe the shape of objects. The association of points is what is known as a **chain**. A chain is the *ordered* connection of points that define the boundary of an object. An analogy of how a chain is constructed is the child's drawing game *Connect the Dots*. The line work (chain) connecting the dots (points) is exactly how objects containing multiple points are described. Understanding this, the "chained" association of points with their corresponding geometry(s) on the individual points in the chain creates circular arcs, smooth curves, and straight lines.

This series of points, the chain, is listed by the surveyor in the order that indicates the succession of points along an object. The line work connecting the successive points define the limits of the object.

Like a point, a chain has a **chain name**. The chain name has a prefix and suffix, and follows the same general rules as point names. A chain name may contain a total of eight characters, where the last numerals are maintained by the EFB.

A chain may be **stationed**, which makes it a baseline, or otherwise known as a **route**. If a chain is stationed, observations may be made to points referencing the stationed chain, which is commonly known to the surveying community as location by station and offset.

The stationing of a chain is input in standard station notation or as a whole number and decimal fraction. An example is:

10+00 or 1000 for station 10+00.000

-or-

13+66.273 or 1366.273 for station 13+66.273

The stationing defines the beginning length for the **first point** in the chain listing, and as progression is made down the chain list, the stationing increases. The station value is not input for any

other point in the chain list, but may be computed in the office by the geometry package(s) available for the EFB. A chain can represent a three-dimensional object, and is controlled by the X,Y,Z coordinates (or Station, Offset, Elevation) of every point included in the chain listing. If any point in the chain listing does not contain a Z ordinate, the chain will be two-dimensional only. If the surveyor includes a point in the chain listing where only an elevation or Z ordinate value may be computed, the chain will be ignored altogether. A two-dimensional chain would be any sequence of points where not all of the points in the chain listing contain computable Z ordinates.

Chains not only represent topographic features, but may be *design* elements of the route alignment. An example of this is a chain containing the critical points that comprise a highway route, which are the PC's, PT's, and PI's.

#### 4. Chain lists

Since a chain is simply a listing of points in sequence, the surveyor must identify the ordering of the points in the **chain list**. The EFB allows any point previously observed to be included in a chain list.

Since the surveyor defined the geometry of points (**P**oint location or **C**urve location) at the time of observation, **arcs**, **smooth curves**, and **straight lines** between points will be generated automatically based upon the sequence of points as they occur in the chain list. The surveyor does not have to define the elements of curves (radius, length, degree of curve, etc.).

#### 5. Rules for chain lists

X Points used to define a chain are listed in the order that the line work (or curve work) connecting the points is to follow (not necessarily the chronological (time) order in which they were surveyed).

Example: ABC1,ABC17,ABC2 point ABC2 must have been observed prior to ABC17, yet ABC17 can occur earlier in the chain list

- X Individual points, or groupings of points in the chain list are separated by commas, which indicates connection will be made between the individual points, or the groups.

Example: XSECT1,BX45,TL1 indicates that line work will connect point XSECT1 to point BX45, and connect point BX45 to point TL1

- X A group of points to be connected in **ascending** order which share the *same* name prefix, may be listed by the name prefix only, thereby **globally** including all points with that prefix in the chain. The order runs from the lowest numbered suffix to the highest numbered suffix.

Example: XSECT if seven (7) XSECT points existed, this global listing connects XSECT1 to XSECT2, XSECT2 to XSECT3, and so on until XSECT7 is reached.

- X In the case of a global listing, the order of points may be **reversed** by placing a dash (-) in front of the listed global prefix to indicate the points are to be taken in **descending** order.

Example: -XSECT if seven (7) XSECT Points existed, this global listing connects XSECT7 to XSECT6, XSECT6 to XSECT5, and so on until XSECT1 is reached.

- X A limited **range** of points may be listed by placing a dash between the beginning point and the ending point of the range desired. The order of the points, ascending or descending, is indicated by the magnitude of the point suffix that occurs earliest in the list.

Example: XSECT1-45 indicates that point XSECT1 through point XSECT45 are to be chained in ascending order, connecting XSECT1 to XSECT2, XSECT2 to XSECT3, XSECT3 to XSECT4, and so on until XSECT45 is reached.

The range may also be listed in descending order, where XSECT45-1 indicate the reversed list of the previous example.

X A double comma(,,) between individual points, global listings, or ranges in a chain list indicates a **gap** or break between the point before and after the double comma (gap).

Example: XSECT1-15,,18-22 indicates there is **NOT** to be a connection of line work between point XSECT15 and point XSECT18, however the ranges indicated in the listing (XSECT1-15 and XSECT18-22) are to connected.

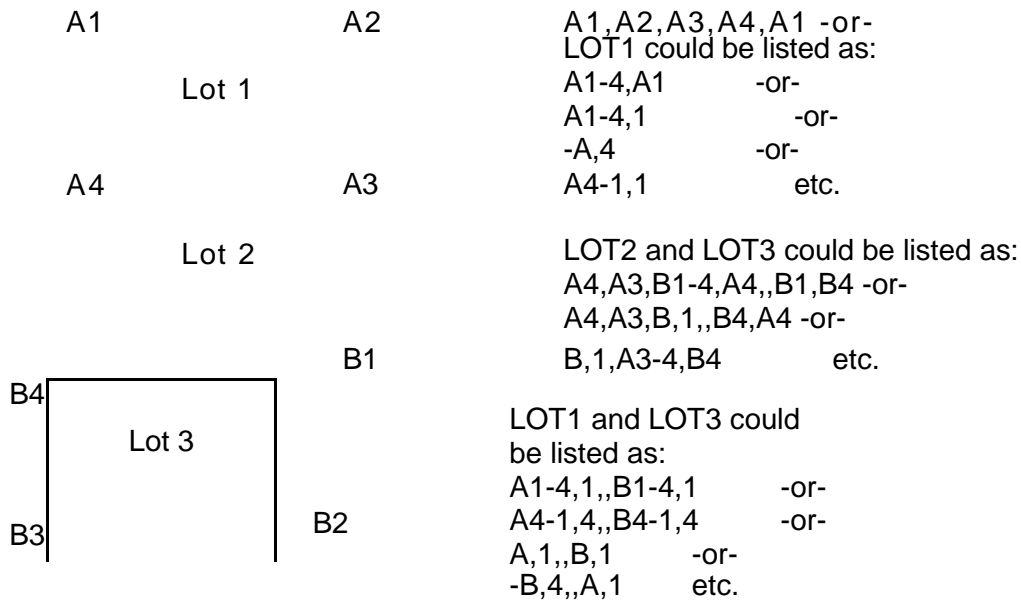
A chain list does not have to be *singular*, which means any number of points with differing point name prefixes may be used in the list.

Example: RD,PAVT1-44,DWY6-14,,15-22,PAVT45-71,,72-108,-  
LAKE

The point name prefix is *implied* or carried through the list until a new point name prefix is encountered. A more expanded listing of the previous example would look like: RD,PAVT1-PAVT44,DWY6-DWY14,,DWY15-DWY22,PAVT45-PAVT71,,PAVT72-PAVT108,-  
LAKE

The user will probably elect to use the abbreviated methods of listing the chain to reduce the amount of typing in the field.

The following example should illustrate how the concepts of *global* listings, *reversed* listings, and *ranges* are used to simplify chain lists. Several examples of valid chain lists are given to describe the lots shown below. The use of the *comma* separator and *gap* is also demonstrated.



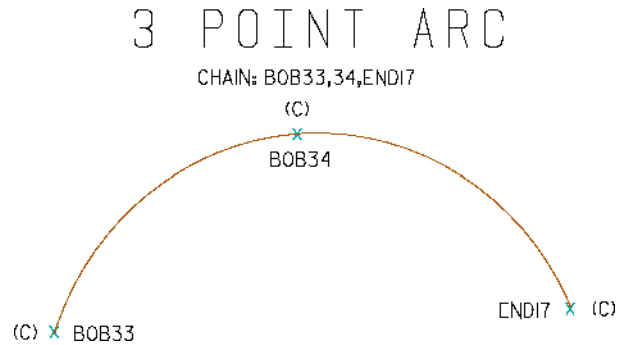
The previous examples demonstrate a variety of ways a *similar* chain can be defined. EFB allows the surveyor flexibility for chain listings. There are many ways to list a chain and achieve the same results. The list is as simple as the surveyor desires, though correct ordering of the list is required to properly describe the object. The lists may become very cryptic as the surveyor attempts to optimize the definition.

Now that we have demonstrated how the chain list is assembled, we will look at how the geometry of points in the chain list affect the graphical presentation of the chain. Remember that it is the **P** and **C** geometry typing of points in the list that influence the way arcs, smooth curves, and line strings are generated in the EFB.

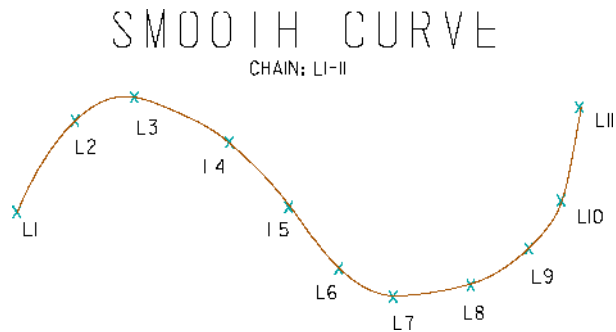
The geometrics of the chain is derived from the geometry of the points included in the chain listing. Since points included in the listing will contain either a **P** or **C** (point or curve respectively) as their geometry type, the frequency of the **C** geometry type will determine how lines and curves in the chain are to be constructed.

Curves are determined in three ways:

- X If three (3) points with geometry type C are encountered sequentially then a circular arc is generated, where the first point is the **PC**, the second a **POC** and the third the **PT**.

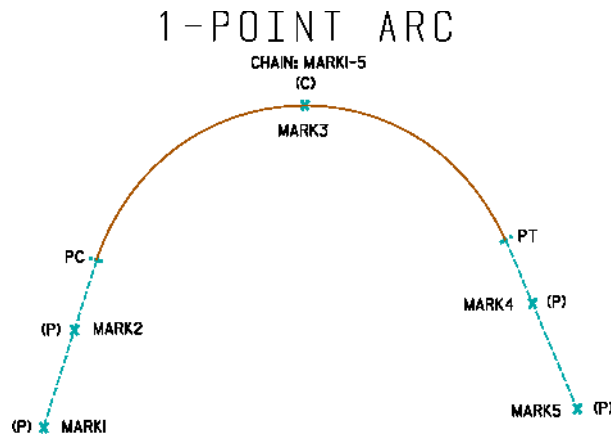


- X If four or more (4 -> N) points with geometry type C are encountered sequentially then a smooth curve is fitted through the points. The first point encountered is the beginning of the smooth curve and the last one encountered is the end.



- X If a pair (2) of points with the geometry type P precede a single point with the geometry type C, then are followed by another pair points with the geometry type P, The first pair define the *back tangent* of the curve, the second pair define the *ahead tangent* of the curve, and the point with the C

geometry type defines the **POC**. In this case the **PC** and **PT**



are computed internally by the EFB.

**Note: If two type C points are encountered in sequence, they are treated as type P points, and will be connected by line segments.**

Examples:

- |    |  |    |   |    |  |
|----|--|----|---|----|--|
| 1) | P<br>P<br>C (PC)<br>C (POC)<br>C (PT)<br>P<br>C (PC)<br>C (POC)<br>C (PT)<br>P | 2) | P<br>P<br>C (BEGIN SMOOTH CURVE)<br>C<br>C<br>C<br>C (END SMOOTH CURVE)<br>P<br>P | 3) | P (BACK TANGENT)<br>P (BACK TANGENT)<br>C (POC)<br>P (AHEAD/BACK TANGENT)<br>P (AHEAD/BACK TANGENT)<br>C (POC)<br>P (AHEAD TANGENT)<br>P (AHEAD TANGENT) |
|----|--|----|---|----|--|

Example 3) would have the *PC* and *PT* points computed and inserted automatically by the EFB when the chain is graphically presented at the computer as the following diagram illustrates:

<u>FROM CHAIN LIST</u>	<u>INTERPRETED AS</u>
P	
P	
C (POC)	
P	
P	
C (POC)	P
P	P
P	PC (CREATED/INSERTED BY EFB)
P	C



PT  
P  
P  
PC

C  
PT  
P

P  
Example 4:

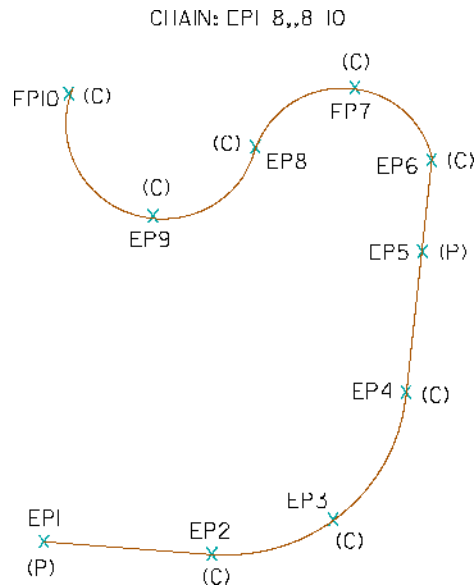
FROM CHAIN LIST

P  
P  
C (POC)  
P  
P (PC)  
C (POC)  
P (PT)  
P  
P

INTERPRETED AS

P  
P  
PC (CREATED/INSERTED BY  
EFB) C  
PT  
P  
P  
PC  
C  
PT  
P  
P

More complicated geometries, such as compound and reverse curves may be shown with *creative* chain lists. Situations like compound and reverse curve are easily handled as the following figure illustrates:



**(d) Vertical Information**

We have seen the importance of points and chains in the description of the planimetric or XY location of objects. We also saw how the geometry

of a point affects how a curvilinear object may be represented. We will now focus our attention on the vertical or Z location of objects and the points and chains which comprise them.

The ground surface or sub-surface is often located by the surveyor with a variety of techniques. One of the most familiar to most surveyors is *elevation* referenced to a vertical datum.

*Terrain Modeling* software has given us the ability to accurately represent the ground or other super/subterranean surfaces. Cross sections may be derived at any orientation or interval along a desired line that passes through the observation data (**model**). Observations taken as *cross sections*, or *random points* may be included in three dimensional chains (representing **break lines** or otherwise known as terrain discontinuities) are used to create computer models of the surfaces.

The *Triangulated Irregular Network (TIN)* is one method that the computer generates models of the surfaces.

Random points may represent the locations of planimetric objects. If a tree is located by the surveyor, and the rodman held the base of the target pole at the ground, the elevation computed from that observation may be used in a TIN.

Cross section data may also be used in a TIN model since the observations that represent the cross sections are usually ground observations. A TIN model could be created exclusively from cross section observations, without additional ground observations between the surveyed stations or having additional three-dimensional chains representing break lines. The resultant TIN model would be weaker because there would be no data *along* breaks in the terrain, and the computer will have to interpolate between sections.

The most important data that may be used in a TIN model are the **break lines**. A break line is surveyed by observing points along the breaks of a particular object, then associating those points together as a chain. This describes the profile of the terrain passing through the points that are included in the chain.

1. **Attribute -** a sub-classification of a point to inform the processing programs what relationship that point's elevation ordinate has to a surface.

The **attribute** of a point is used to tell the EFB how the elevation computed for that point will be related to a particular surface.

There are four attribute(s) defined for the EFB:

**G - Ground Point - a point whose computed elevation is on the specified surface.**

These points may occur individually, or are often connected together in a chain to describe a terrain discontinuity or the three dimensional geometry of an object along the surface. This constrains the TIN model to the elevations of the surface.

**X - Cross Section - a surface point observed at a station and offset to a particular baseline, whose elevation and position (SO or XY) is used to define an end area profile.**

The treatment in a terrain model of the *X* attribute is similar to that of the ground point (*G*) described above, since cross section attributes should ordinarily be on the surface. One difference that should be noted is that these points are surveyed with a unique spatial relationship, therefore the surveyor will want to differentiate these points using the *X* attribute. We will also see later that the program running on the field computer will behave differently when this attribute is selected for a point.

**F - Feature Point - a point that indicates a *planimetric* object only, whose elevation is NOT to be used in the surface model.**

**U - User Point - a point whose elevation is *generally* not to be used when defining the surface for terrain modeling, but has a special meaning for the user, such as utility data.**

**2. Zone - A tag to differentiate attributes between differing surfaces for terrain modeling.**

The **zone** may be used to differentiate between different vertical surfaces. The user may desire to perform two independent TIN models of the same general vicinity, such as the existing ground before some construction activity and the *as-built* surface after

construction. Points and chains may be retrieved from a database using the zone number as a search key.

The zone is designated for an object (point or chain) by its zone number. The zone number is a digit from one (1) through nine (9). The user may easily define up to nine different zones for each attribute.

(e) **Identifying Objects**

Until now, we have input into the EFB only how a point or chain is to be used. It is also important to tell the system (and other users of the data) what the object really is, for purposes of graphical representation and information sharing.

1. **Feature Code - a group of a maximum eight alphanumeric characters that identifies a point or chain as a particular object.**

A by-product of surveying usually is a scaled map based upon the survey measurements. To do this in an automated fashion, the user must communicate the graphical significance of objects to the computer. This *communication* is accomplished in the EFB by tagging selected points and all chains with **feature codes**. The feature code is information that identifies a point or chain as a particular object. The system will interpret the feature code based upon a table (discussed later) and place symbology or line work for points and chains representing objects.

The symbology and lines have varying shapes, color, thickness (weight) and line style for objects identified by their feature codes.

The user instructs the system as to what the points and chains represent by using feature codes. The feature code indicates which symbol to plot for individual points, and what type of line to plot for chains.

A feature code *could* be assigned to each point observed by the surveyor, however those points included in chains generally do not have to have a feature code. **It is not necessary or recommended to assign a feature code to each point observed.** Only points requiring an individual graphic symbol on a map need be assigned feature codes. Each chain must be assigned a feature code in order for it to be plotted with other than the default line style, weight, and color.

If a series of points in a chain have no graphical significance (except for the chain itself), such as points along an edge of pavement, no feature code need be assigned to the individual points when they are observed. The chain that contains those points to describe the edge of pavement will be assigned a feature code. The converse is true for a power line, for example, that may span many supporting poles. The poles will be assigned the appropriate feature code because each pole is a planimetric map item. The chain connecting the poles representing the power line must also be assigned the correct feature chain feature code. The poles themselves are graphically significant, as well as the chain representing the power line.

## 2. **Graphically mixing chains and points**

Chains will plot with the graphics associated with the chain feature code. Individual points in the chain will plot with the cells associated with their individual feature codes.

## 3. **Feature code organization**

Appendix D of this documentation lists the feature codes to be used by the Department. It also contains a brief description of the object(s).

## 4. **Feature code options: Adding Text**

It is important to minimize the total number of feature codes used, because a long list is cumbersome in the field, and yet retain enough codes to effectively define most objects. Some objects that may be encountered in a field survey may not have been assigned feature codes. User defined text extensions to the feature codes may be used in those situations.

The **description** is a text annotation that follows the feature code, and separated from it by a dash (-). Since the feature code field is 18 characters long, a surveyor can use descriptions to place additional information about a point or chain in the EFB. If the feature code itself is eight characters, then nine characters are available for the description (one character is used by the dash(-)). An example is a tree. For example, TREE is the default feature code for any tree in the current FDOT feature table. To describe a tree fully, the description could be used, as shown on the next page.

Example: TREE-48" WHITE OAK

Thus any size and species of tree is easily accommodated with the typed-in description.

EFB also supports aliases in its feature code list. Entering an alias code will cause the system to automatically substitute the current alpha numeric equivalent feature code from the cross-referenced TS\_FEAT.COD file. This is useful if feature codes are complicated, and a more simple designation would be appropriate for field personnel. This feature code will be substituted into the F: field when entry is terminated by .

Text alone without a symbol may also be displayed in the graphics at a point, by the use of special feature code "99." Only the text extension is displayed.

Example: 99-PLACE TEXT HERE

For descriptions that exceed the 18 character limitation, the comment field (described later) could also be used.

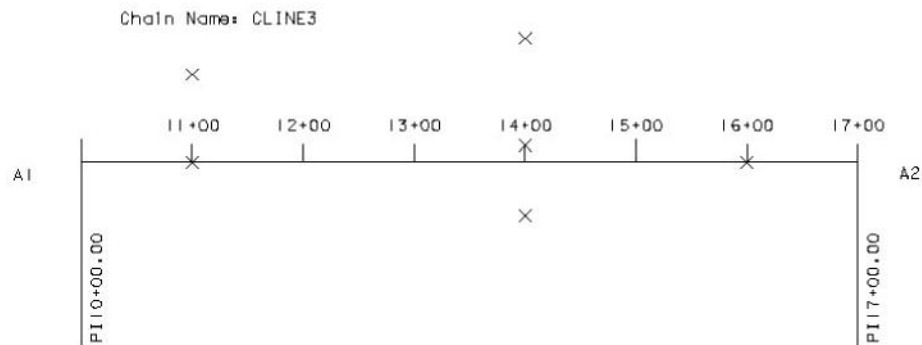
5. **Feature code options: HVD Cross Sections**

A unique option for feature codes exists when cross sections are taken with the use of the total station. The total station measures **H**orizontal direction, **V**ertical (Zenith) direction, and slope **D**istance (HVD). When the total station is used in a cross sectioning mode, the feature code acquires a computational rather than graphical significance. The feature code for cross section operations with a total station must contain the **alignment name** (a valid chain name) to which the observations will be referenced, the **station number** along the chain, and the **orientation** to the chain of the point observed. This information is used to tell the EFB that a *greater weight* is given to the station value as measured in the field, than the station value that may be computed in the geometry system from the coordinate values computed from the HVD observations. The feature code *field* (a *field* is an area in a data screen to input a particular type of data) is affected by the contents of the attribute field. When the attribute of a point is set to **X**, the feature code must take the following format:

**alignment name, station number, orientation**

The following example will better illustrate how this works:

Consider the alignment between points A1 and A2. A chain was created between these points with station of 10+00 at A1. Since the stationing increases as you progress along the chain in the order of the listing, A2 will have a greater stationing value than A1. The symbol (X) indicates where the HVD cross section observations were taken.



In the illustration above, for every series of shot(s) taken left or right of the baseline "CLINE3", there is a required shot taken on the baseline. This is necessary for the processing program that resolves HVD cross section data to be able to compute the offset distance from the baseline, without having information about the chain geometry.

The feature codes are shown that are used with an attribute of X. Proceeding along the chain, the following feature codes must be used for the observations taken at the X's, for an X attribute:

CLINE3,11+00,B  
CLINE3,11+00,L  
CLINE3,13+00,B  
CLINE3,14+00,B  
CLINE3,14+00,L  
CLINE3,14+00,R  
CLINE3,16+00,B  
CLINE3,16+00,R

Notice that the format of the data keyed in for the example above lists the chain name first, then the station separated by a comma, and then finally the orientation to the baseline also separated by a comma.

The orientation options are:

**L** - left of baseline, **R** - right of baseline, **B** - on the baseline.

For **EVEN** (100 meter) stations, the XX+00 notation is not required. For stations such as 16+32.581 or 19+18.673, the "+" may be omitted in the list to reduce keystrokes. The station could be typed as 1632.581 and 1918.673 respectively.

## 6. Available feature codes

APPENDIX D lists the default feature codes that have been defined for the EFB. The user may modify the default feature table, and create any numeric feature codes desired. Later in this document, the feature table and it's field description file are presented and fully discussed.

### (3) THE OPERATION OF EFB FIELD SOFTWARE

**EFB** is the name used throughout the remainder of this documentation for the computer program operating on the hand-held computer used to gather data.

EFB is a single program. The DOS name for the program may be **HUSKY.EXE**, **RHC44.EXE** or **MICROPLM.EXE**, although the executable may be renamed to whatever the user wishes. EFB was designed to guide the surveyor through the data collection operation. Imbedded in EFB are routines that perform checks for data integrity to help ensure the data gathering process proceeds smoothly and with minimum error. The user is appropriately warned of a variety of potential problem situations. The program also uses two companion files that reside on the RAM disk of the hand held computer in the field. The first, **TS\$MENU.DAT**, is used to define the appearance of the menus that appear in EFB, and the layout of the functions that EFB can perform. The second companion file, **TS\_FEAT.COD**, is used by the feature code confirmation system and contains the short descriptions of the feature codes displayed on the screen when a supported feature code is keyed in.

For EFB to operate properly, the program must know where to place data and where to find the **TS\$MENU.DAT** and **TS\_FEAT.COD** files on the RAM disk. This is accomplished by setting some **environment variables** (see your DOS manual for a complete description of the DOS environment). The environment



variable **TSDATA** tells EFB on what disk and directory to read and write all survey data. The environment variable **TSMENU** tells EFB where to find the files TS\$MENU.DAT and TS\_FEAT.COD. The reason for this is that often on some hand held computers, RAM disk space is limited, therefore sometimes the survey data, or the program and its menu definition, may reside in different places. Ordinarily, a batch file ( a DOS text file with a .BAT extension) is used to set these environment variables and start the program. An example of such a batch program is:

```
ECHO OFF
SET TSDATA=x:\
SET TSMENU=y:\
SET TZ=ESTnEDT
CLS
ECHO Please Wait While EFB Loads ...
HUSKY.EXE
CLS
```

where **y** is the drive where the files TS\$MENU.DAT and TS\_FEAT.COD files reside and **x** is the drive where the survey data is read from and written to. The trailing back-slash (\) must be placed at the end of the path to the environment variables. The ESTnEDT string is used to set the number of hours different from Greenwich time. In Florida, it would be EST5EDT or EST4EDT, depending on whether it was daylight savings or not. Usually the batch file described above is given the name *EFB.BAT* so it is remembered by field personnel and may be easily typed on the field computer keyboard.

#### (a) Controlling the System – Menus

Operation of EFB is based on a system of menus and data screens. A menu item is selected by pressing the appropriate *digit* on the keypad corresponding to the task the surveyor wishes to accomplish.

#### (b) Controlling the System - Data Prompts

Once the user has selected an operation from a menu, a data screen appears for data entry. Maintenance of data screens is performed by a screen manager routine running on the field computer. The screen manager defines the rules of operation and the set of functions that provide cursor movement and data manipulation through **data fields** that appear on the data screens.

Data is entered into a data field by pressing the letter key (**prompt letter**) corresponding to the data field desired to be edited. A **message field** at the bottom of the data screen displays information about the field

selected. The cursor is automatically placed in the chosen field, indicating EFB is waiting for input. This assists the user in placing data in the appropriate locations. When editing of a data field is complete, pressing `ESC` returns the cursor to **standby status** in the message field at the bottom of the data screen.

A system of locks deactivates portions of the keyboard before and during data field editing to help prevent erroneous data being accidentally input.

In a few instances, a data field is limited to a specific set of data, such as the geometry and attribute data items discussed earlier. In this case, a **toggle** limiting selection to an appropriate option is used. In such situations with limited choices of data entry, pressing the prompt letter key repeatedly will toggle through all of the possible options for that field, without requiring the user to enter the field and edit it. **When using a toggle, pressing `ESC` is not required to terminate entry and will close the screen, returning the system to the previous menu.**

Data will remain in a data screen until the user is ready to record the information in order to verify that all data fields are correct. A message is displayed (the amount of available space left on the collector) indicating if the record operation was successful. Corrective action may be taken if an error occurred, or if any mandatory items have been left blank. If erroneous data is not detected, and the record operation was successful, the user has an additional opportunity to correct any mistakes using functions described later.

### (c) **Files and Data Management**

EFB allows the user to gather survey measurements and data by either automatic entry from electronic surveying equipment or by manual key-in of data at the keyboard. The situation and the type of equipment used will determine how data will be entered.

All files created for a particular project share a common **filename**. Because of this, EFB knows where to place data across multiple data files, and the surveyor only has to deal with a single filename. Each file for a project has an **extension** after the period (.) following the filename. With the use of different extensions, the survey data is segregated into different types of files. Files on the field computer are one of three types:

X      *executable* programs (i.e. *HUSKY.EXE*, *EFB.BAT*)

- X data files used in the correct operation of the executable programs (*TS\$MENU.DAT*, *TS\_FEAT.COD*)
- X survey data (*filename.RAW*, *filename.PRE*, *filename.CHN*, *filename.CPX*, *filename.TAP*).

The contents of the .RAW, .PRE, .CHN, .CPX, and .TAP files will be discussed later, after we have discussed the types of data that the EFB is designed to gather.

#### (d) Starting EFB

Start-up of EFB on the various hand-held computers depends on the configuration, and type of field computer being used. Normally, the program for the various EFB executables pertaining to a particular computer variety (HUSKY.EXE, RHC-44.EXE or MICROPLM.EXE) will be loaded on a RAM disk on the hand held computer, with the batch file EFB.BAT to start it. Data files *TS\$MENU.DAT* and *TS\_FEAT.COD* would also be loaded to the RAM disk. The disk configuration for each of the hand-held computers varies, and the user should consult the documentation provided by the manufacturer of the field computer being used as to which RAM is best suited for operations.

**Note: The user should consult the operations manuals of his particular hand held computer to perform system operations, disk formatting, and first-time program loading. Each system is delivered with a complete set of user documentation, and the user must be thoroughly familiar with the operation of his hand held computer before proceeding any further in this documentation!**

EFB is started by typing the name of the batch file at the DOS prompt. The batch file EFB.BAT (described earlier) may be executed that sets the environment variables ***TSMENU*** and ***TSDATA***. EFB is then executed by the batch file.

(e) **The Opening Screens**

The first screen shown to the user upon start-up is the Copyright screen as shown below:

```
Electronic Field
Book Data Collector
Copyright 1995
State of Florida
Department
Of
Transportation
```

After pausing on the above screen a display prompting for the **time zone** to be used for time and date stamping of the observations will be displayed.

```
VER. 2.55 31-JUL-96
Select Time Zone..
1) EST 5) EDT
2) CST 6) CDT
3) MST 7) MDT
4) PST 8) PDT

Enter Choice [EDT]:
```

The number corresponding to the local time zone the work will be performed in should be keyed in. The default time zone is Eastern Daylight Time, and pressing  to accept the default at the prompt will suffice, if the default is appropriate.

The time zones available are as follows:

EST - Eastern Standard Time  
CST - Central Standard Time  
MST - Mountain Standard Time

PST - Pacific Standard time EDT -  
Eastern Daylight Time CDT - Central  
Daylight Time MDT - Mountain  
Daylight Time PDT - Pacific Daylight  
time The next screen displayed is the local  
system time to be used for time stamping of  
the survey data.

The screen looks like:

```
VER. 2.55 31-JUL-96  
  
Time: XX:XX:XX  
Time:
```

This screen sets the EFB software clock. A new local time may be keyed in using the same format as the displayed time, followed by pressing , or simply pressing

Note: Those who wish to calibrate the system time to Coordinated Universal Time for astronomic observations should anticipate the "tone" on time radio (WWV, etc.) by a few seconds and key in the LOCAL time ahead of that when the CUT will be broadcast. When the "tone" is heard, pressing

The program clock is set when

In the same screen, a second prompt for the date is then made, and should be set to the local date. The screen now has the following appearance:

```
Time: XX:XX:XX
Time: nn:nn:nn

Date: MM-DD-YYYY
Date:
```

Like the time, the system date may be changed by typing in new values in the format as the displayed, then pressing `<Enter>`. The default date displayed may be accepted by pressing `<Enter>` alone.

After a few seconds, EFB attempts to load the menu file (TSMENU.DAT) if the environment variables are set. If an error in the menu file is detected, the nature of that error is displayed to the screen for the user. If no error is detected, EFB begins running.

**(f) Main Menu**

Once EFB is running, the opening menu is titled **MAIN MENU**. This menu contains the primary operations that are performed when surveying with EFB. The MAIN MENU screen is shown below:

**(g) Segment Manager - (Main Menu, Option - 1)**

The **Segment Manager** is where all file services take place. Under this option, the surveyor has control of the creation, use, and manipulation of segment files. All segments begin in the Segment Manager.

The MAIN MENU is a menu screen. To select an option in a menu screen, press the digit key corresponding to the option desired.

When Segment Manager is selected, the following menu screen will appear:

```
SEGMENT MANAGER
0: List
1: Create/Activate
2: Next Segment

Segment? _____
```

1. **List Segments - (Segment Manager, Option - 0)**

When **List Segments** is selected, EFB will list the current segments by name that are on the RAM disk of the field computer. The segment(s) are listed, a page at a time, as well as their size in bytes.

The amount of remaining memory for additional work is listed in bytes. The RAM disk of the field computer may contain any number of segments, and are listed on sequential screens, provided the entire list can not be displayed at once. Pressing *any* key will display additional pages if there are more than one, eventually clearing the List Segments screen(s) and returning the user back to the Segment Manager menu.

A sample screen showing four segments on the RAM disk looks like:

```
SR319A           4569
SR319B          364482
SR319C           83745
SR319D           66387
371712 free

Any Key to Continue!
```

The List Segments screen also displays which segment is currently being worked on. An **active segment** is the segment that data will be added to when surveying begins. The List Segments screen displays the active segment by placing brackets < > around the segment name. The active segment may be changed by use of functions in Segment Manager. The screen below shows what the surveyor would see if the segment SR319C was active:

```
SR319A      4569
SR319B      364482
< SR 3 1 9 C > 8 3 7 4 5
SR319D      66387
371712 free

Any Key to Continue!
```

When any key is pressed, the List Segments function returns to the Segment Manager screen.

2. **Editing the Segment? prompt - (Segment Manager, Option - S)**

Options 1 and 2 of the Segment Manager menu require that the surveyor indicate the segment that he desires to perform Segment Manager operations on. This is accomplished by editing the field following the **Segment?** prompt.

The desired segment is keyed into the segment data field. These options operate on the segment in the data field only, and have no effect on other segments on the RAM disk.

All **field prompts** in all subsequent data screens (which will be discussed) contain a capitalized letter, such as the letter **S** in Segment. This capitalized letter indicates the key that will place the cursor into the data field next to the prompt for data input. Pressing the **prompt key** takes the cursor into the selected field for editing. A message is usually displayed in the message field at the bottom of the data screen indicating the selection. When editing of the field is completed, pressing **any key** brings the cursor back to *standby status* in the message field. Review the Segment Manager screen earlier, as the other options in this screen are discussed.



### 3. **Create/Activate - (Segment Manager, Option - 1)**

Selecting **Create/Activate** will create a segment on the field computer RAM disk that has its files named the same as that indicated in the segment field. When a new segment is created, it becomes the active segment as it is created. This may be confirmed by listing the segments using **List Segments** as previously discussed. A message indicates that the segment is being created by displaying:

```
SEGMENT MANAGER
0: List
1: Create/Activate
2: Next Segment

Segment? EXAMPLE_
MSG>Creating Segment
```

then displaying:

```
SEGMENT MANAGER
0: List
1: Create/Activate
2: Next Segment

Segment? EXAMPLE_
MSG>Segment Created!
```

**Create/Activate** has a dual function if it is desired to make an old segment active. Selecting Create/Activate when the old segment name is in the Segment field will activate the old segment. The message field will indicate that a segment is being activated, rather than being created. Again, it is wise to verify the correct segment is active by using List Segments option before continuing. The surveyor will see the following on the display(s) during activation of an old segment:

then displaying:

If any errors are detected in structure of the old data files, EFB will display a message.

#### 4. **Next Segment - (Segment Manager, Option - 2)**

Selecting **Next Segment** will cause EFB to create new segment files for the segment named in the Segment? field. The .PRE and .CPX files from the current active segment will be carried forward to the new segment specified in the Segment? field. The user is placed at the Header screen with the new segment name already loaded. After any edits the header screen is ready to be saved.

```
SEGMENT MANAGER
0: List
1: Create/Activate
2: Next Segment

Segment? OLDSEGMT
MSG>Segmnt Activated
```

Begin by activating the source segment if it is not already active. Then select the Segment? field and enter the name of the new segment and then . Then select <<2>> from the Segment Manager menu. Blank .RAW, .CHN, and .TAP files will be created and the .CPX and .PRE files will be copied from the source segment to the new segment and renamed. The Header screen appears with the units correctly selected, new segment name, and the R: field copied from the previous Header. This Header will not have been recorded in the new segment yet. It can be edited at this time and then must be recorded.

#### (h) **Data Transfer - (Main Menu, Option - 2)**

EFB has **no** internal ability to transfer programs and data to and from the Host PC computer.

**Users should consult the manuals and documentation from the manufacturer of the particular field computer being used for their serial communications options.**

(i) **Functions**

It is appropriate to introduce the concept of **functions** at this time, since we will use one of them to record the Header into the segment file on the RAM disk. Manipulation of data and data screens are performed also through the use of **functions**. The *function keys* are assigned to the numeral keys <<1234567890>> on the field computer, and are active only when the cursor is in standby status in the message field, not when editing a data field is taking place. All that is required to activate a function is to press the appropriate numeral key, and the function selected is performed.

Pressing            to complete a function is not required, although some functions that potentially have detrimental effects on the data processing will require the surveyor to confirm his choice of action (usually a confirmation prompt) before the function executes. The location of each function is mapped to a particular numeral key for individual data screens. There are never more than ten functions per data screen to remember, and many functions perform similar operations in all data screens as well will see later.

(j) **Survey - (Main Menu, Option - 3)**

Upon selecting **Survey**, the Survey menu screen appears. This screen indicates the available surveying **tasks** supported by EFB. As you can see below, the Survey screen has many options. The options will be discussed one at a time and in great detail, since they are the "meat" to using EFB as a data collection system.

```
                SURVEY
1:Header  6:SOR-Obs
2:Calib   7:Remarks
3:Test   8:Chains
4:Setup   9:Taping
5:HVD-Obs 0:Search

MSG>
```

Surveying operations are divided into general categories, or tasks. The tasks currently supported are as follows:

HEADER	User information about the Segment
CALIBRATION	User information about environment, crew and instrument, selection of instrument, and instrument testing
TEST	A test screen for Axis and Peg testing
SETUP	Data about the point the instrument occupies
HVD-Obs	Data about the point the target occupies, and measurement data (horizontal angle, zenith angle, and distance combinations)
SOR-Obs	Data about the point the target occupies, and measurement data (station, offset, and rod reading combinations)
REMARKS	General remarks during the data collection process
CHAIN	Construction of curvilinear geometric objects (chains)
TAPING	Remote taping operations independent of the setup
SEARCH	Searches for a data record by setup, reference name, prefix, or point name

A detailed description of the tasks will be included when discussion of the data screens used to perform the task is presented.

The general philosophy of EFB data collection is that the user should have total flexibility, subject to statutory and contractual requirements. There are no *system* requirements for data structure, such as the number of angle or distance repetitions. Survey structure, which deals with such subjects as precision and accuracy, connectivity and control, are left to the user and the appropriate Department references.

(k) **Header**

The **Header** contains the opening pieces of information that go in the EFB observation file (the observation file is a binary file called ***filename.RAW***).

The Header is the first record in any EFB segment. The Header only occurs once per segment. The Header contains descriptive information about the *nature* of the segment itself. The data items to be placed in the Header include a toggle for units of measurements between English and Metric, a **segment name** (which should not be confused with the segment file name input in the Segment Manager screen), and space for a short paragraph of **remarks**. There is only one Header in an EFB segment. The only data required for the Header is a segment name and the units. The segment name in the Header allows a longer, and more descriptive name than the *segment filename* input in the Segment Manager screen.

The header data screen:

```

U: _____ HEADER
N: _____
R: _____
_____
_____
_____
_____
MSG>

```

<<U>>: Units of linear measurements

HEADER      Screen title

<<N>>: Segment name field

<<R>>: Remarks field about nature of the segment

MSG>      Message block for communicating status of operations to the surveyor

The segment name may be up to 18 characters in length. An example would be:

*I-75 COLUMBIA CO.*

Remarks are used to input a brief description about the work to be performed. The surveyor has space to input up to 98 characters (including spaces) for the description. An example would be:

*Additional lane widening of i-75 from Georgia line to Alachua co. North line, x-sections and topo*

When typing in remarks, or any long listings of data, EFB will automatically wrap the text to the next line to keep all of the text visible on the screen. A warning beep will indicate when the end of the data field is reached.

The actual screen the surveyor sees after input of the above example is:

```
U:METRIC HEADER N:I-  
75_COLUMBIA_CO_  
R:additional lane wi  
dening of I-75 from  
Georgia line to Alac  
hua Co. north line, x-  
sections and topo_  
MSG>
```

Information is placed in the screen by manipulation of the cursor. This is done by pressing the **prompt key** on the keyboard representing the letter in the field to be edited or by toggling. The cursor is then placed in the selected data field for editing (most cases) or by toggling between the embedded values or strings, as in the case of the **U:** field, and a corresponding message will appear in the message field explaining the action that has been taken. The field may now be edited.

The **U:** field toggle will allow the choice between English or Metric units. Once this header screen has been recorded the units will have been selected for the project and cannot be changed from within the software. The decimal precision of distance inputs will be to the millimeter (.001) for metric units. If English units are selected the precision is set to the hundredth of a foot (.01).

When editing is complete, pressing  returns the cursor to **standby status** in the message field. With the exception of data **toggles**

(described later), which change the contents of data fields without a key-in, editing of most data fields takes place in the manner just described.

When editing any data screen, the information input remains in the **screen manager** until the user decides to record the information to the segment data file(s) on the RAM disk. This allows the user to correct mistakes prior to recording the data permanently.

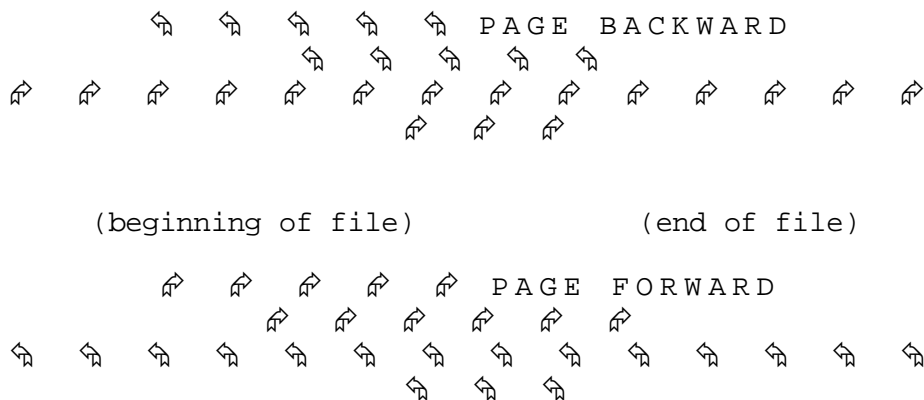
## Functions Available: Header

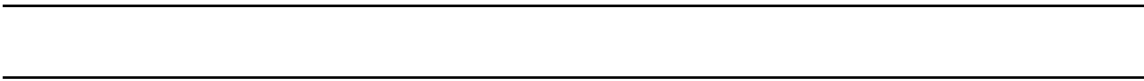
### 1. Record

The **Record** function is used to record the contents of a data screen to the segment file (**filename.RAW**) located on the RAM disk. When selected, the Record function checks the contents of the data screen to ensure that the required data is input in the right format. If an error is detected, the surveyor is warned with the appropriate message printed in the message field. If an attempt to record the data screen is successful, the number of available bytes on the RAM disk is displayed in the message field, indicating the Record function was successful in its operation. The Record function will always be on <<0>>, for all data screens.

### 2. Page Back/Page Forward

Two functions exist that allow the surveyor to effectively "turn the page" of the field book to any of the previously recorded data screens. The **Page Backward** and **Page Forward** will display each recorded data screen (<<1>> and <<2>> for **Page Backward** and **Page Forward** respectively). The functions operate in a revolving manner, displaying the next/previously recorded screen in sequence depending on whether the surveyor is Paging Back or Paging Forward. The functions will also "revolve" past the end or beginning of the recorded data as the following illustration depicts:







This allows the user to page continuously in either direction where the paging does not end with either the beginning or the ending of the recorded data, similar to a Rolodex.

The function key map for the Header is: