

## DEVELOPMENT OF ESSOL-V2 FOR ENGINEERING SURVEY CALCULATIONS

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### ABSTRACT

*Computer application had been a tremendous asset to a construction company since information technology raised rapidly in the era of digital. Computer provide a clean sweep in surveying field by doing design, running analysis, and compute result in a split second which also reduce possibilities of making mistake in the surveying calculation. For this project, Microsoft Office Excel 2003 and Microsoft Visual Basic 6.0 be applied to develop software to be used in engineering survey that named as 'Electronic Survey Solutions Version 2 (ESSol-V2)'. Engineering survey module for leveling, traverse booking, tacheometry, design of road curve (horizontal and vertical curves), omitted line computations and traverse by radiation is integrated in ESSol-V2 programming. The result is digital electronic forms where it can be used by surveyors to solve their engineering survey calculation. ESSol-V2 evolved from an older version of digital electronic forms of survey, accompanying the revolution in this program was an additional function of surveying which makes it to become more friendly yet powerful for surveying.*

**Keywords:** ESSol-V2, engineering survey module, survey calculations

### INTRODUCTION

ESSol-V2 is a survey data calculations software. The digital spread sheets in ESSol-V2 created by Microsoft Office Excel 2003 has been designed and labeled clearly to be the same as the paper data's sheets inside surveying field notes. Engineer would be required to fill in dataset on digital spread sheets according to row and column which had been labeled with subjects. Then, by manipulating ESSol-V2, the data can be saved in computers and analysed.

During field work, the surveyor often makes some measurements and then has to stop and make what are sometimes rather involved calculations before surveyors proceed with field work [1]. Occasionally, one or more angles and or the lengths are not measured in the field and their values are computed later at the office. There could be several reasons for not completing the field measurements, such as difficult terrain, obstacles, hostile landowners, lack of time, sudden severe weather conditions, and so on.

With respect to checking when using traditional field notes and manual computations, no confidence is placed in results that have not been checked, and important results preferably are checked by more than one method. These lead to repetitions of calculations on the measurement's result. Beside, if the surveying was not comply with the requirements such as leveling that have misclosures over the limits, mean the surveying has to redo and at last will caused the calculation of misclosures need to perform again with the difference data. These repeated calculations would expand the time of the survey if manually calculate using the calculator and the mistakes often occur during the manual calculation progress.

Besides, the appearance on the field notes is not presentable and not appropriate to be a part of the project documents. Mistake in the entry of measured data are to be carefully lined out, not erased [2]. Field notes could be untidy with all the mistakes in the entry lined out by pen. In the worse case, those who practice bad hand writing would make the field notes messy and unreadable.

ESSol-V2 is a suite of surveying software; it can be installed to Microsoft Window operation system which means personal computer and also personal digital assistance (PDA) with mini window as operating system is possibly equipped with ESSol-V2 as well. Surveyor may bring along ESSol-V2 in PDA gadgets on the site record measured data with ESSol-V2 instead of copy onto field note paper.

In the other hand, the ESSol-V2 is a learning tool that has helped students and inexperienced engineers to be productive and creative while intended to learn surveying. Some students may find, at first, that it is very difficult to understand the principles of surveying. Therefore, ESSol-V2 have tried to show some graphics to explain theory and concepts of survey, thereby the presentation of ESSol-V2 would turn surveying into a subject of interest form the outset.

The objective of this project is to develop software for engineering purposes such as leveling, traverse booking, techeometry, road curves calculation, omitted line computations and traverse by radiation. The software developed in this project is Electronic Survey Solutions Version 2 (ESSol-V2), which means solving surveying calculations by using electronic approach or facilitates by the computers.

ESSol-V2 was evolved from an existing software Electronic Solution for Engineering Survey (ESES) [3]. The old versions of ESES provided a limitation of digital spreadsheet, there only included leveling, traverse surveys and tacheometry. ESSol-V2 has an objective to improve the ability of the previous software by refer lacking and deficiency in previous software, we got new idea and more features implemented in the project in order to provide more powerful tools for engineer in survey solutions.

## MATERIALS AND METHODS

A project methodology has been planned to be completed within five steps (see Figure 1). This flow chart gives an overview about the methodology of this project including the steps to develop ESSol-V2. Besides, the flow chart would also be a guidance on the process of building up ESSol-V2, a guidance that show the activities that have to be completed in order to make the project a success.

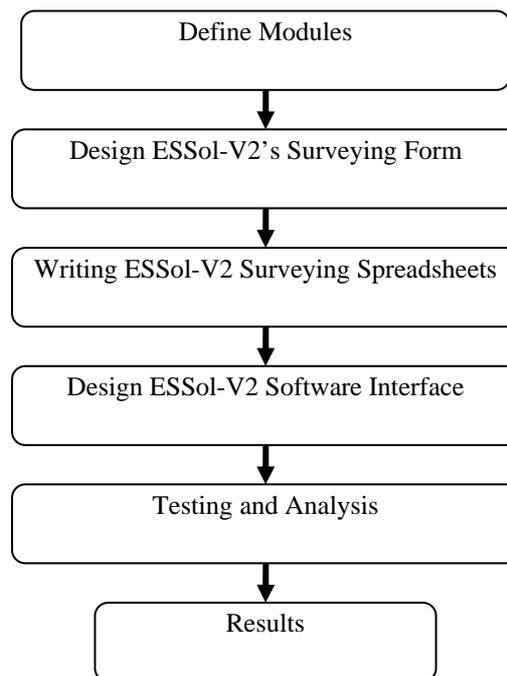


Figure 1: Research Methodology Flow Chart

### *Define modules*

There is a variety of mechanisms for splitting software into independent modules or expressed another way, grouping together items that have some mutual affinity [4]. Before process of ESSol-V2 design, ESSol-V2 modules have to be identified so that the design would not be aimless. The role of modules defining is to supplement some design guideline during the process of design. ESSol-V2 software had break into modules, included leveling, traverse surveys, tacheometry, road curves, omitted line computations and traverse by radiation. ESSol-V2 software designed in sequence of module, thus the enormous amounts variables in each module would not be messed up with another. This step could speed up the ESSol-V2 software development.

### ***Design ESSol-V2's Surveying Form***

Surveying forms in ESSol-V2 is a Microsoft Excel's spreadsheet layout for surveying measurement entries. High quality design should have characteristics that lead to quality products, ease of understanding, ease of implementation, ease of testing, ease of modification, and correct translation from the requirements specification [5]. For purpose of easy understanding, the surveying form design to be similar as the form in the field notebook. All the surveying variable and constant labeled and describe clearly on the layout. This move would avoid ambiguous data entries and reduce blunders while entering data [6]. The step of design surveying forms is to set up the surveying forms as a spreadsheet by entering text in cells. After that follow by formatting data, formatting a spreadsheet is the process of altering the appearance of data in one or more spreadsheet cells. Using the appropriate formatting renders a worksheet easier to read and understand and enhances a spreadsheet's overall appearance, making it more user friendly [7].

### ***Writing ESSol-V2 Surveying Spreadsheets***

Programming is matching design with implementation. Design is a guide to the function or purpose of each component, while implementation is to create component that has it functions. The first step in writing ESSol-V2 software is formulating the problem of the survey and enters the formulas into the spreadsheet cells. The second step is to program the ActiveX control button with VBA scripts. The ActiveX control button comprise of Close, Empty data, Print and Save buttons (see Figure 2).



Figure 2: ESSol-V2 Spreadsheet's Command Buttons

### ***Design ESSol-V2 Software Interface***

ESSol-V2 interface designed and build by using Visual Basic 6.0. The interface was designed to have three buttons on the menu bar; the button included open module button help button and exit button. Each button programmed to serve difference purpose. For open module button, it involved various Visual Basic script procedures that associated with Microsoft Excel spreadsheets [8]. When the button clicked, the ESSol-V2 surveying spreadsheet instantaneously initiated. Beside the menu buttons, the interface also fills with informative and surveying related graphics like the total station and leveling instrument to enhance the software appearance (see Fig. 3).



Figure 3: ESSol-V2's User Interface

Software interface need to be compiled after designed. The compiling could make the ESSol-V2 interface load on window without Visual Basic program. In compiling an application means that Visual Basic translates the application and all its projects into an executable file [9]. In the process of compiling Visual Basic converts the designed ESSol-V2 interface into a single executable file. The executable ESSol-V2 file has the .exe filename

extension, and the users can run the application from the Start menu's Run option or from an entry that add to the Start menu.

### Testing and Analysis

A predetermined set of surveying data would feed ESSol-V2 surveying forms which programmed by Microsoft Office Excel 2003, the predetermined data was calculated by the surveying software which has the related features of calculations such as SURVEY software [1]. The ESSol-V2 calculation result would compare to the SURVEY software calculation result in order to make verification to it results, which means if the calculations results of ESSol-V2 is same with the SURVEY software result then the ESSol-V2 calculation results is undoubtedly precise.

### Results

The Package and Deployment Wizard in Visual Basic 6.0 software would compress all the ESSol-V2 component included several Microsoft Excel surveying spreadsheets and the compiled interface into distribution disks. The production of ESSol-V2 distribution disks would end the step of ESSol-V2 software. ESSol-V2 software is expected to provide surveying forms in the format of Microsoft Office Excel 2003 spreadsheets. The designed software has to prove that the program fulfils the objectives of the project.

## SOFTWARE ANALYSIS

Analysis of ESSol-V2 will have relative comparison with SURVEY software results. The comparison's measurements comprise of horizontal and vertical curve calculations, omitted line computations and traverse by radiation calculations. The comparison of the suggested applications is mainly ordained on capability of software and accuracy of outputs.

### Horizontal Curve Analysis

The result generated by using ESSol-V2 horizontal spreadsheet and SURVEY software as shown no difference in all the results. The chord lengths for horizontal curve design are designed to be adjustable in ESSol-V2 horizontal curve's spreadsheet, whereas chord lengths in SURVEY software are not adjustable. Chord lengths are set to be adjustable in ESSol-V2 software because its need to suite the staking conditions, in town area there need a shorter chord length because a lot of obstruction along the curve layout on site (see Figure 4 and Table 1).

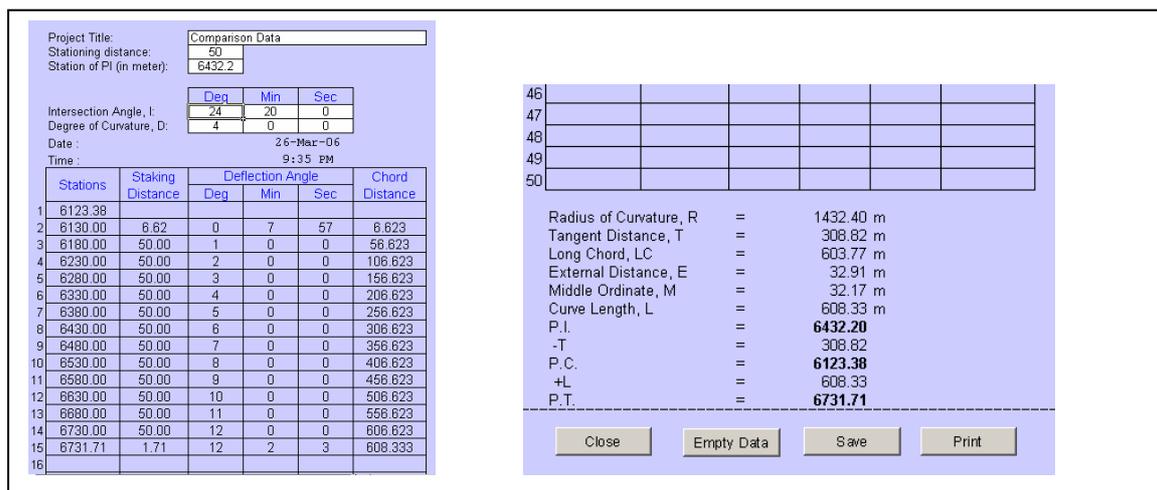


Figure 4: ESSol-V2 Horizontal Curve Calculations and result comparison

Table 1: Horizontal Curve comparison

| No | Specification                     | ESSol-V2  | SURVEY                 |
|----|-----------------------------------|-----------|------------------------|
| 1. | Radius of Curvature, R            | 1432.40 m | 4699.47 ft (1432.40 m) |
| 2. | Tangent Distance, T               | 308.82 m  | 1013.20 ft (308.82 m)  |
| 3. | Long Chord, LC                    | 603.77 m  | 1980.88 ft (603.77 m)  |
| 4. | External Distance, E              | 32.91 m   | 107.98 ft (32.91 m)    |
| 5. | Middle Ordinate, M                | 32.17 m   | 105.56 ft (32.17 m)    |
| 6. | Curve Length, L                   | 608.33 m  | 1995.85 ft (608.33 m)  |
| 7. | Intersection Chainage (P.I)       | 6432.20 m | 211+03.01 ft           |
| 8. | Point of curvature Chainage (P.C) | 6123.38 m | 200+89.81 ft           |
| 9. | Point of tangency Chainage (P.T)  | 6731.71 m | 220+85.66 ft           |

**Vertical Curve Analysis**

ESSol-V2 has a vertical curve diagram which will display the stations along the curve according to entry measurements. Further more, users may manipulate the value of the curve by using the spinning positioned beside the graph. With the graph in ESSol-V2, it would draw attention of the users, users can foreseen the sharp of the desire vertical curve; users need no sketching curve on papers to preview the shape (see Figure 5).

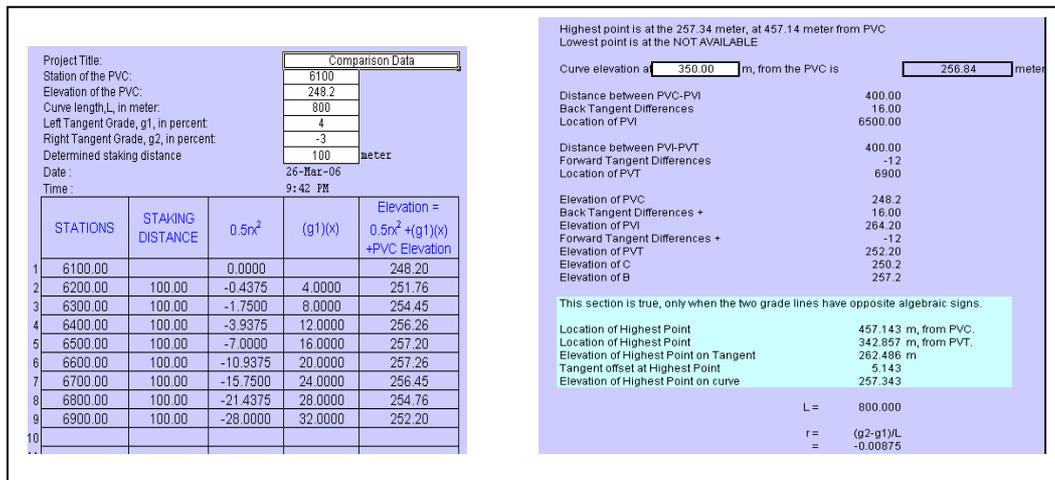


Figure 5: ESSol-V2 Vertical Curve Calculations

Table 2: Vertical Curve comparison

| NO. | Specification              | ESSol-V2  | SURVEY               |
|-----|----------------------------|-----------|----------------------|
| 1.  | Highest point on the curve | 257.34 m  | 844.28 ft (257.34 m) |
| 2.  | Elevation of PVC           | 248.20 m  | 814.29 ft (248.20 m) |
| 3.  | Elevation of PVI           | 264.20 m  | 866.78 ft (264.20 m) |
| 4.  | Elevation of PVT           | 252.20 m  | 827.41 ft (252.20 m) |
| 5.  | Elevation of C             | 250.20 m  | Not available        |
| 6.  | Elevation of B             | 257.20 m  | Not available        |
| 7.  | r value                    | -0.00875  | Not available        |
| 8.  | Vertical curve diagram     | Available | Not available        |

There are some important value in the parabolic calculations are not shown by the SURVEY software (see Table 1.0). All the all values can be found in the ESSol-V2 vertical curve, it is useful for the users to check the calculations manually if there is necessary to do it. Those useful values made ESSol-V2 as a practical tool for beginner who learning road curve design.

**Omitted Line Computations Analysis**

The result generated by using ESSol-V2 omitted line computations spreadsheet and SURVEY software are definitely same. The design of omitted line computations imitated SURVEY software by using the same equations as in SURVEY software that adopted from Surveying fifth edition by Jack McCormac [1].

**Traverse by Radiation Analysis**

The result generated by using ESSol-V2 traverse by radiation spreadsheet and SURVEY software are be seen that the area enclosed is difference. ESSol-V2 spreadsheet shows that the area is 79274.64 m<sup>2</sup> whereas SURVEY software shows 123260 m<sup>2</sup>. The manual calculation had been performed to identify which is the correct answer, and it will define output accuracy for the software. From the calculations shown that the accurate answer is belong to ESSol-V2 traverse by radiation spreadsheet. Based on this fact, it is known that the ESSol-V2 software is more reliable and provide accuracy output in comparison to the SURVEY software (see Figure 6).

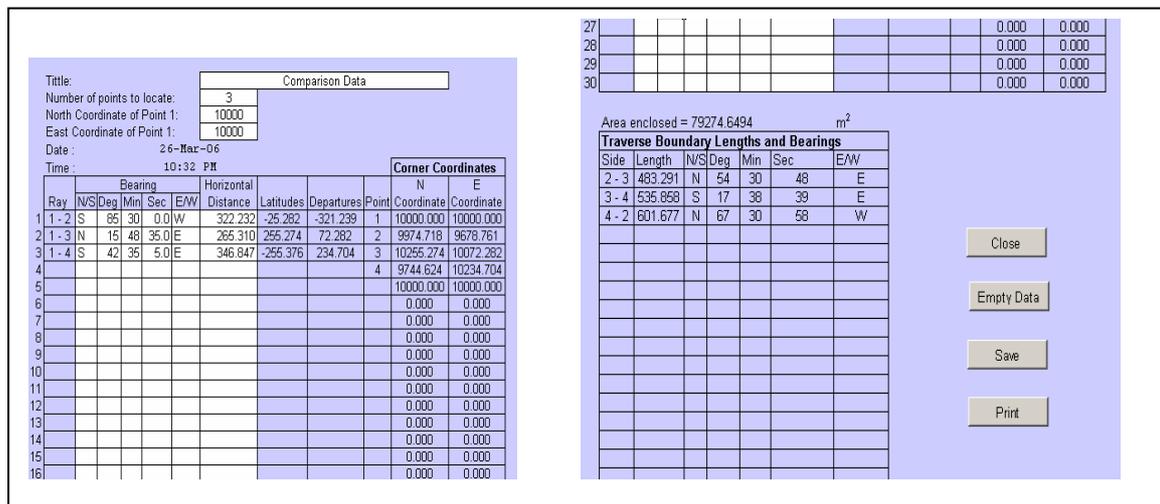


Figure 6: ESSol-V2 Traverse by Radiation Calculations

**CONCLUSION**

ESSol-V2 software may be used conveniently during the field work. It could be installed in a portable computer and surveyors could do computation instantly in the field. For surveyors, the software may be ran also without the delays and inconveniences involved in returning to the office just for making calculations before proceed with the rest of the field work.

From the project that had been carried out. The time when ESSol-V2 software successfully developed, the first objective of this project which is develop software to solve surveying problems for engineers is achieved. On the other hand, the second objective is to improve the capabilities of the previous software, and it is fulfilled by adding four brand new calculations spreadsheets into the software, the spreadsheets comprise of horizontal curve, vertical curve, and omitted line computations and traverse by radiation calculations. For the third objective which is to guide students get to know basic principles of basic surveying calculation is then achieved by showing miscellaneous values and adding diagrams for assisting in surveying calculations comprehension in ESSol-V2 spreadsheets. ESSol-V2 software is suitable in guiding student get to learn surveying graphically since it performs as much as SURVEY software (see Figure 7).

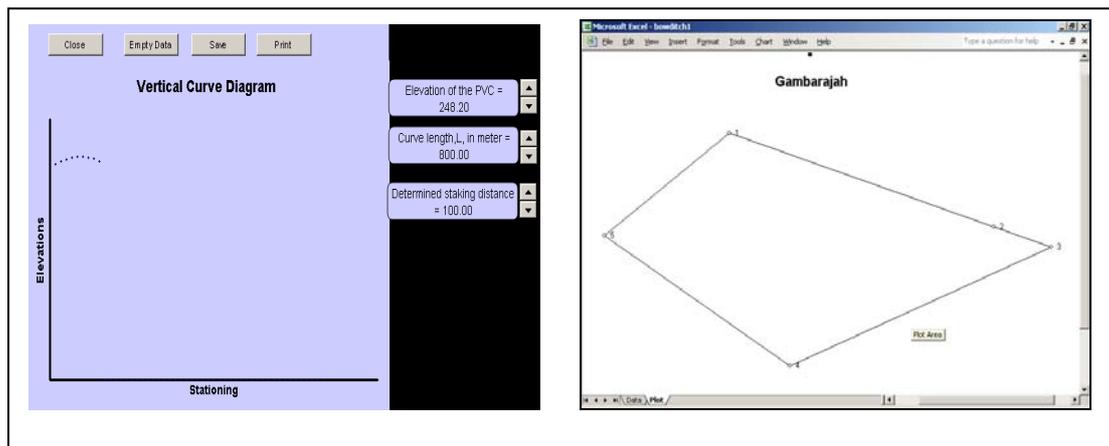


Figure 7: ESSol-V2 Vertical Curve Diagram and Traverse Diagram in Excel Spreadsheet

By using Visual Basic 6.0 Package and Development Wizard, ESSol-V2 was successfully created and its compatible with Microsoft Window included handheld PC, Personal Digital Assistance (PDA) and laptops as well. After ESSol-V2 installed into a PDA it could be used as electronic data collectors. Electronic recording devices are used to automatically collect, store, and display the data acquired by the electronic surveying instruments. This helps to eliminate possible blunders that may occur when data are manually transcribed into a field book. It is important to remember that good field notes must be clear and legible, complete, and accurate; and ESSol-V2 provides all these things. Beside, engineers could do computation instantly in the field without the delays and inconvenience involved in returning to the office just for making calculations before proceed with the rest of the field work. It is a suitable tool in solving surveying problems for engineers.

Software have its weaknesses no matter how powerful a software is, so in order to upgrade ESSol-V2 software, one can rebuild it by programming the whole surveying software in Visual Basic scripts. With that, ESSol-V2 needs not to depend on Microsoft Excel. Beside, the latest version of ESSol-V2, there is only vertical curve spreadsheet showing diagram of surveying work. Ideas arise that every spreadsheet needs to have its graphical representation like graphs and diagrams (see Figure 7). From experience, we realized that many data entries especially for coordinates of certain points, error can be detected by viewing diagrams. Further more, there is another option to upgrade ESSol-V2 that is to send the surveying measurements in it into CAD application so that the graphical surveying result could be edited and plotted with CAD application.

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