ROBOTIC TOTAL STATION PERFORMANCE IN INDUSTRIAL DEFORMATION SOLUTION

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ABSTRACT

Robotic Total Station or Robotic Tachometry System (RTS) widely used for surveying purpose and solution. From surveyor to archeologist, professional used RTS to solve many problems in collecting data such as to mapping the land use, archeology excavation site or used in construction field. Latest technology adopted in modern total station is servo motors to drive both the horizontal and vertical motion of the instruments. This technology designed special to search automatically for prism target known as Automatic Target Recognition (ATR). Manufacturers such as Leica Geosystem, TOPCON Instrument, Trimble and Geodimeter have designed an instrument with automatic target recognition (ATR). This technology utilizes an infrared light bundle sent co-axially through the telescope. Usually, RTS will be used in precise measurement application such as deformation monitoring or dimensional surveying for industrial. Both applications needed high precision instrument and accuracy. This paper presented the developed software system known Industrial Deformation Data Acquisition and Analysis (InDA) using ATR functions of Leica Robotic Total Station. The data has validated by well-known software, Leica APSWin. Developed software can avoid gross error from observer and also systematic error for further analysis. The data from APSWin has analyzes and compared to observation data from InDA.

1.0 Introduction

This paper deals with real time data acquisition for industrial deformation application. A module known as Communication (COMM) and Data Acquisition (DAQ) module has developed using Microsoft Visual C++ 6 based on Microsoft Foundation Classes. COMM and DAQ are two main units from RTS-Computer Interfaces for Industrial Deformation Data Acquisition and Analysis or InDA. The database management system implemented to support huge amount of measurement data. Open Database Connectivity or ODBC have been using for this software system and linked to Microsoft Access. The measurement data collected from COMDA was proof by commercial software Leica APSWins.

The result shows consistency during the one-hour observation campaign between two-software systems. APSWin has integrated with build-in Automatic Target Recognition (ATR) inside robotic total station. While, ATR function must be activate from robotic total station and COMDA software module will order the instrument doing the measurement.

The motivation inside this research have considered several factor such as expensive price and licensing for commercial software, error in measurement data issues and analysis aspect in commercial software. Due to this problem, InDA will be develop to minimizing the error in measurement, lost cost software systems and will provide robust analysis.

2.0 The Instrumentations

Surveying technology allows the determination of 3-dimensional determination and movement. Current technology provides robotic total stations that are able to measure angle with an accuracy of $\pm$0.5” (0.15 mgon) and distance with an accuracy$\pm$1mm+ppm in standard measurement mode (Leica Geosystems, 2000).

Actually, TCA2003 produces by Leica Geosystems AG, which is designed for conducting deformation-monitoring survey. But certain researcher has been used this TCA2003 model for industrial measurement. Dünish & Kuhlman, (2001) and Kuhlmann, (2001), claim tracking moving target is possible with modern tachometry in setting out rail geometry.

With this latest technology, robotic total station allow the measurement of many points on a surface. Then the points will be monitored within a short period of time. All the operation done using Automatic Target Recognition (ATR) technology (Leica Geosystem, 2000) each prism can be found. **Figure 1** show the concept of ATR technology where the telescope center identified to provide precise targeting pointing.

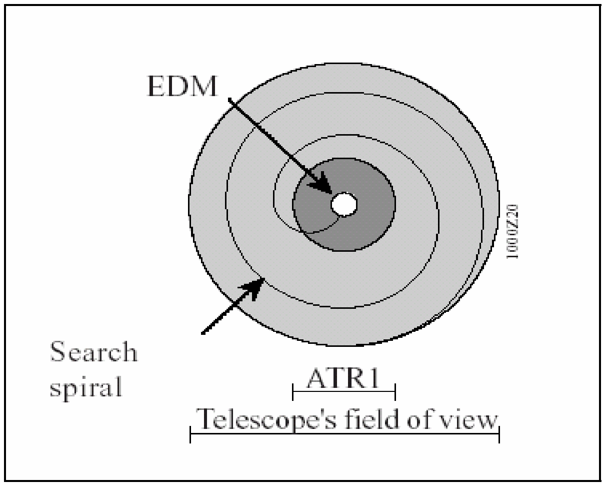

Figure 1: Automatic Target Recognition Concept (Leica Geosystems, 2000)

3.0 Automatic Polar System for Windows (APSWin)

APSWin manufactured by Leica Geosystem to conduct real time deformation monitoring to any engineering structure. This system supports automatic operation, data capture and data processing for all motorized Leica theodolite (TM3000x, TPS1000 family). Change in instrument position (translation along x, y, z), theodolite rotation and factor affecting the vertical readout can be determined for individual cycle including in station calculation. There are two different types of station calculation namely linear transformation and Helmert transformation.

The linear transformation is a simple transformation procedure in which only two pair of points is required. The defined connections to the reference points are use to determine the parameter of linear transformation and provide with mean value and a standard deviation. For Helmert transformation, the coordinates of the reference point for the actual cycle transform so that the sum of the squares of residual divergences is a minimum (Leica, 1998). Some testing has conducted by Universiti Teknologi Malaysia, Skudai on APSWin capability (Halim & Khairulnizam, 2005). **Figure 2** show us how APSWin data flow from data capture through data bank and station calculation.

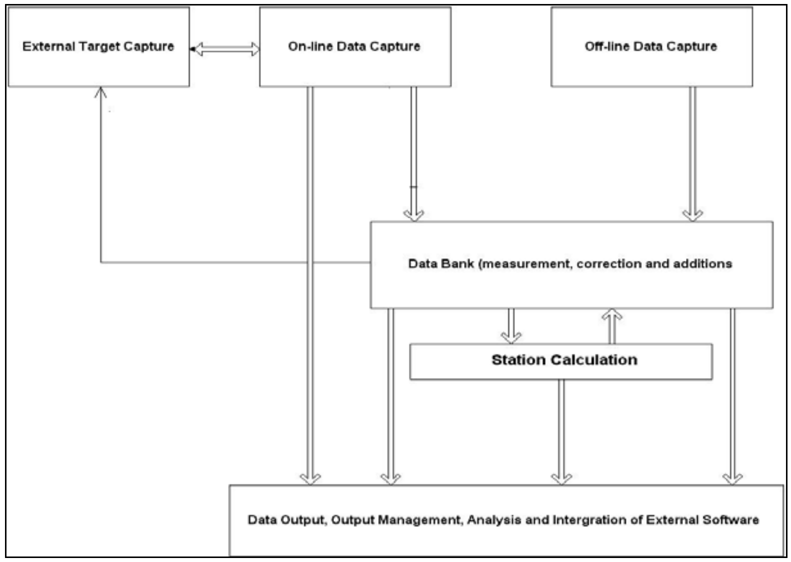

Fig 2 Overview of APSWin data-flow

4.0 Industrial Deformation Data Acquisition and Analysis (InDA)

The InDA software system contains two parts, first is instrumentation and second is software. Instruments were selected is Leica Robotic Total Station (RTS) TPS1000 family. TCA2003 (TPS1000) were installed an active beam sensing capability. An emitted IR signal transmitted to the prism that passively reflects the signal back to the instrument. The return spot imaged on a high resolutions (500 x 500) pixel CCD array (Leica, 2000). In this research, TCA1103 plus installed as an "active units.

The main engine of this software is a communication protocol between instruments and computer based. The communication protocol used GeoCOM command set. Instrument with GeoCOM are able to recognize and act on certain sequences of character (commands) that send via the serial port. The basic communication concept of GeoCOM is a point-to-point communication system. The two communication participants know as the client (external device) and the server (TPS1000 instrument) (**Figure 3**).

Fig 3: Communication between client and server.

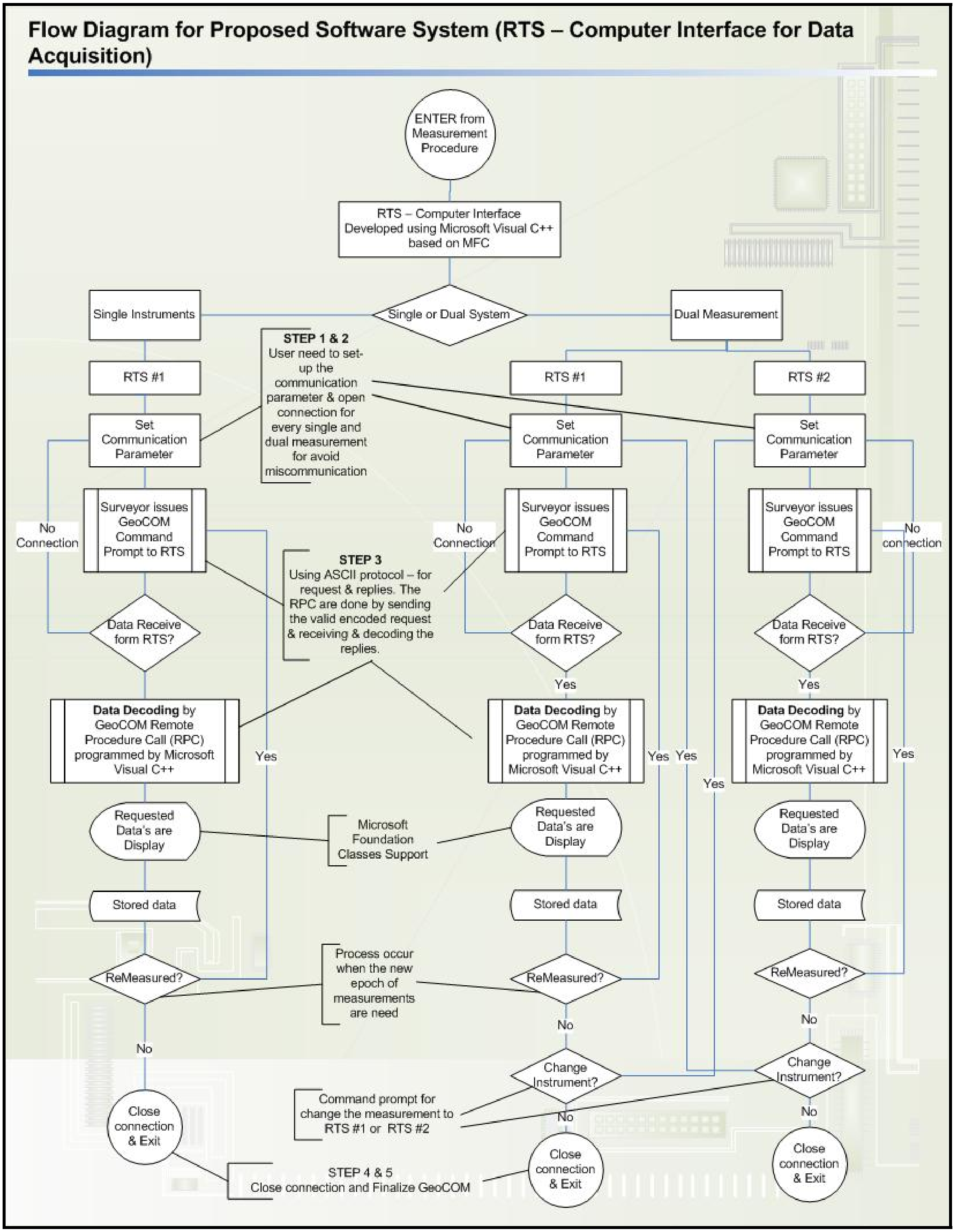

Figure 4: Flowchart for Robotic Total Station

RTS – Computer Interface Module	Major Hardware/Software
Unit one – Initialized Communication (COMM)	- Leica TCA2003/1800 - Portable Notebook - In house developed InDA software system - Communication by RS-232
Unit two – Database and Measurement Process (DAQ)	- InDA software system - PC-based database; Microsoft Access/Excel

Table 1: Robotic Total Station (RTS) – Computer Interface overview

In the field, Leica TCA2003 motorized total station with Automatic Target Recognition will take the measurement to the target point and field notebook will perform field data reduction. With software will be developed using Microsoft Visual C++ programming language, the behavior of deformation structure or shape and dimension parameter will be define. The distance, horizontal angle and vertical angle directly get from instrument command function. The InDA software system will be dividing into three modules showed in **Table 1**. **Figure 4.2** shows about flow of RTS – Computer Interface module. According to flowchart, there are two type of system, one is single instrument and other is dual instrument. This paper only deals with single instruments unit, while dual instrument is still under development. **Figure 5** shows us an interface for single instrument of RTS - Computer Interface module for COMM and DAQ units in InDA software system (as in **Table 1**).

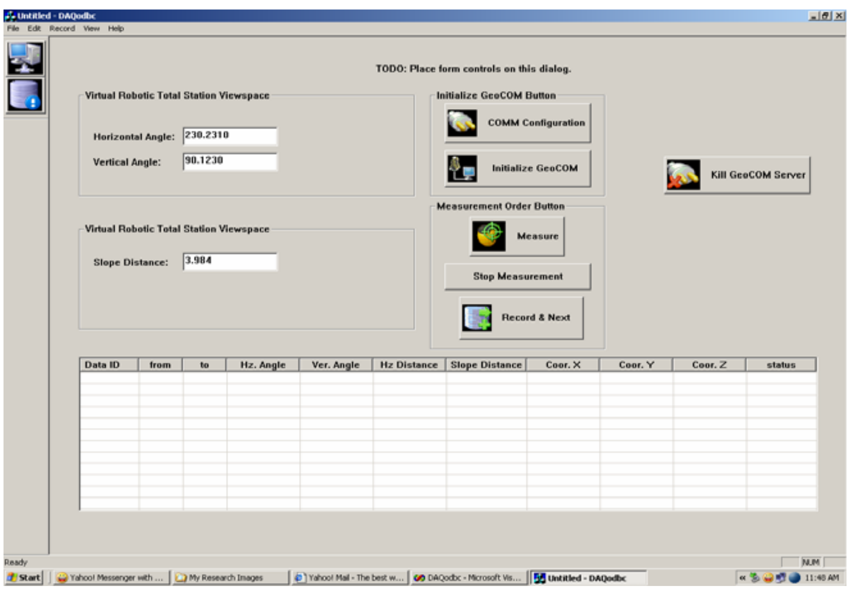

Figure 5: RTS – Computer Interface for Single Instrument

6.0 Leica APSWin and RTS – Computer Interface

Research was applied Leica APSWin software to check the reliability, ability and capability of RTS-Computer Interface module. The simulation tests were done in Surveying Engineering Research Group Laboratory. Three points are setup around the laboratory and only one instruments used to measured the data. Leica TCA1103plus was selected in this research. Leica TCA1103plus equipped with ATR function which has capability to measure the targets in fully robotic control from Leica APSWin software. The RTS-Computer Interface did not implemented robotic function for measure the targets. Operator still needed to aim the robotic total station telescope to the target, and then ATR function will be when the measure order given **Figure 6** shows the schematic diagram of survey network (target: PQ, Pobj1, Pobj2 and Pobj3).

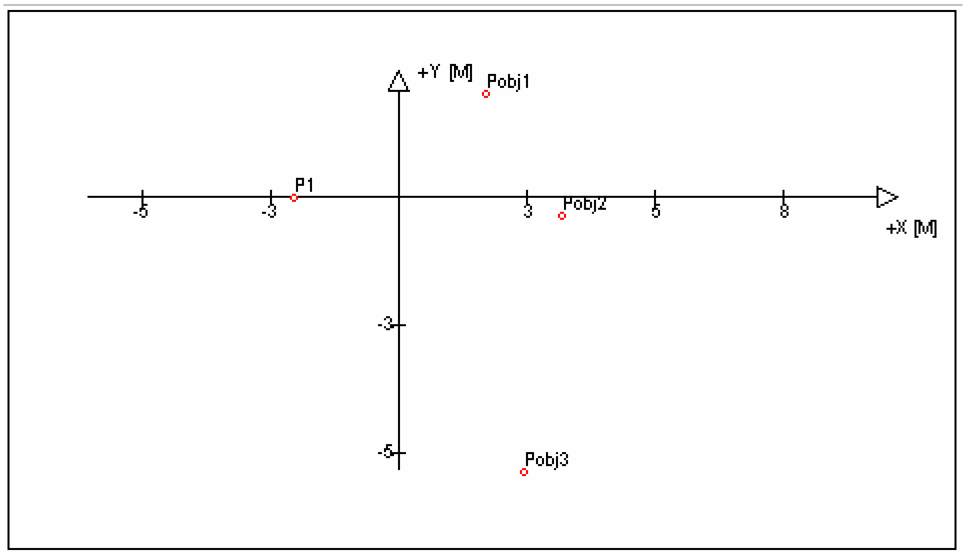

Figure 6: Survey Network

Two campaign of measurement were done between Leica APSWin and RTS – Computer Interface module. For Leica APSWin, one hour observation campaign was setup and produced 36 cycles of observation. For RTS – Computer Interface, the observation also collected 36 cycles taken one and half hour. The first cycle taken as reference cycle

The result below shows there is different in Leica APSWin and RTS-Computer Interface for observation of coordinate x and the coordinate difference (**Figure 7**) between actual and reference cycle (**Figure 8**) for target P1. The different may be caused by inconsistency of instrument and the laboratory condition. The technique of measurement also is one of the factors. But the observation data still in tolerance range about 1 mm accuracy. The highest different is 0.00015 meter at cycle 8 and 0.00014 at cycle 24 for target P1.

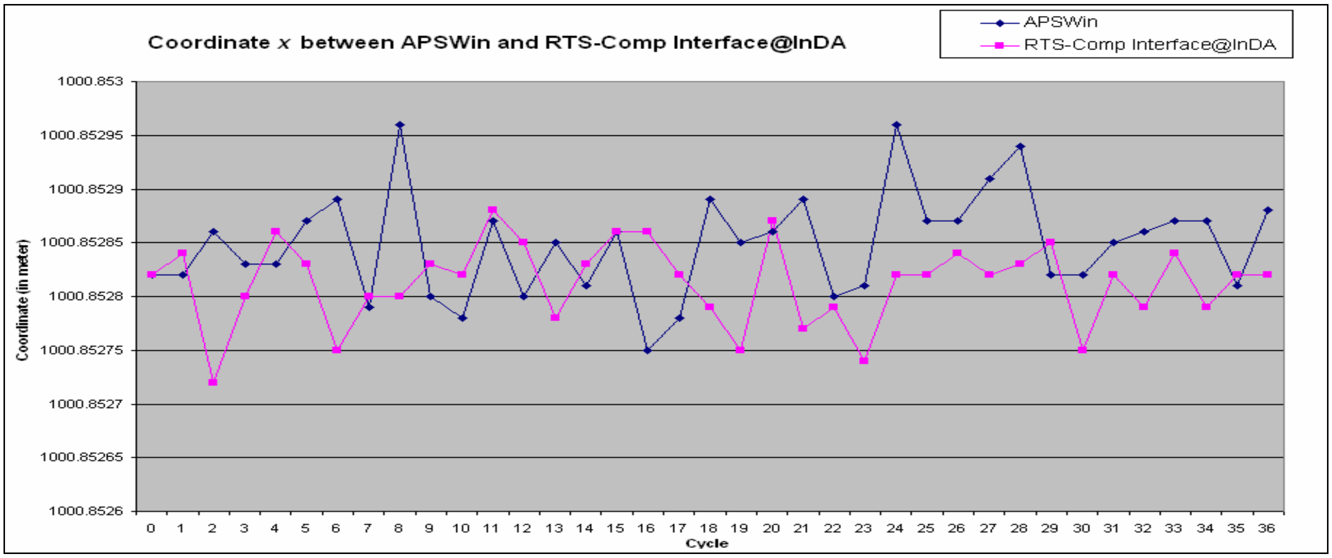

Figure 7: Coordinate *x* observation data

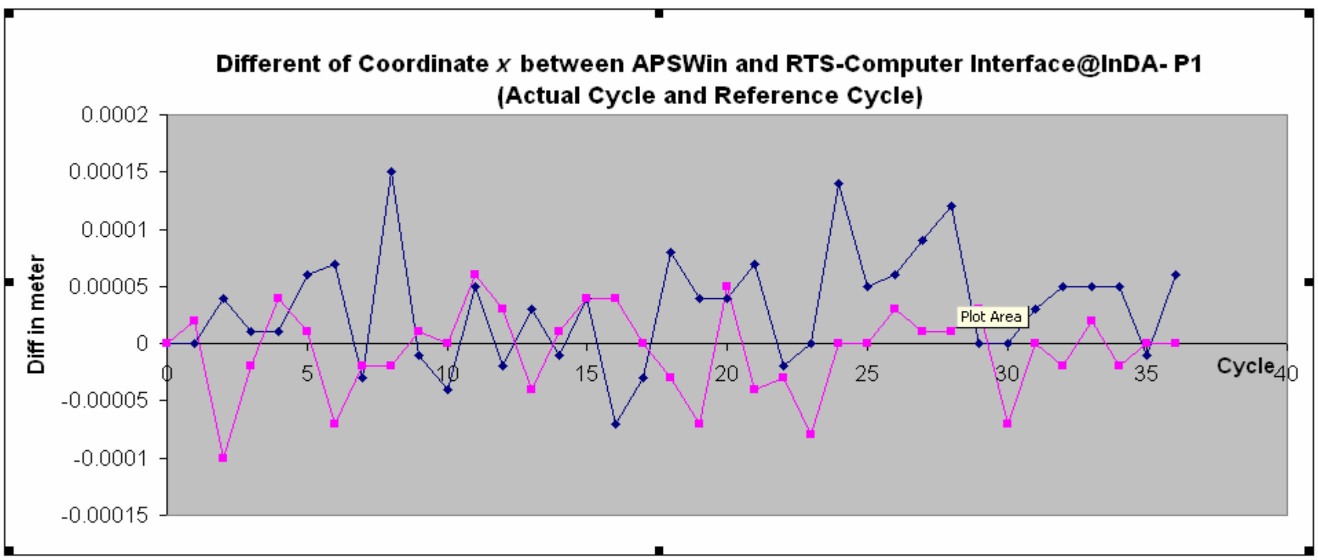

Figure 8: Coordinate *x* observation data (between actual and reference cycle)

The observation on target P1 also show the different and shape changed on coordinate x and y consistence as shown on radar chart (**Figure 9**). Other example is observation of target Pobj3. The radar chart (**Figure 10**) shows the observation data still under the tolerance (1mm). The data from RTS – Computer Interface (**Figure 10**) show the higher different between actual and reference cycle is 0.001 meter at cycle 24 (coordinate x).

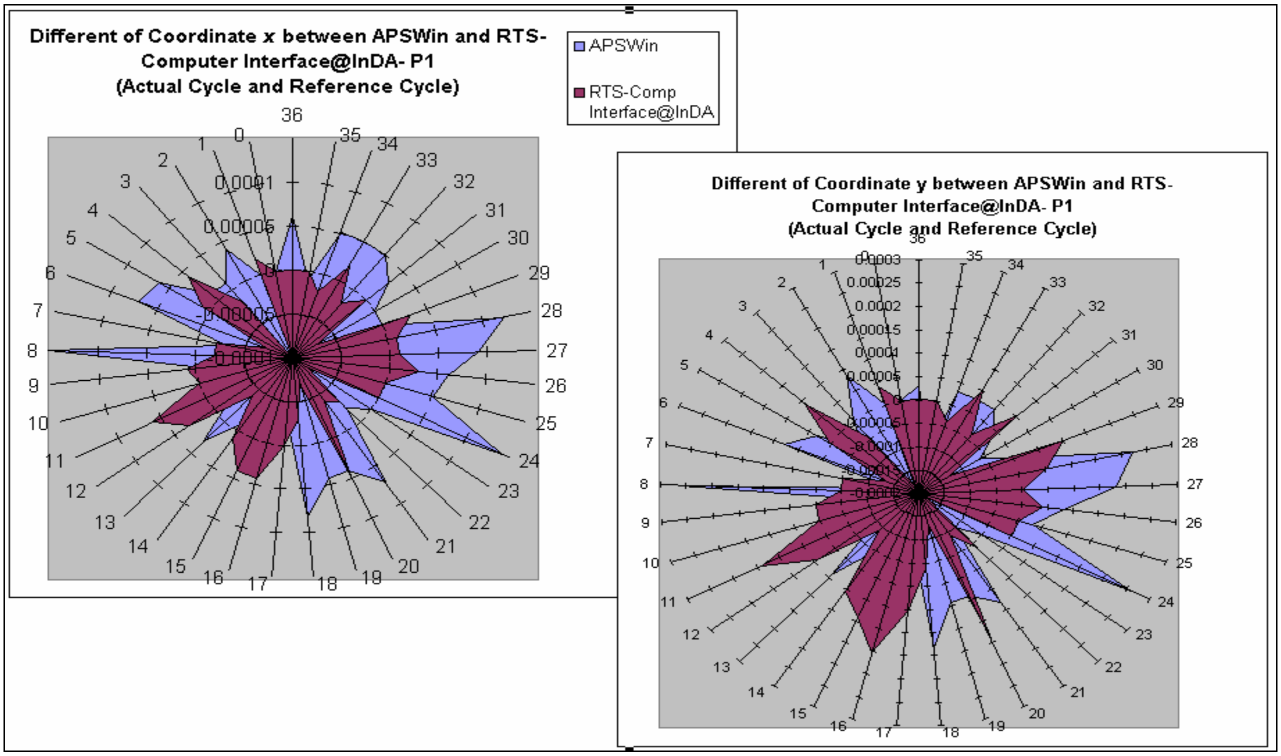

Figure 9: Coordinate *x* and *y* (between actual and reference cycle) – Tatget P1

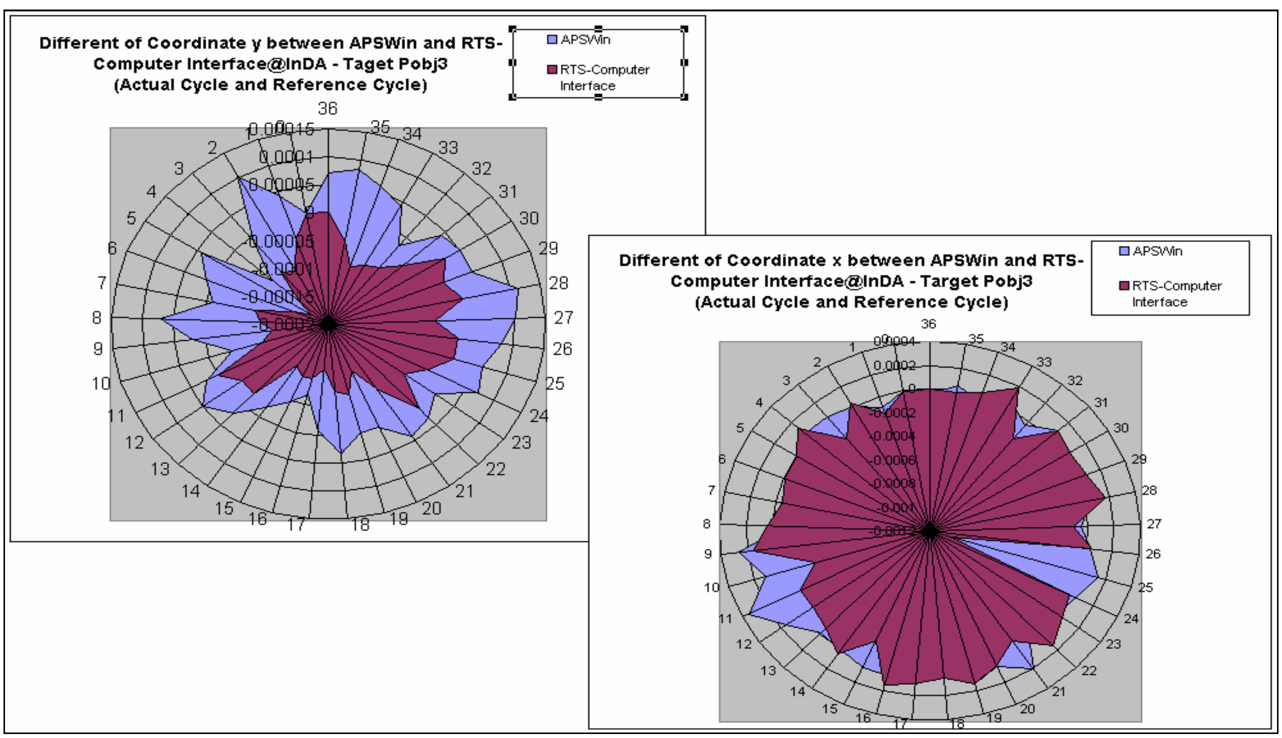

Figure 10: Coordinate *x* and *y* (between actual and reference cycle) – Target Pobj3

7.0 Conclusion

The system when finished will be fully automated data gathering and analysis for industrial deformation monitoring. In early stage integration between robotic total station and system software module, researcher found it helped surveyor to reduce gross and systematic error.

8.0 Acknowledgement

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9.0 References

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