AUTOMATIC DATA GATHERING DAN PROCESSING SOFTWARE SOLUTION FOR INDUSTRIAL DEFORMATION ANALYSIS

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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 is designed specially 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). Usually, RTS will be used in precise measurement application such as deformation monitoring or dimensional surveying for industrial applications. Both applications needed high precision and accuracy instrument and also robust data analysis. This paper describes and discusses about industrial deformation software known as InDA (Industrial Deformation Analysis Software). The discussion include from the development process and then the testing of the software. The data gathered from InDAS are compared with other instrumentation, measurement technique and commercial software.

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 been 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 is implemented to support huge amount of measurement data. Open Database Connectivity or ODBC have been used for this software system and linked to Microsoft Access. The measurement data collected from COMDA was verified by commercial software APSWins (Leica).

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 (RTS). While, ATR function must be activated from robotic total station and COMDA software module will instruct the instrument to perform 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 developed to minimize 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 (RTS) that are able to measure angle with an accuracy of ± 0.5" (0.15 mgon) and distance with an accuracy $\pm$ 1mm+ppm in standard measurement mode (Leica Geosystems, 2000).

Actually, TCA2003 RTS (produced by Leica Geosystems AG) is designed for conducting deformation-monitoring survey. However, researchers have used TCA2003 for industrial measurement. Dünish & Kuhlman (2001) and Kuhlmann, (2001), claimed that tracking of moving target is possible with modern tachometry in setting out rail geometry.

With this latest technology, RTS allows the measurement of many points on a surface. Then the points will be monitored within a short period of time. All the operations are done using ATR technology (Leica Geosystem, 2000), and each prism can be found automatically. **Figure 1** shows the concept of ATR technology where the telescope center is identified to provide precise targeting and pointing.

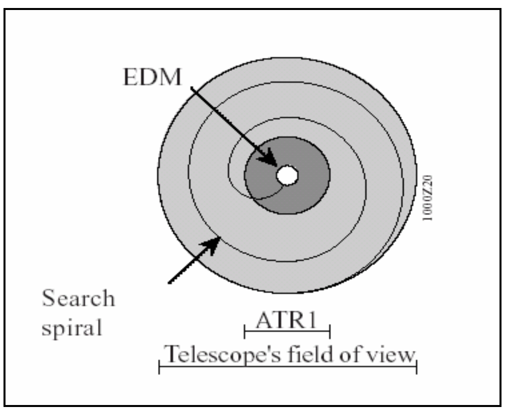

Figure 1: Automatic Target Recognition Concept (Leica Geosystems, 2000)

3.0 Automatic Polar System for Windows (APSWin)

APSWin was manufactured by Leica Geosystem to conduct real time deformation monitoring of 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) 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 pairs of points are required. The defined connections to the reference points are used to determine the parameter of linear transformation (and mean value & standard deviation). For Helmert transformation, the coordinates of the reference point for the actual cycle are transformed so that the sum of the squares of residual divergences is a minimum (Leica, 1998). Some testing has been conducted at Universiti Teknologi Malaysia, Skudai on APSWin capability (Halim & Khairulnizam, 2005). **Figure 2** shows how APSWin data flow from data capture through data bank and station calculation.

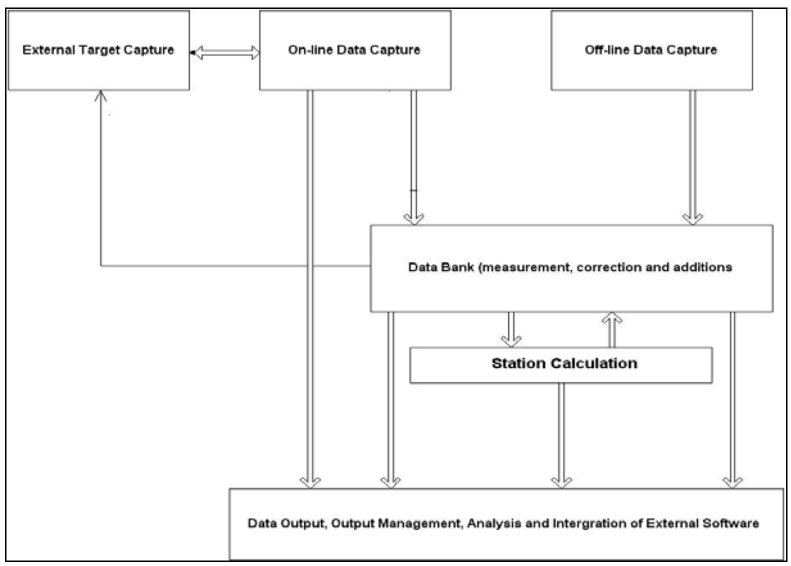

Figure 2: Overview of APSWin data-flow

4.0 Industrial Deformation Data Acquisition and Analysis (InDA)

The InDA software system contains two parts, instrumentation and software. The Instrument used is Leica Robotic Total Station (RTS) TPS1000 family. TCA2003 (TPS1000) was installed as 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 is imaged on a high resolutions (500 x 500) pixel CCD array (Leica, 2000). In this research, TCA1103 plus is installed as an active unit.

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

Figure 3: Communication between client and server

In the field, Leica TCA2003 motorized total station with ATR will take the measurement to the target point and the field notebook will perform the field data reduction. The distance, horizontal angle and zenith angle will be obtained directly from instrument command function. The InDA software system (developed using Microsoft Visual C++ programming language) will be divided into three modules (**Table 1**). **Figure 4** shows the flow of RTS–Computer Interface module. InDA could handle two types of system, one is single instrument and other is dual instrument. This paper only deals with single instruments unit, while dual instrument module is still under development. **Figure 5** and **Figure 6** show an interface for single instrument of RTS - Computer Interface module for COMM and DAQ units in InDA software system (as in **Table 1**).

Another module of InDA will be developed to determine the behavior of deformation structure or shape and dimension parameter.

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

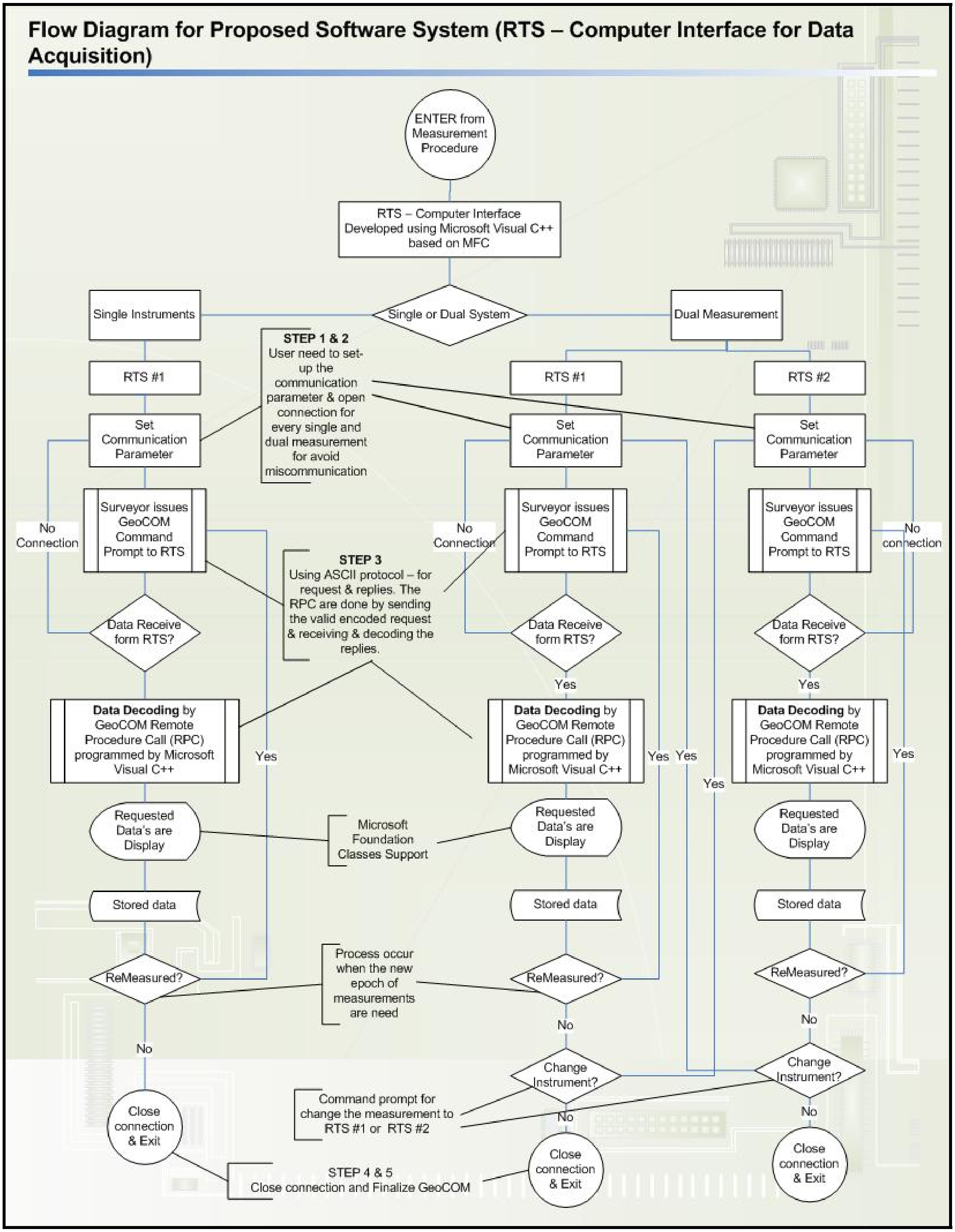

Figure 4: Flowchart for RTS-computer interface

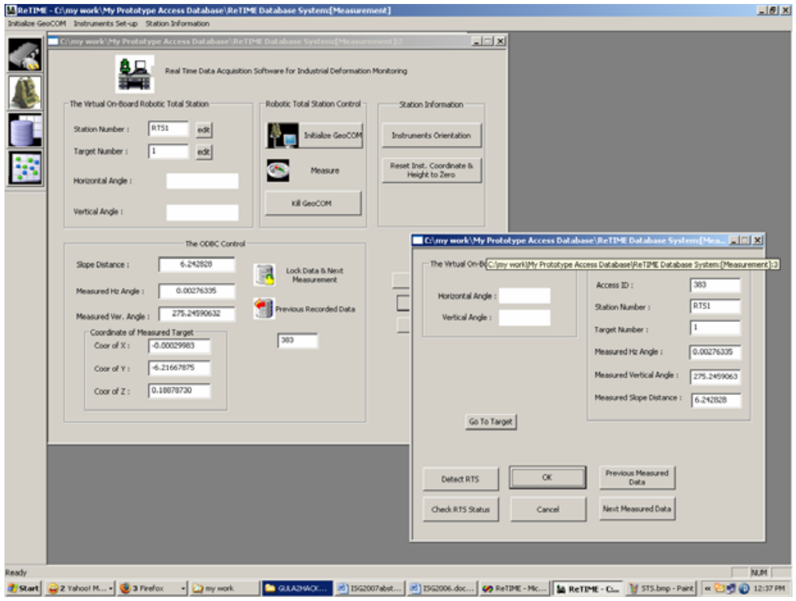

Figure 5: RTS – Computer Interface for Single Instrument

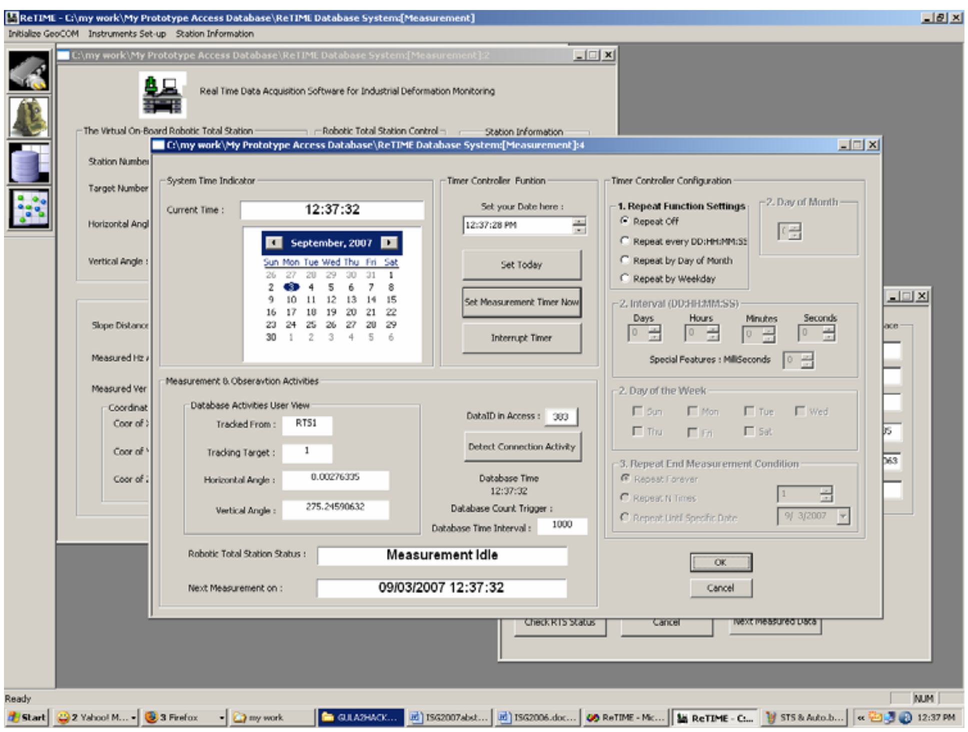

Figure 6: RTS – Computer Interface for Single Instrument in Automatic Mode

6.0 Leica APSWin and RTS – Computer Interface

This research 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 were setup around the laboratory and only one instruments used to measured the data. Leica TCA1103plus was selected in this research. Leica TCA1103plus is 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 implement robotic function to measure the targets. Operator still needed to aim the robotic total station telescope to the target, and then ATR function will be activated when the measure command is selected. **Figure 7** shows the schematic diagram of survey network (target: P1, Pobj1, Pobj2 and Pobj3).

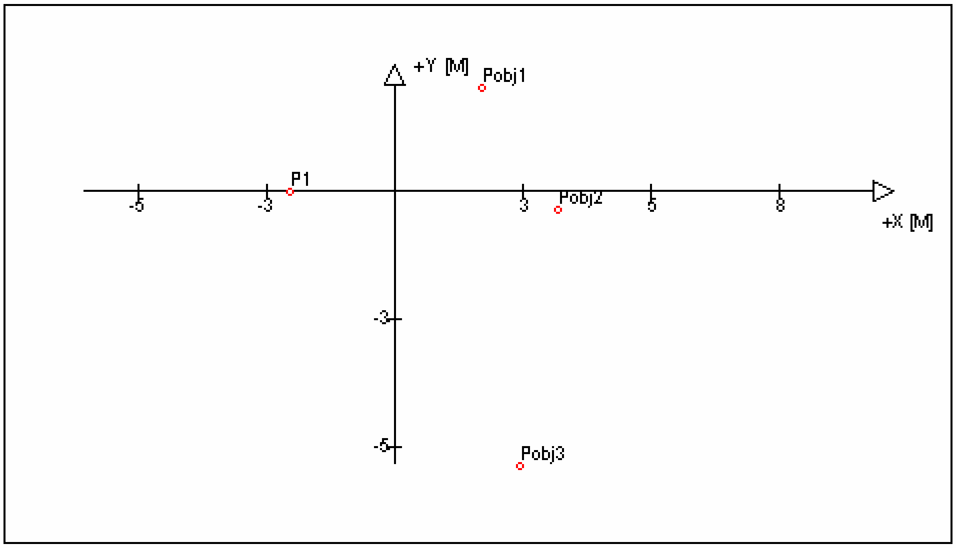

Figure 7: Survey Network

Two campaign of measurement were done via 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 was taken as reference cycle.

The results below show some differences in Leica APSWin and RTS-Computer Interface for observation of coordinate x and the coordinate difference (**Figure 8**) between actual and reference cycle (**Figure 9**) for target P1. The difference may be caused by inconsistency of instrument and the laboratory condition. The technique of measurement is also one of the factors. But the observation data is still in the tolerance range of about 1 mm accuracy. The highest different is 0.00015 meter at cycle 8 and 0.00014 at cycle 24 for target P1.

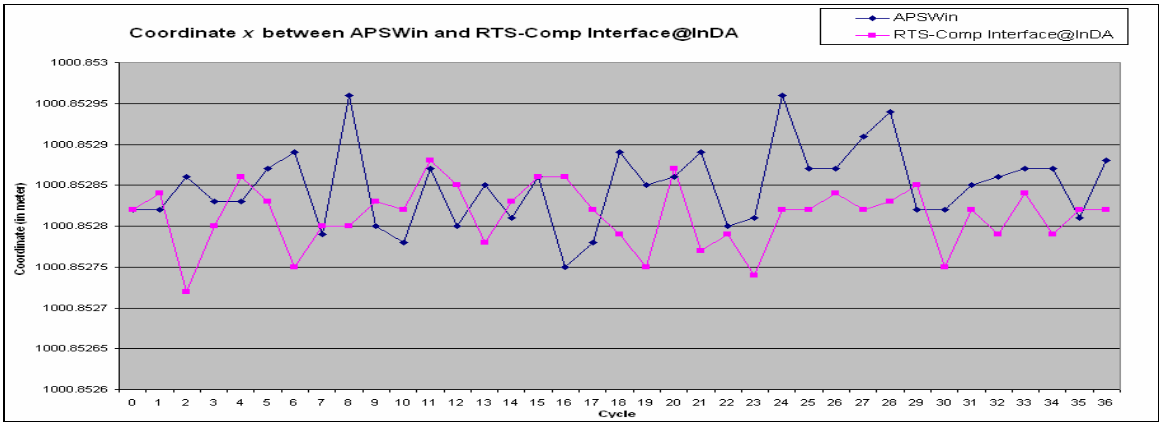

Figure 8: Coordinate *x* observation data

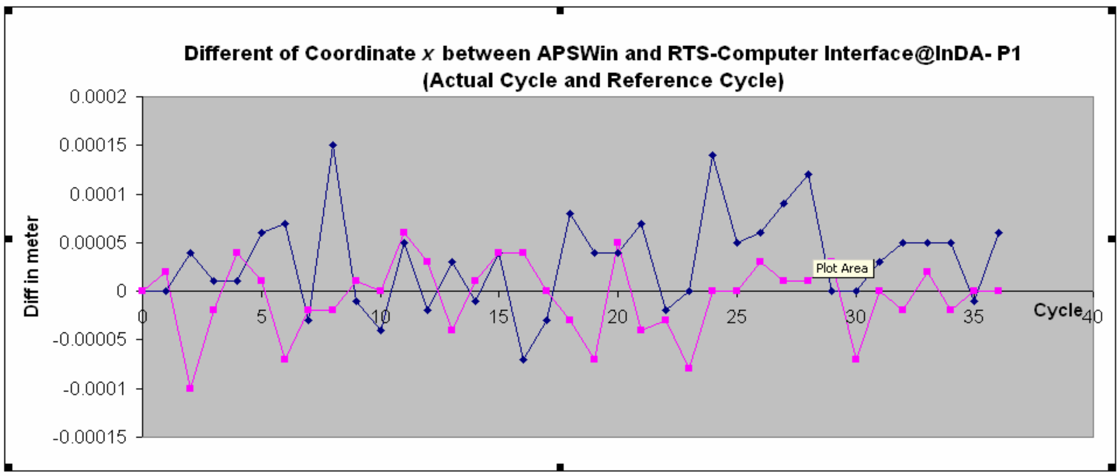

Figure 9: Coordinate *x* observation data (between actual and reference cycle)

The observation on target P1 also show the differences and shape changed on coordinate x and y consistence as shown on radar chart (**Figure 10**). Other example is observation of target Pobj3. The radar chart (**Figure 11**) shows the observation data still under the tolerance (1mm). The data from RTS – Computer Interface (**Figure 10**) show the higher differences between actual and reference cycle is 0.001 meter at cycle 24 (coordinate x).

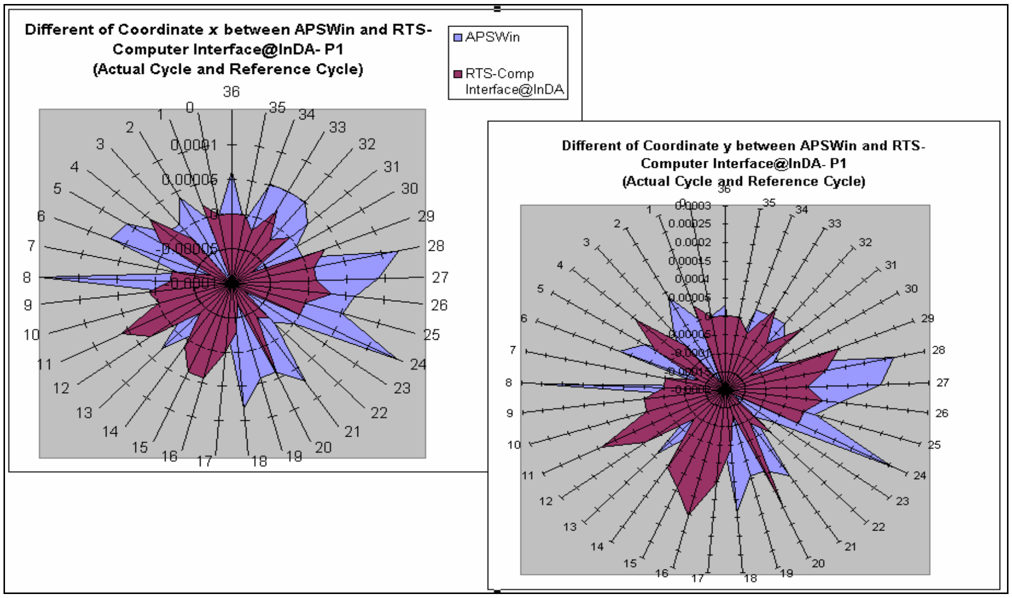

Figure 10: Coordinate *x* and *y* (between actual and reference cycle) – Target P1

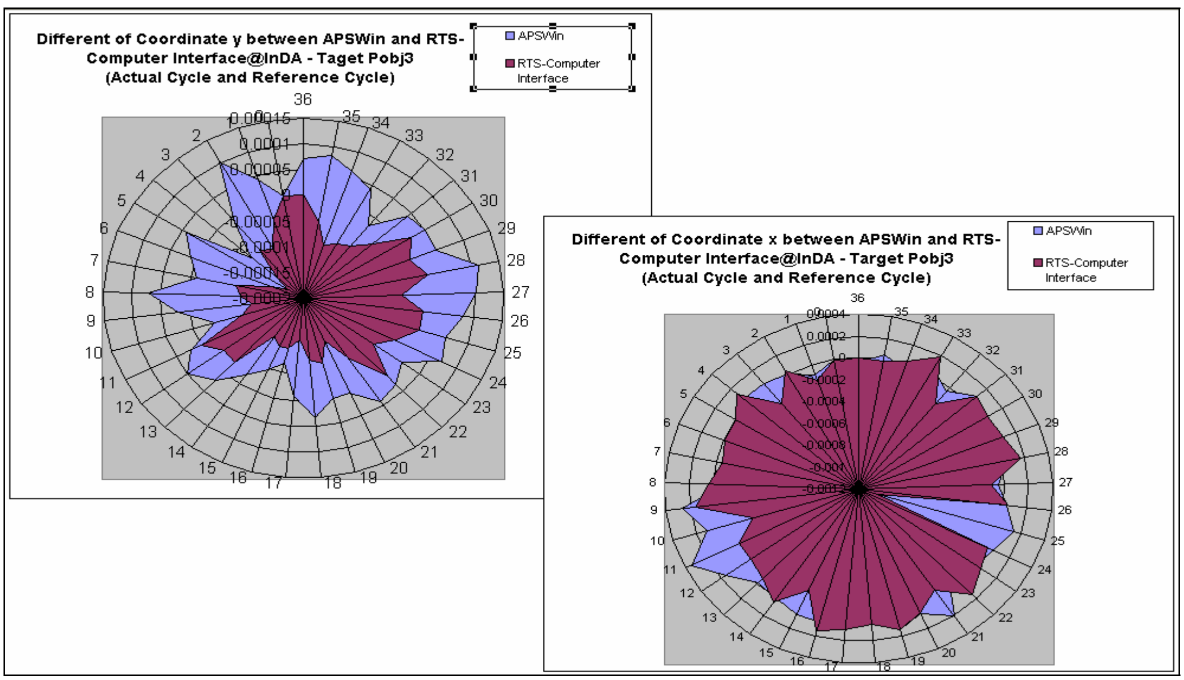

Figure 11: Coordinate *x* and *y* (between actual and reference cycle) – Target Pobj3

7.0 Conclusion

The InDA software system, when completed will be fully automated data gathering and analysis for industrial deformation monitoring. The results to date show that the integration between robotic total station and system software module helped surveyor to reduce gross and systematic error.

Acknowledgement

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