

COMMUNICATION AND DATABASE MODULES FOR AUTOMATIC DATA ACQUISITION

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ABSTRACT

Robotic Total Station or Robotic Tachometry System (RTS) are widely used for surveying purpose and solution. From surveyor to archeologist, professionals used RTS to solve many problems in data collection such as 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 ATR). Manufacturers such as Leica Geosystem, Topcon Instrument, Trimble and Geodimeter have designed an instrument with ATR. Usually, the RTS can be used in precise measurement such as deformation monitoring or dimensional surveying for industrial. Both applications needed high precision instrument and also robust data analysis. This paper describes and discusses an industrial deformation software known as InDA (Industrial Deformation Analysis Software). The discussion includes the development process and the testing of the software. Also the data gathered from InDA were compared with Leica APSWin (commercial software). From the testing, the observation tolerance between InDA and Leica APSWin is less than 1 mm.

Keywords: Robotic Total Station, Precise Measurement, Industrial Deformation.

1.0 INTRODUCTION

The measurement technique for spatial data collection for industrial measurement and deformation detection usually employed by surveyors are based on the geodetic method. Industrial measurement and deformation detection commonly consists of data collection and processing modules. Data collection is one of the important aspects where all the spatial information collected must not contain gross error (Wolf and Ghilani, 2006). Gross error is normally contributed from surveyor or observer blunders. Observer blunders are usually caused by misunderstanding of the problem, carelessness, fatigue, missed communication or poor judgment (Mikhail, 1976; Wolf and Ghilani, 2002). Software implementation during data gathering can reduce and avoids gross error or observer blunders.

This paper deals with real time data acquisition for industrial deformation application. A module known as Communication (COMM) and Data Acquisition (DAQ) modules 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 Analysis Software or InDA. The database management system is implemented to support huge amount of measurement data. Open Database Connectivity or ODBC has been used for this software system and linked

to Microsoft Access. The measurement data collected from InDA was verified by commercial software Leica APSWin.

The motivation inside this research have considered several factors 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 is developed as a low cost software system, to minimize the error in measurement, and provide robust analysis.

2.0 THE INSTRUMENTATION

Surveying technology allows the determination of 3-dimensional (3D) coordinates and movement. Current technology provides robotic total stations (RTS) that are able to measure angle with an accuracy of $\pm 0.5''$ (0.15 mgon) and distance with an accuracy of $\pm 1\text{mm} + \text{ppm}$ in standard measurement mode (Leica Geosystems, 2000). For example, TCA2003 produces by Leica Geosystems AG, which is designed for conducting deformation-monitoring survey. Many researchers have used the TCA2003 model for industrial measurement; see Dünish and Kuhlman (2001) and Kuhlmann (2001). Their studies claimed that tracking moving target is possible with RTS in setting out rail geometry. Radovanovic and Teskey (2001) used Leica TCA2003 for measuring several points in continuous mode and the results were compared with GPS technique. Lutes et al. (2001) implemented DIMONS software (and supported by Leica TCA2003) for monitoring a water reservoir dam in Canada.

With this latest technology, the 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 Automatic Target Recognition (ATR) technology (Leica Geosystem, 2000), where each prism can be found automatically. **Figure 1** shows the concept of ATR technology where the telescope center is identified to provide precise targeting pointing. The instrument selected in this study is Leica TCA2003.

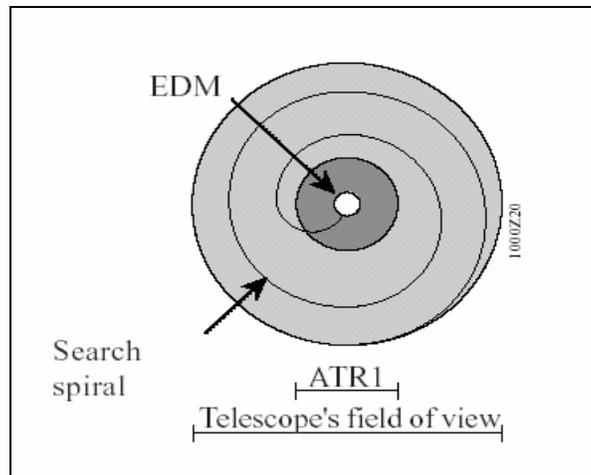


Figure 1. Automatic Target Recognition Concept (Leica Geosystems, 2000)

3.0 AUTOMATIC POLAR SYSTEM FOR WINDOWS (APSWin)

APSWin is 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 theodolites and total stations (TM3000x, TPS1000 family). Change in instrument position (translation along x, y, z), theodolite rotation and factor affecting the vertical readout can be determined in station calculation for individual cycle. 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, mean value and standard deviation. For Helmert transformation, the coordinates of the reference points for the actual cycle are transformed so that the sum of the squares of residual divergences is a minimum (Leica, 1998). Some tests were conducted at Universiti Teknologi Malaysia, Skudai on APSWin capability (Halim and Khairulnizam, 2005). **Figure 2** shows how APSWin data flow from data capture through data bank and station calculation.

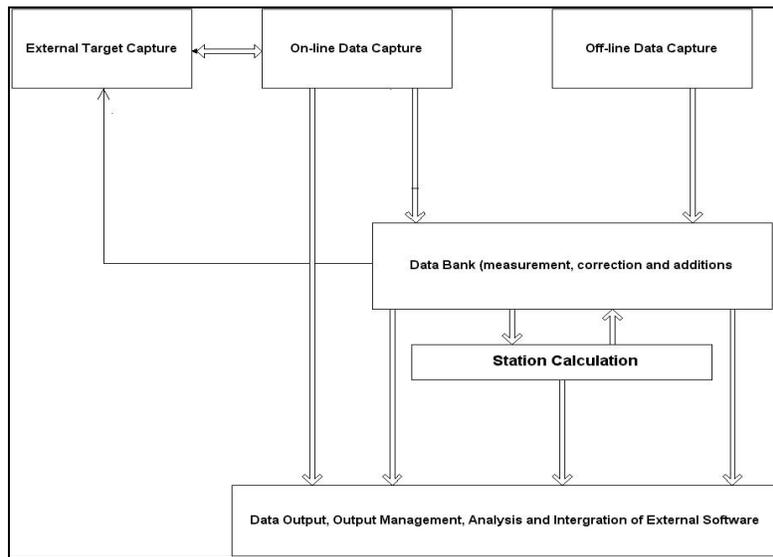


Figure 2. Overview of APSWin data-flow

4.0 INDUSTRIAL DEFORMATION DATA ACQUISITION AND ANALYSIS (InDA)

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

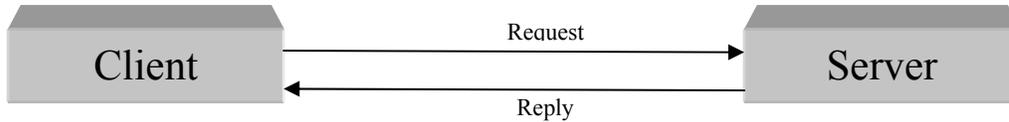


Figure 3. Communication between client and server.

During the measurement, 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. The distance, horizontal angle and vertical angle will be obtained directly from instrument command function. The InDA software system is divided into three modules, namely COMM, DAQ and ANALY, see **Table 1. Figure 4** shows the flow of module one and module two. InDA could handle two types of system, one is single instrument and other is dual instrument. This paper only deals with single instruments unit. **Figure 5** and **Figure 6** show an interface for single instrument of module COMM and module DAQ in InDA software system, respectively. Another module of InDA is ANALY. Module ANALY is developed for industrial deformation analysis.

Table 1. InDA software system overview

RTS – Computer Interface Module	Major Hardware/Software
Module 1 – Initialized Communication (COMM)	<ul style="list-style-type: none"> - Leica TCA2003/1800 - Portable Notebook - In house developed InDA software system - Communication by RS-232
Module 2 – Database and Measurement Process (DAQ)	<ul style="list-style-type: none"> - InDA software system - PC-based database; Microsoft Access/Excel
Module 3 – Database and Analysis (ANALY)	<ul style="list-style-type: none"> - InDA software system - PC-based database; Microsoft Access/Excel - MyLSE for least square estimation - ADDS for deformation detection - 3DCDS for form fitting determination

5.0 LEICA APSWIN AND COMM DAQ MODULES

Research study has utilized Leica APSWin software to check the reliability, ability and capability of COMM and DAQ modules. The simulation tests were done in Surveying Engineering Research Group Laboratory. Three points were setup around the laboratory and Leica TCA2003 was used to collect the data. Leica TCA2003 is equipped with ATR function which has the capability to measure the targets in fully robotic control from Leica APSWin software. The COMM and DAQ modules did not implement robotic function to measure the targets because an operator is still needed to aim the RTS telescope to the target, and then ATR function will be activated when the measure function (**Figure 6**) is selected. **Figure 7** shows the schematic diagram of survey network of the test (target: P1, Pobj1, Pobj2 and Pobj3).

Two campaign of measurement were performed with Leica APSWin and InDA (via COMM and DAQ modules). For Leica APSWin, one hour observation campaign was setup and produced 36 cycles of observation. For COMM and DAQ modules, the observation also collected 36 cycles for one and half hour. The first cycle was taken as reference cycle.

The results in **Figure 8** and **Figure 9** show some differences in Leica APSWin vs COMM and DAQ modules for observation of coordinate x and the coordinate difference between actual and reference cycle for target P1, respectively. The differences may be caused by inconsistency of instrument and the laboratory condition. The technique of measurements is also one of the factors. The observation data is in tolerance range about 1 mm accuracy whereby the highest different is 0.00015 meter at cycle 8 and 0.00014 at cycle 24 for target P1.

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

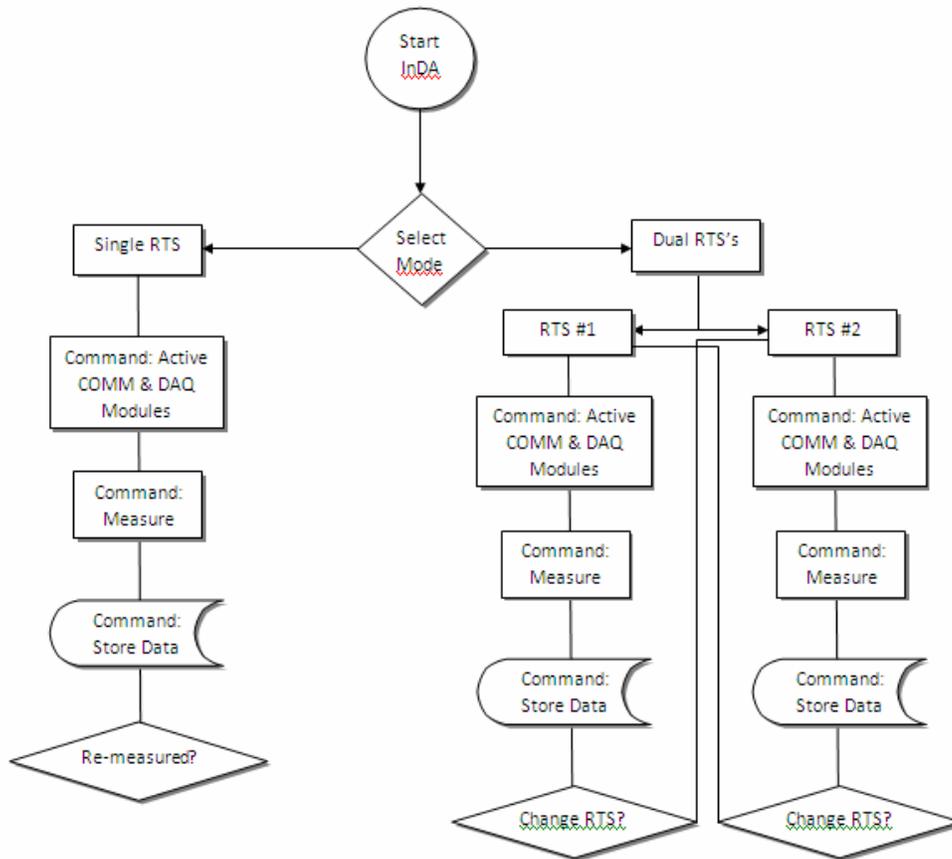


Figure 4. Flowchart for InDA: COMM and DAQ modules.

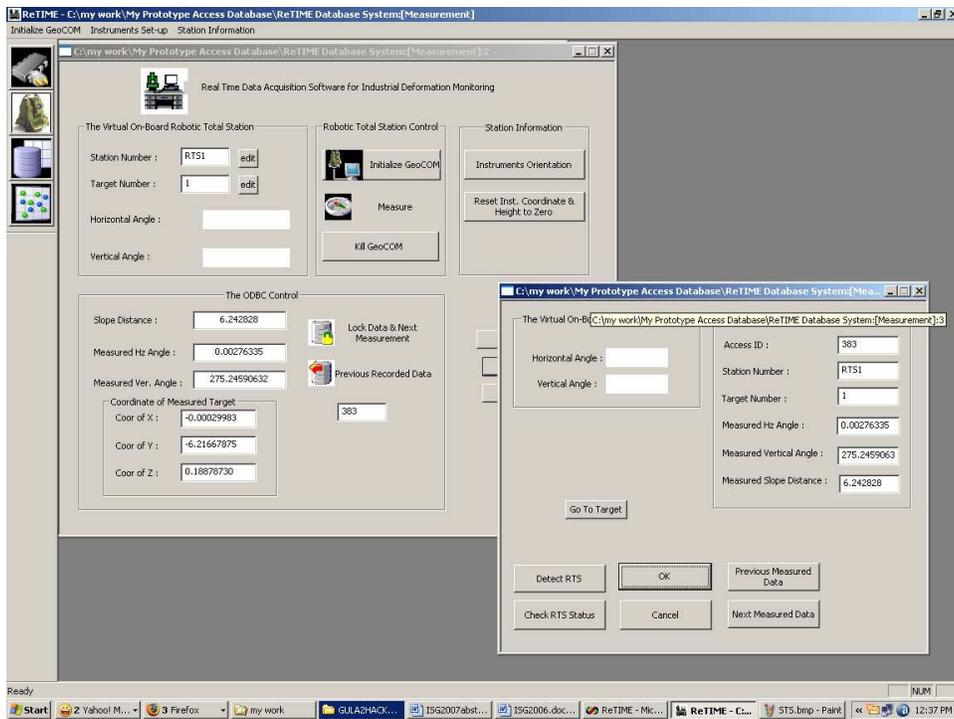


Figure 5. RTS – Computer Interface for Single Instrument

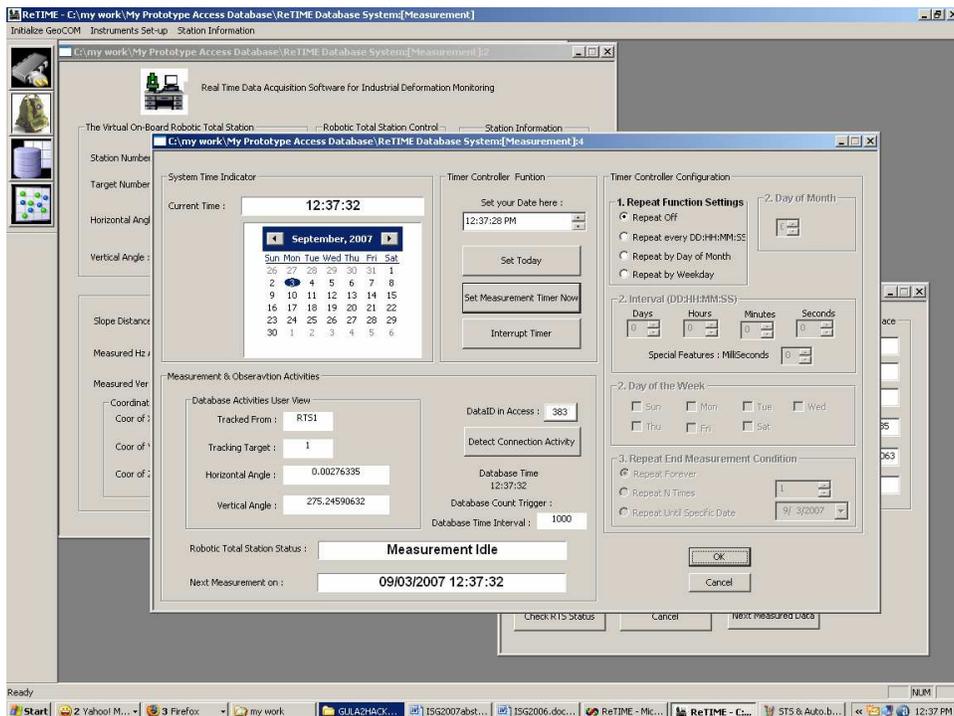


Figure 6. RTS – Computer Interface for Single Instrument in Automatic Mode

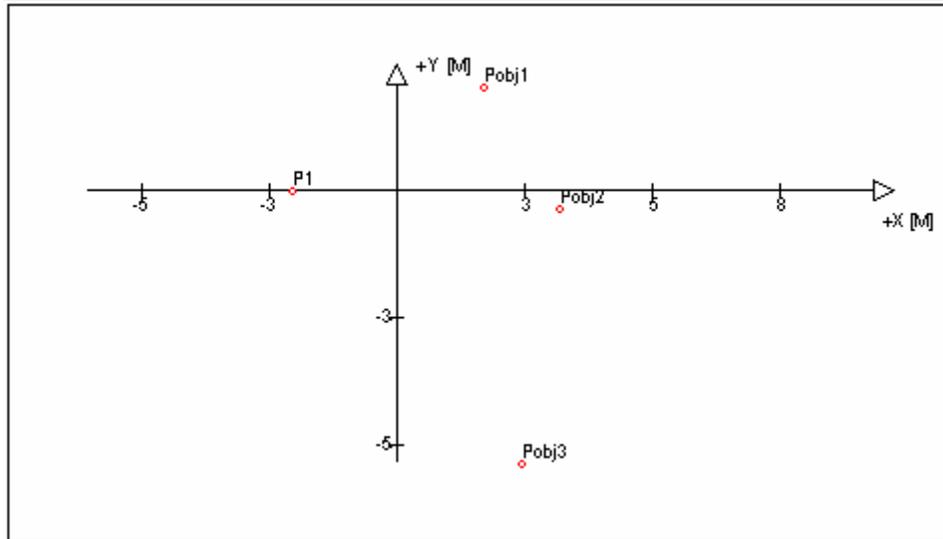


Figure 7. Survey Network

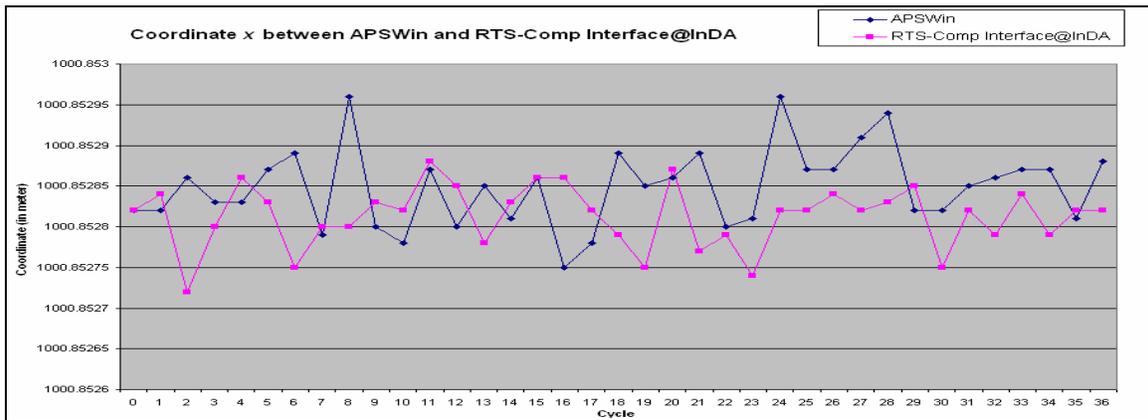


Figure 8. Coordinate x observation data

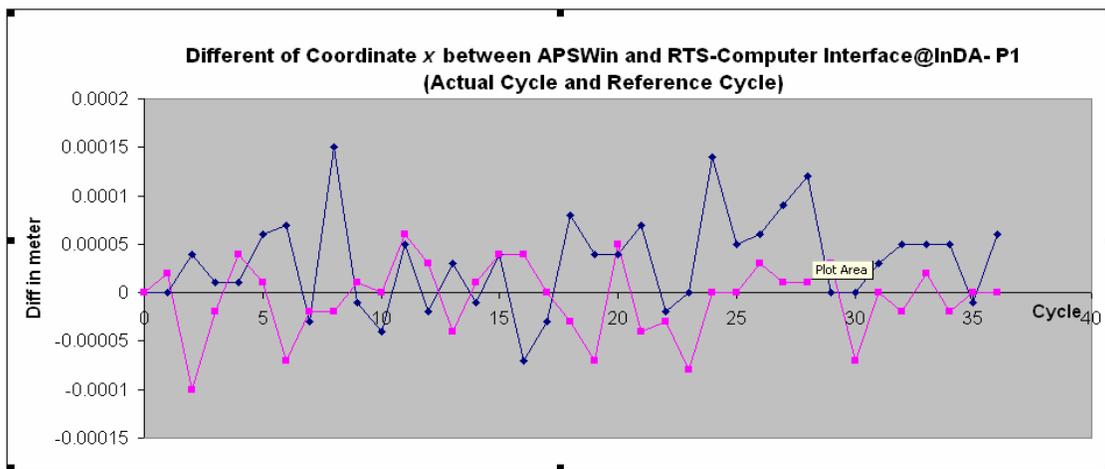


Figure 9. Coordinate x observation data (between actual and reference cycle)

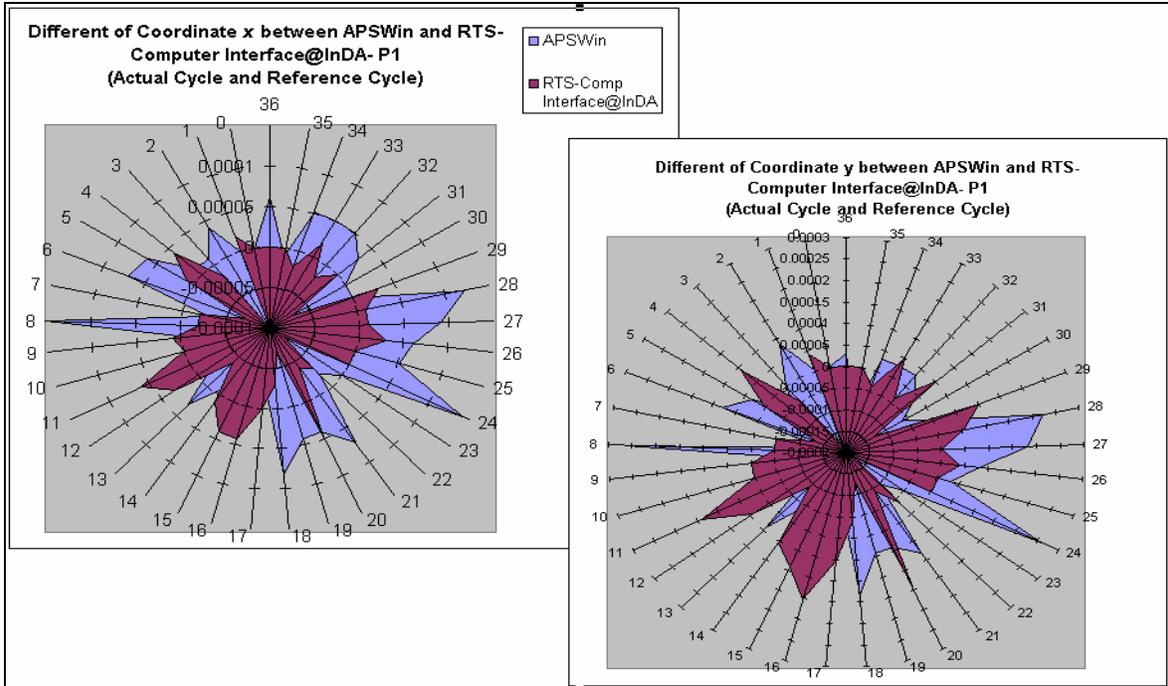


Figure 10. Coordinate x and y (between actual and reference cycle) – Target P1

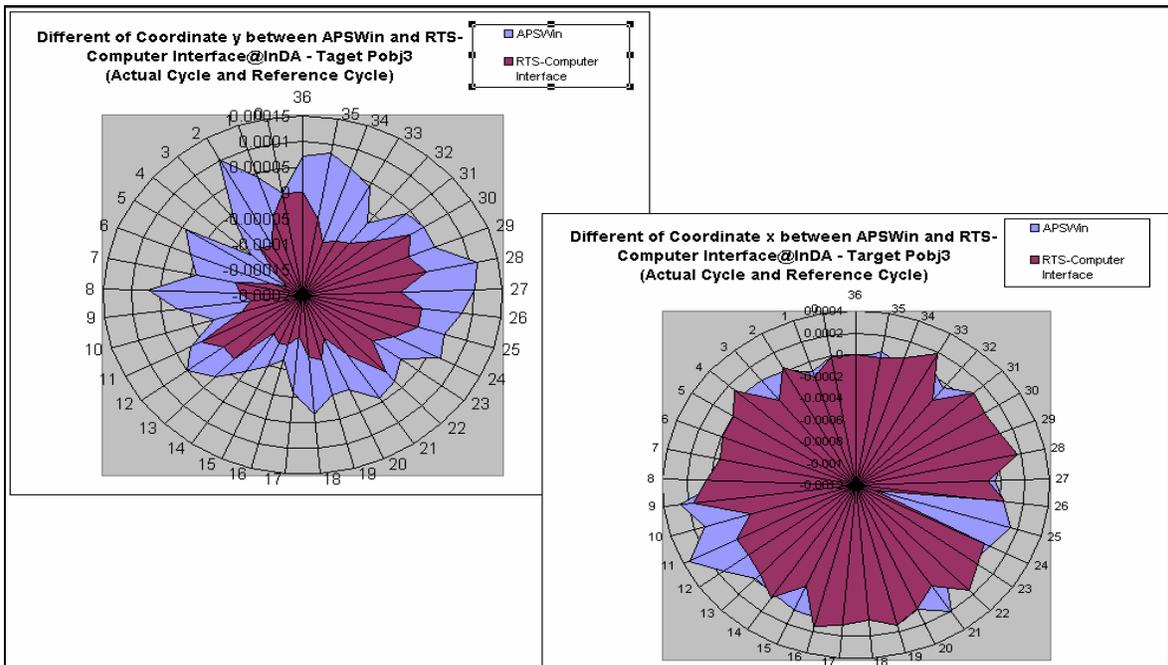


Figure 11. Coordinate x and y (between actual and reference cycle) – Target Pobj3

6.0 CONCLUSIONS

The results show consistency during the one-hour observation campaign between the two software systems, InDA and APSWin. APSWin has been integrated with build-in Automatic Target Recognition (ATR) inside RTS. However, in InDA, the ATR function is activated from RTS and InDA software module will then control the instrument to do the measurement. Complete development of the system will be fully automated data gathering and analysis for industrial deformation monitoring. In the early integration between robotic total station and system software module, researcher found it helped surveyor to reduce gross and systematic error.

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