Dual-Mode GPS Real-Time Kinematic System for Seamless Ultrahigh-Precision Positioning and Navigation

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BACKGROUND

The University of New Brunswick (UNB) RTK (real-time kinematic) software, initially designed for a gantry crane auto-steering system in commercial operations at Korea International Terminals' Kwangyang Port in South Korea, is able to provide navigation solutions in real time at an 10 Hz update rate commensurate with the dual-frequency data rate. The software for this system works in conjunction with a GPS receiver and IEEE 108.11b compatible 2.4 GHz wireless LAN (WLAN) master unit at a base station and two dual-frequency GPS receivers and a WLAN adapter installed on the cranes.

We have explored the capabilities of the software in new GPS applications. Recently, tests of this software for deformation monitoring have been carried out at Highland Valley Copper Mine in British Columbia, Canada. Also, tests to investigate the performance of the software under long-baseline situations including on-land and offshore environments are being conducted. Dedicated UHF point-to-point, WLAN and LAN communications have been used for real-time testing. From the initial investigations for new RTK applications, a second generation of the UNB RTK software has been developed which improves system performance for different applications. One of the main features of the new software is dual-mode communication which can switch between WLAN and dedicated UHF automatically if either communication link is not available. (This feature can be easily extended to use different types of serial and Ethernet communication equipment.) As a result, dual-mode communication increases availability of the RTK system and hence, it is able to provide seamless RTK services for clients moving through different environments. Another feature of the new system is its ability to provide navigation solutions in real time at up to a 25 Hz update rate commensurate with a receiver's dual-frequency data rate. In this case, the use of WLAN (more preferably, IEEE 108.11a or 108.11g compatible 5 GHz wireless LAN) is recommended.

DUAL-MODE UNB RTK SYSTEM

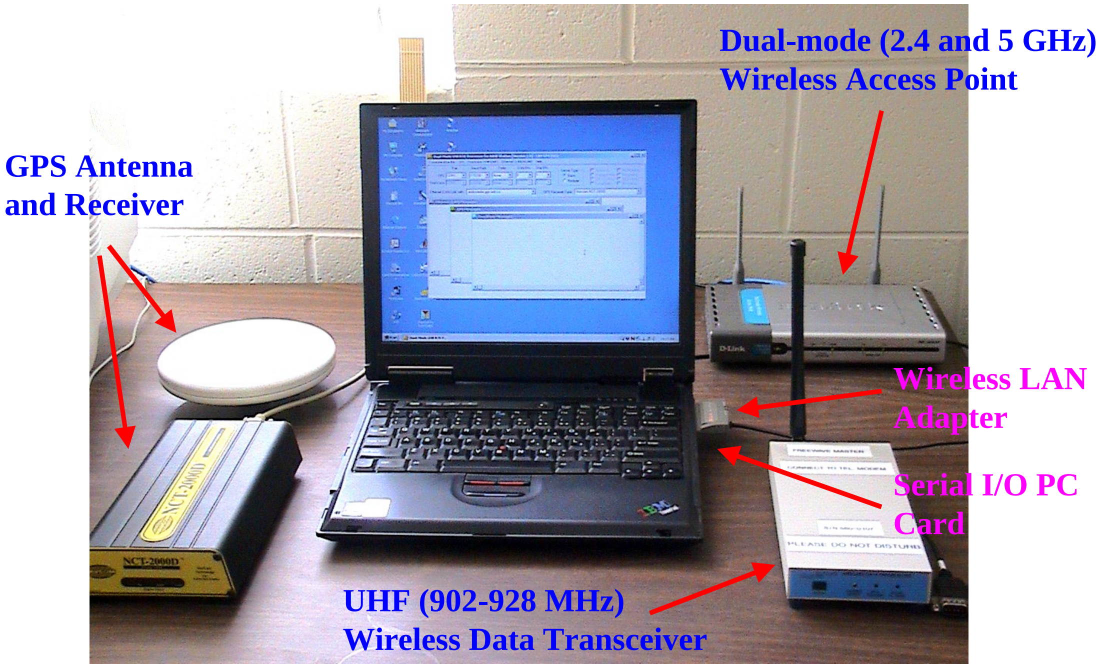

Figure 1. System components: GPS (antenna and receiver), wireless LAN (adapter and access point), and wireless data transceiver (FreeWave radio and serial I/O PC card).

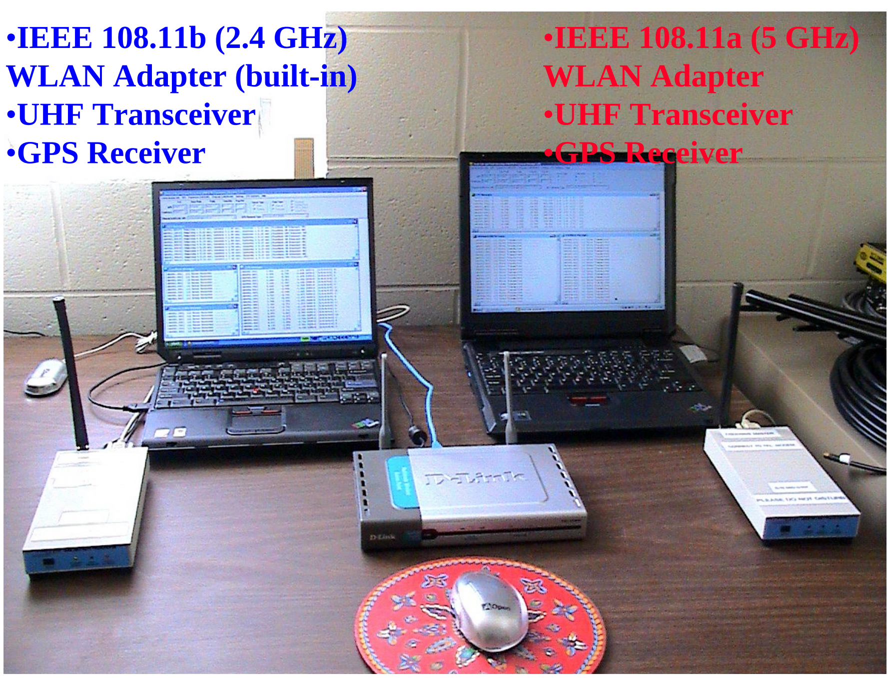

Figure 2. System configuration: base and remote stations.

DUAL-MODE UNB RTK SOFTWARE

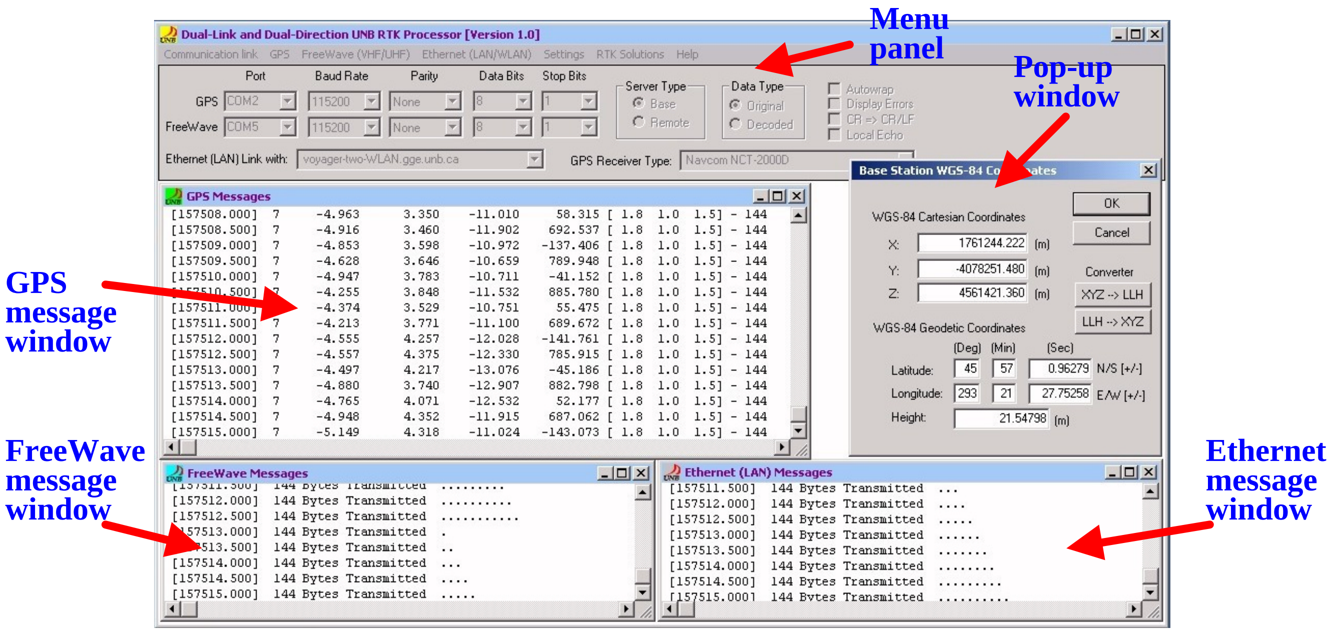

Figure 3. Base station GUI (graphic user interface): GPS message window, FreeWave message window, Ethernet message window, and many other pop-up windows activated by menu options.

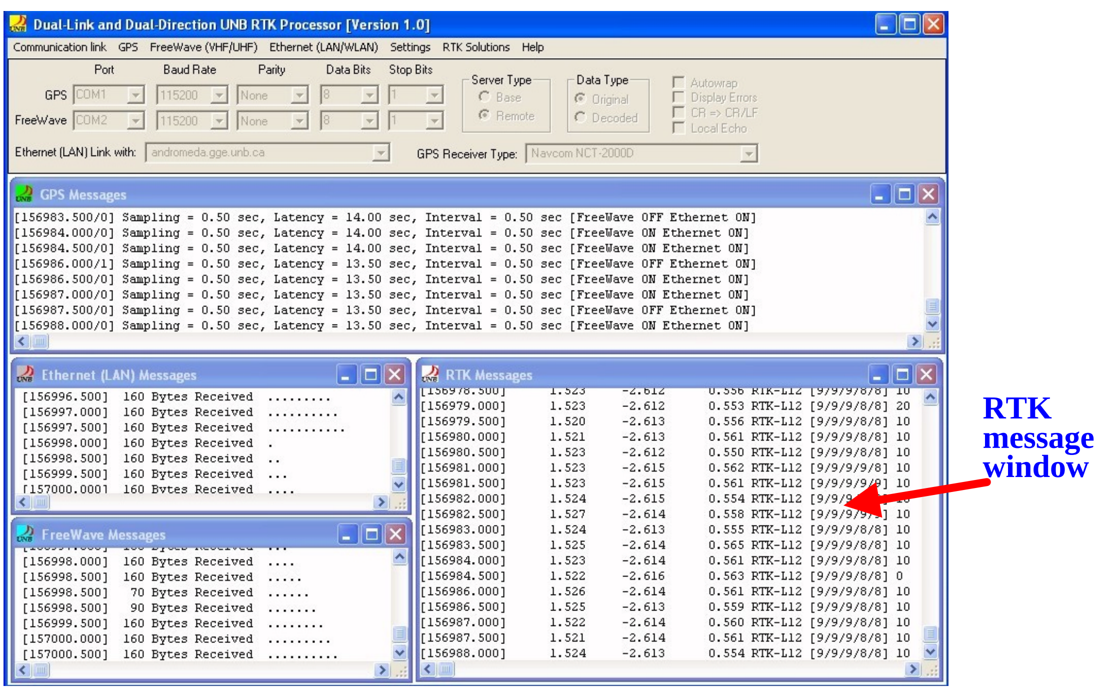

Figure 4. Remote station GUI: GPS message window, FreeWave message window, Ethernet message window, RTK message window, and many other pop-up windows activated by menu options.

CASE STUDY: Deformation monitoring at Highland Valley Copper Mine, B.C., Canada, October 2002 (non-real-time).

For the purpose of this case study, float ambiguity estimation routines based on sequential least-squares estimation and batch processing routines have been temporarily implemented in the original UNB RTK software which is based on an epoch-by-epoch solution approach. The main reason for this implementation was a lack of visible satellites as seen from the station at the bottom of the mine (PIT).

Figure 5. Highland Valley Copper Mine: taken from the top of the backwall of the pit. This is the view from the pit control centre. This picture gives a good idea of the immense scale of the pit [http://minto.sd74.bc.ca/ashphotos/gallery8/hvcopper.html]

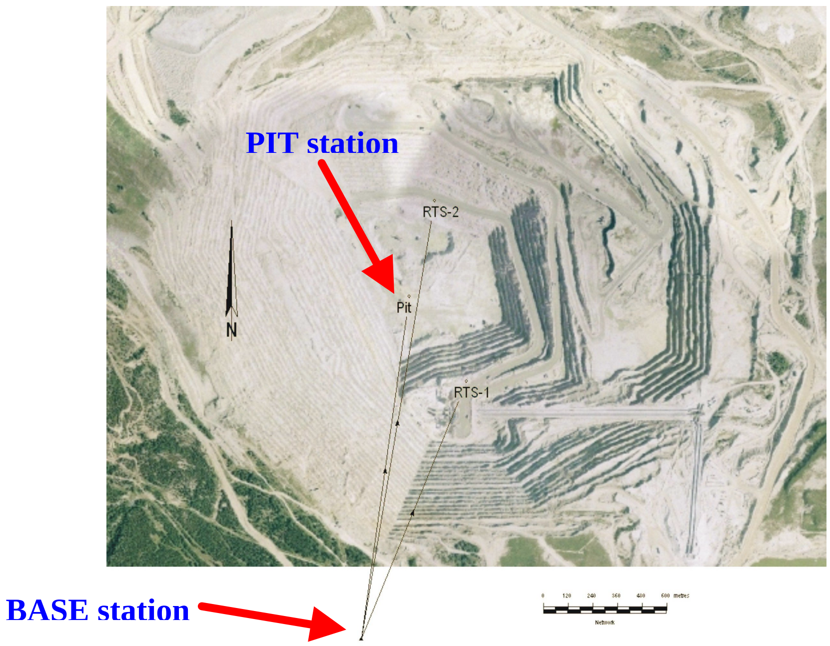

Figure 6. GPS monitoring stations: BASE and PIT [source: CCGE].

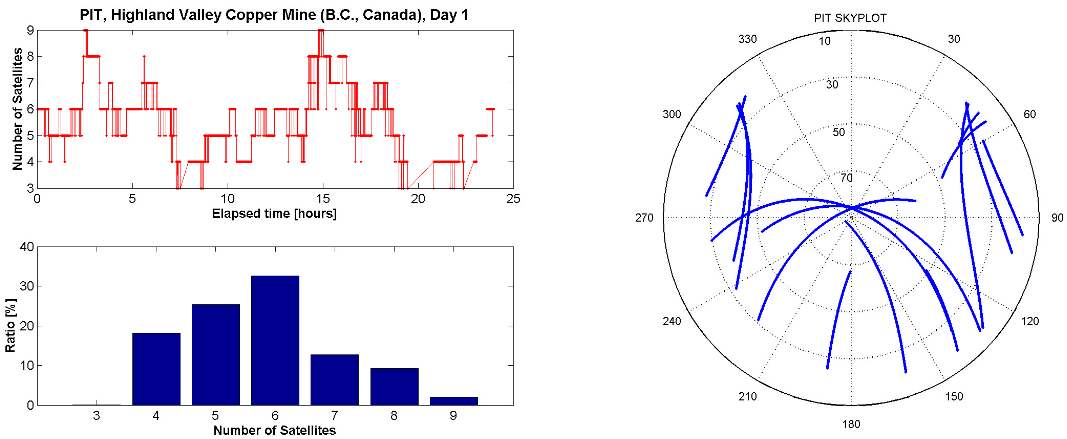

Figure 7. Number of satellites and skyplot over 24 hours at station PIT: fewer than 7 satellites are available over about 80% of the day. Elevation cut-off angle due to the open-pit environment ranges from 15 to 35 degrees.

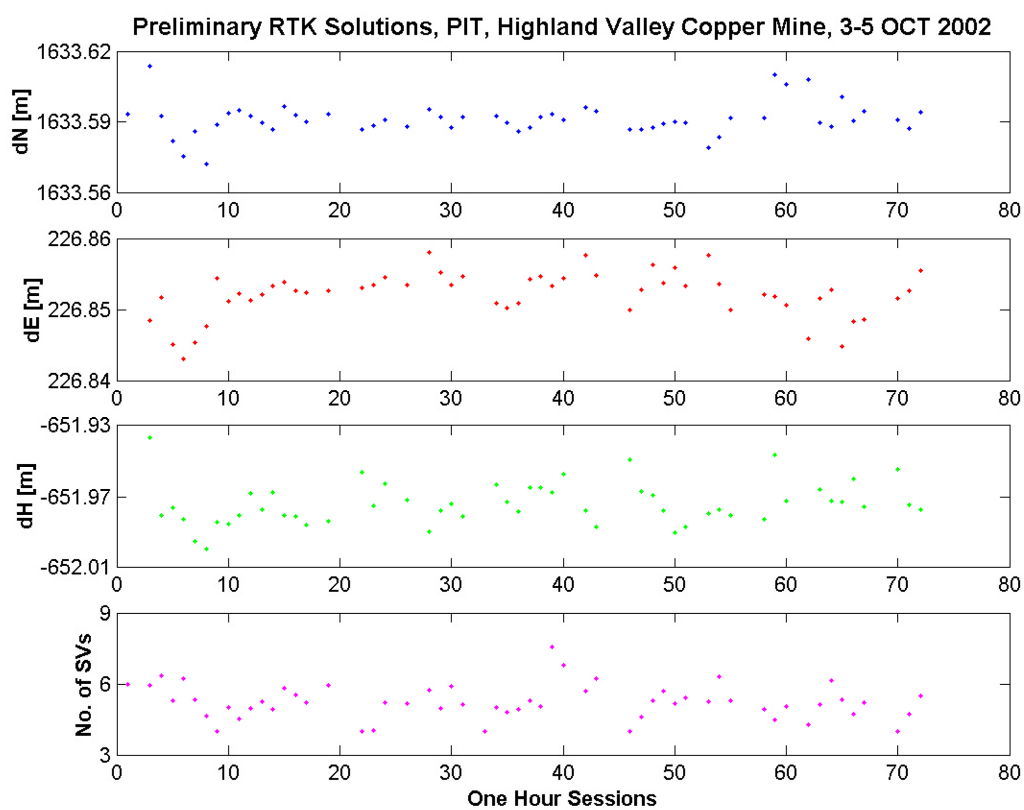

Figure 8. Example of UNB RTK solutions over 3 consecutive days: processed each one-hour session independently and computed mean values of each one-hour session. The last panel shows the mean number of satellites used for computing RTK solutions. Note that there are several one-hour sessions where RTK solutions were not available due to lack of satellites being tracked. Further work involving longer averaging intervals and displacement detection are planned.