United States
Department of
Agriculture

Forest Service

Technology &
Development
Program

Engineering and Fire
October 2007
0771–2832–MTDC

Evaluation of Two Fully Rugged Laptop Computers for the Forest Service

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October 2007

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Introduction

The Missoula Technology and Development Center (MTDC) evaluated two fully rugged laptop computers at the request of the Forest Service Chief Information Office (CIO) Mobile Computing Program. General Dynamics' GoBook XR-1 and Panasonic's Toughbook CF-30 laptops (figure 1) were evaluated. Both manufacturers are industry leaders in developing rugged computers for field use.

Figure 1—The General Dynamics' GoBook XR-1 (left) and Panasonic's Toughbook CF-30 laptops. Both manufacturers are industry leaders in developing fully rugged laptops.

Users of the fully rugged mobile computers could include Forest Service law enforcement officers (LEOs), firefighting personnel, researchers, and others. A Forest Service-sponsored review by JPR Wood Consulting concluded that Forest Service law enforcement officers and special agents need fully rugged mobile computers. Other Forest Service personnel, such as firefighters and researchers, may need fully rugged mobile computers, although the business case for such users has not yet been reviewed. Semirugged mobile computers may suit their needs better.

The specific tests used in MTDC's evaluation were selected by technical representatives from the Forest Service's Mobile Computing, Law Enforcement and Investigation, Fire and Aviation, and Research and Development Programs, and from MTDC. These tests examined the essential attributes of a fully rugged mobile computer. The individual test results are included in the appendixes. Some tests, such as the environmental tests (drop tests, moisture resistance, etc.), verify manufacturers' claims for the two laptops.

The specifications and features of both laptops are similar. Both use the Windows XP operating system. Both have Intel Core Duo processors, although the XR-1 laptop has a 1.83 GHz processor rather than the 1.66 GHz processor of the CF-30 laptop. They each have a magnesium alloy chassis and are designed to meet MIL-STD-810F (Department of Defense Test Method for Environmental Engineering Considerations and Laboratory Tests). Both have a touchscreen. The CF-30 laptop has a slightly larger (13.2 in) and brighter (1,000 nits) screen than the XR-1 laptop (12.1 in, 500 nits). The brightness of LCD screens is measured in nits (candelas per meter squared). Both laptops have a CD/DVD drive, integrated GPS, and include wireless local area network (WLAN) and wireless wide area network (WWAN) capabilities. Both have a touchpad, standard interface ports (USB, network, etc.), biometric (fingerprint) scanner, and backlit keyboard. The CF-30 laptop has a larger capacity battery (8.55 Ah) than the XR-1 (7.2 Ah). The CF-30 laptop weighs more (8.4 lb) than the XR-1 (6.8 lb).

Test Methodology

The evaluation started on August 9, 2007. Three General Dynamic GoBook XR-1 laptops and one Panasonic Toughbook CF-30 were delivered for testing. Environmental tests included operation during extremely hot or cold temperatures, rain/moisture resistance, drop/shock resistance, and ability to withstand vibration. Feature tests evaluated the touchscreen's brightness and visibility, the battery life, benchmarking performance, GPS accuracy, and WLAN and WWAN capabilities.

A systematic method (Choosing by Advantages) was used to determine an overall score for each laptop based on individual test scores and weighting factors. Weighting factors were determined by polling personnel from different resource areas about the attributes that are most critical for their use of rugged laptops in the field.

A questionnaire developed by MTDC was distributed to 20 law enforcement officers, half of whom were using CF-30 laptops and half of whom were using XR-1 laptops during field evaluation of a new software application for law enforcement officers. Respondents were asked to provide feedback on how well the laptop they used performed during everyday operations and to give their impressions about certain features. The questionnaire's findings are presented in appendix L.

After MTDC's testing was completed in late August, General Dynamics introduced a new touchscreen (DynaVue) that enhances screen visibility, especially in sunlight. The DynaVue screen version of the XR-1 laptop was delivered to MTDC on September 10, 2007. Lack of time and funding prevented MTDC from completing full tests of the XR-1 laptop with the new DynaVue screen.

Preliminary testing shows that the DynaVue screen is much better than the previous XR-1 screen when viewed in direct sunlight. The effects the new screen might have on other tests have not been determined. Initial tests indicate battery life will be reduced 28 percent from the previous XR-1 touchscreen model. Performance benchmarking was not affected by the new screen. More tests should be completed to determine whether the new DynaVue XR-1 laptop passes tests for shock, moisture resistance, operation in extremely hot and cold temperatures, and ability to withstand vibration.

Test Results

Environmental and feature comparison tests for fully rugged mobile computing on the CF-30 and XR-1 laptops were conducted at MTDC. Environmental tests were performed with guidance from MIL-STD-810F. They included:

- Startup and operation during extremely cold and hot temperatures—These tests assessed the laptops' ability to start up and operate at extreme conditions (-15 °F and 120 °F). Both laptops passed each test.
- Moisture/rain—This test assessed the laptops' ability to withstand a 4-in/h, 40-mi/h rain for 10 min on all sides (figure 2). Both laptops passed each test.

Figure 2—The laptops were tested for rain/moisture resistance. The laptops were sprayed for 10 minutes on each axis with a simulated rain of 4 in/h at 40 mi/h. Both laptops passed all rain/moisture tests.

- Drop/shock—This test assessed the laptops' ability to withstand drops and sudden shocks. The laptops were dropped six times (one drop on each axis) from 36 in onto 2-in-thick plywood placed on concrete. After each drop, the laptops were investigated for damage and tested for functionality. The CF-30 laptop passed all drop tests. The XR-1 laptop developed a crack (figure 3) in the plastic around the screen after one of the drops. It still functioned normally, but its integrity was compromised.

Figure 3—The laptops were drop tested to test shock resistance. The laptops were dropped onto plywood from 3 feet on all six axes. The XR-1 laptop developed a crack in the case around the screen after one of the drops.

- Vibration—This test assessed the laptops' ability to withstand vibration. Each laptop was placed on a vibration table for 1 h and then turned on to verify that all components operated. Both laptops passed the vibration test.

Comparison tests of different features included:

- Screen brightness and visibility—Screen brightness and visibility were compared in several different situations and configurations. Photographs were taken of the laptop screens in full sun and in a dark room. The laptop screens were compared with black lettering on a white background and also with a color palette as a background. Results showed that the CF-30 screen set at 1,000 nits was brighter and easier to read than the original XR-1 screen, especially when the laptops

were tested in full sun (when it is most difficult to read text and see graphics on a screen, figure 4). Although the new XR-1 DynaVue screen is not as bright as the CF-30 screen, the DynaVue screen has less glare and better color contrast in full sun, making it easier to read text and see graphics. The XR-1 has a lower screen brightness in a dark setting (figure 5). Dimmer screens are important for law enforcement officers, who do not want to draw attention to themselves when they are working at night.

Figure 4—The laptops were compared side-by-side to determine how well the screen could be seen in direct sunlight. While the screen of the CF-30 laptop was brighter, the new DynaVue screen of the XR-1 laptop had better contrast and less glare, making it easier to view.

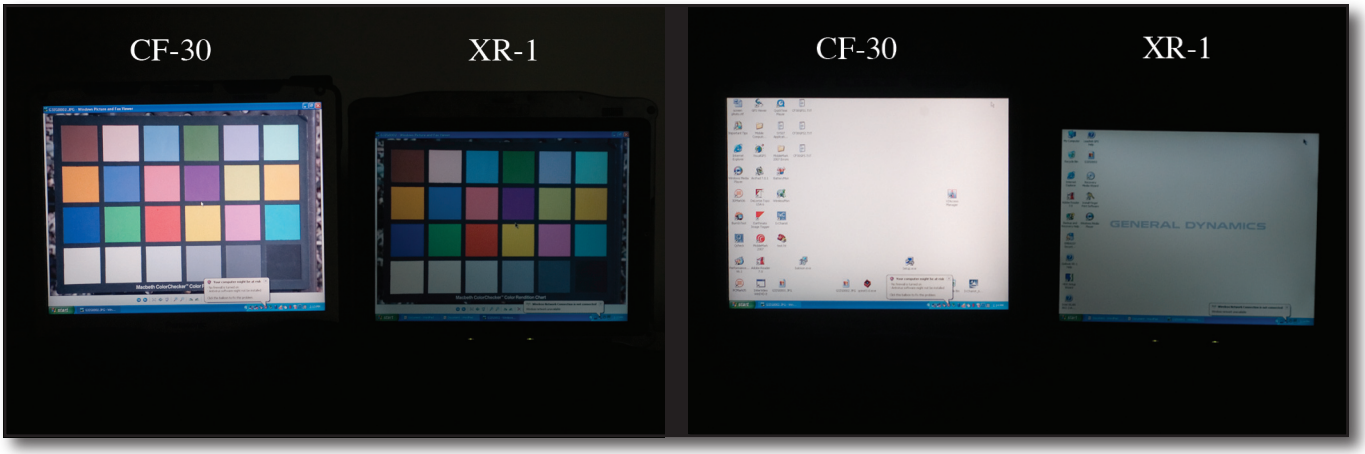

Figure 5—The laptops' screens were also compared in a dark setting. It is important to law enforcement officers that the screen is not too bright in the dark so their position is not compromised. The XR-1 screen (the right screen in each pair of photos) was much darker (but readable) at its lowest setting.

- Battery life—Battery life is critical when users are collecting field data. MobileMark 2007 battery performance software was used to measure the battery life of each laptop in different modes. The CF-30 laptop had a much longer battery life, especially when compared to the new XR-1 laptop with the DynaVue screen (figure 6). The battery in the CF-30 laptop lasts about 6 h (368 min) when set at 500 nits, about 129 percent longer than the battery in the XR-1 laptop with the DynaVue screen (161 min). Even when the display in the CF-30 laptop is set to 1,000 nits, the battery lasts 84 percent longer (297 min) than the battery in the XR-1 laptop with the DynaVue screen.
- Performance benchmarking—Three different industry standard performance benchmarking software suites (FutureMark's PCMark and 3DMark tests and the PassMark Performance Test 6.1) were used to test the laptops' processor and components. On average in all three software suites, the XR-1 laptop tested 29 percent higher than the CF-30 laptop (figure 7).

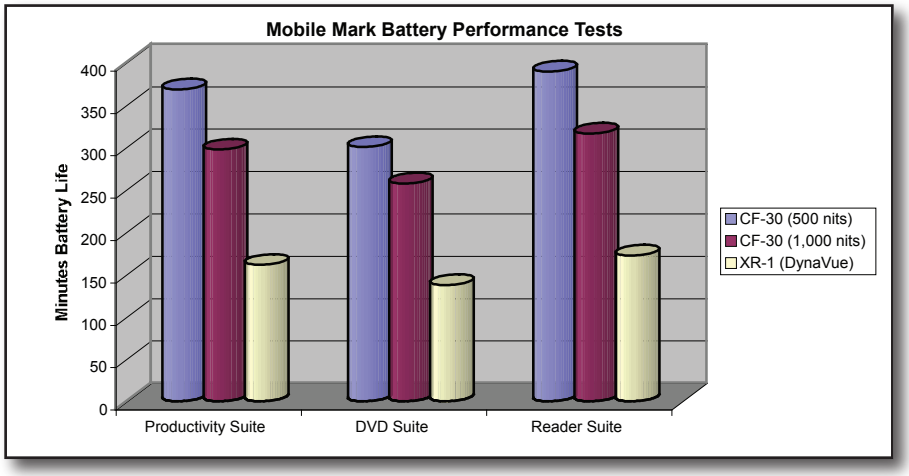

Figure 6—MobileMark 2007 battery performance software was used to measure battery life. The CF-30 battery lasted nearly twice as long as the XR-1 battery.

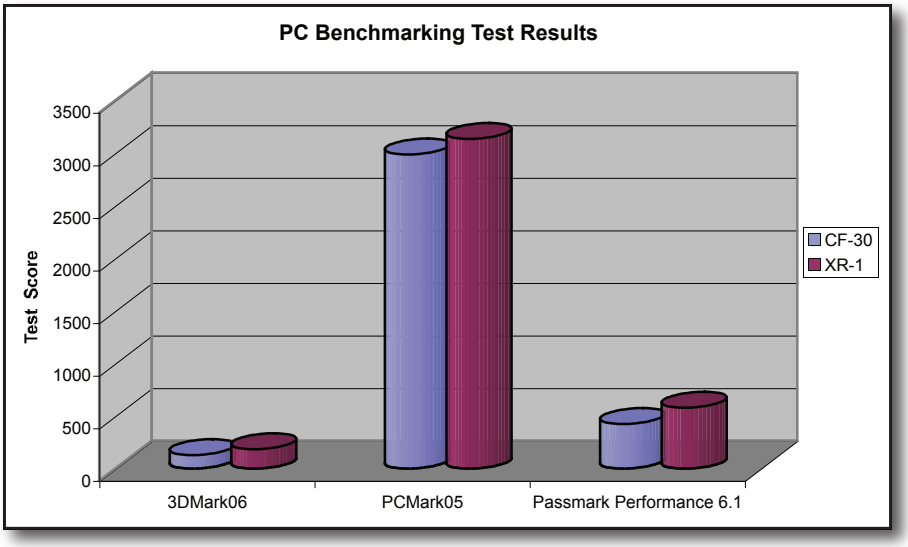

Figure 7—Three different performance benchmarking software suites were used to test the laptops' processor and components. The XR-1 performed better in all benchmarking tests.

- GPS accuracy—The accuracy of the laptops' internal GPS (global positioning system) receivers was tested by comparing the locations reported by the GPS receiver to known surveyed locations. These tests were conducted at the MTDC GPS test course in the University of Montana's Lubrecht Experimental Forest near Missoula, MT, and at MTDC. Tests were conducted in an open canopy and in a forested canopy, and from inside or outside of a vehicle. The GPS receiver in the XR-1 laptop was more accurate, especially at the forested canopy location. On average, it was twice as accurate (figure 8).
- WLAN throughput testing—Both laptops have built-in WLAN (IEEE 802.11, commonly known as Wi-Fi) wireless networking. The throughput of each laptop was tested at three different signal strengths using Ixia's IxChariot software. Throughput tests showed little difference between the two laptops. The signal strength of each laptop also was compared to the other. Each laptop was placed on the dash of a vehicle and the vehicle was driven around a parking lot near a WLAN access point. The PassMark WirelessMon 2.0 software logged the signal strength of each laptop with a time stamp. Results showed no difference between the two laptops.
- WWAN throughput testing—Each laptop's Verizon Wireless Aircard was tested using a protocol similar to that used during the WLAN testing. Throughput testing was conducted at three different signal strengths. The XR-1 laptop had much better throughput results, probably because it had a newer generation Verizon Wireless Aircard than the CF-30 laptop.

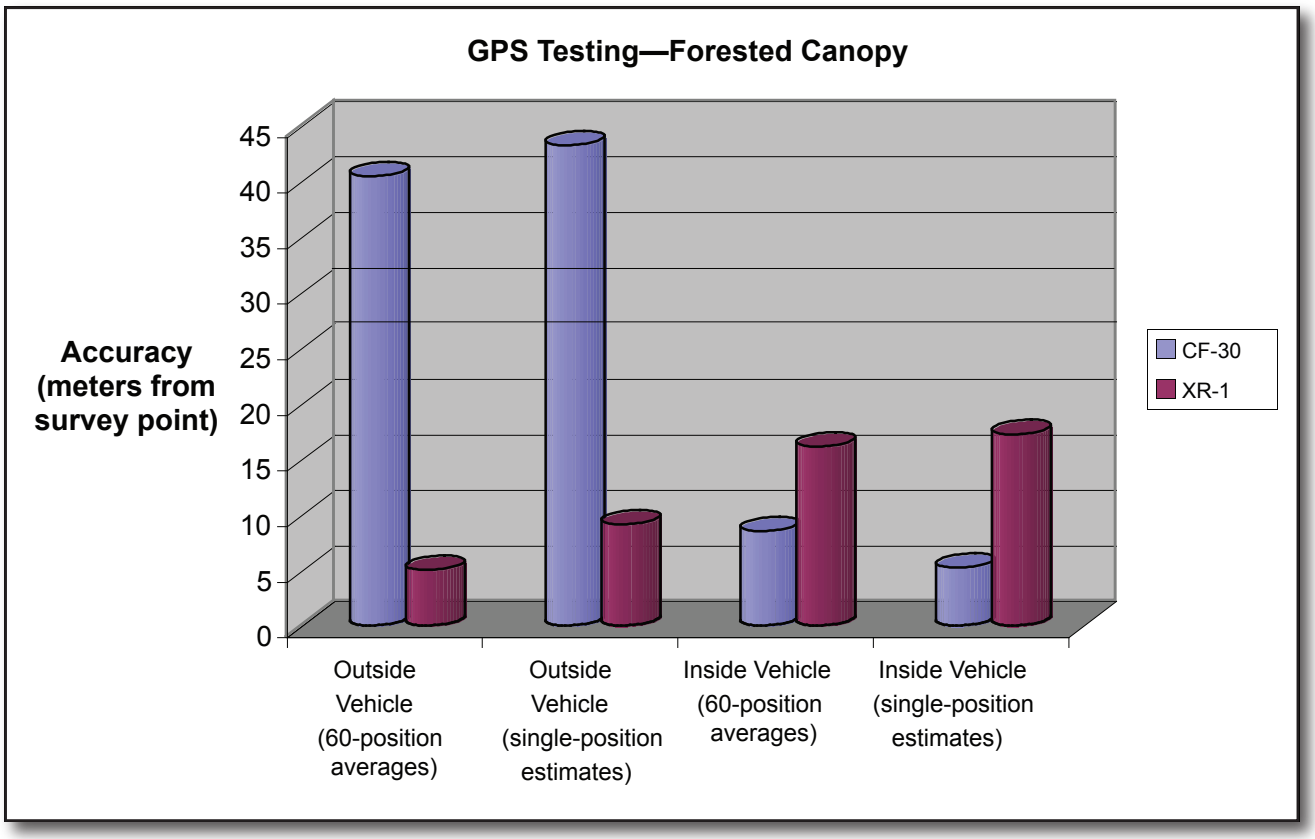

Figure 8—Results from the forested canopy GPS accuracy tests at the Lubrecht Experimental Forest GPS test course. Accuracy results are based on National Standard for Spatial Data Accuracy formulas. Lower values mean better accuracy.

Questionnaire

A questionnaire was sent to 20 law enforcement officers who were field testing a new software system (Law Enforcement and Investigations Management and Attainment Reporting System also called LEIMARS). Ten officers tested the LEIMARS system on the CF-30 laptop while the other 10 used the XR-1 laptop. Respondents provided feedback on how well the laptop performed during everyday operations and gave their impressions about certain features, including: the user interface (screen display, touchscreen, touchpad, keyboard), hardware features (battery life, USB ports, CD/DVD drive, biometrics), use of the laptops in vehicle mounts and office docks, and general impressions of how well the laptop performed. The respondents also were asked how easy the laptop was to use and how well it met their needs.

Overall, the CF-30 laptop rated slightly higher than the XR-1, although all results were within error margins because of the small sample size (table 1). The CF-30 laptop ranked higher for its user interface, hardware features, and users' general impressions.

Table 1—A comparison of mean scores for laptop user interface; hardware, vehicle and office mounting capabilities; and general features. The scale is from 1 to 5, where 1 is a strongly negative evaluation and 5 is a strongly positive evaluation.

	Panasonic CF-30			General Dynamics XR-1			
	Mean	Std. Dev.	*N*	Mean	Std. Dev.	*N*	Sig.
Interface	3.6	0.46	7	2.9	1.31	8	0.210
Hardware	3.4	0.47	5	2.5	1.08	9	0.102
Mount	1.9	1.00	6	2.2	1.49	9	0.714
General impressions	3.8	0.59	7	3.1	1.21	9	0.167

The CF-30 laptop also ranked higher on ease of use and how well it met users' needs (table 2).

Table 2—A comparison of how well respondents felt the laptop met their needs and how easy it was to use, based on a scale of 1 to 10.

	Panasonic CF-30			General Dynamics XR-1			
	Mean	Std. Dev.	*N*	Mean	Std. Dev.	*N*	Sig.
How well did the laptop meet your needs?	8.7	1.20	6	6.87	1.81	9	0.058
How easy was the laptop to use?	8.3	0.82	6	6.88	1.73	8	0.820

Choosing by Advantages

A matrix based on Choosing by Advantages was developed to determine which laptop rated higher based on Forest Service corporate needs. Both laptops performed identically on certain tests, such as moisture resistance. Disregarding tests with identical results, five attributes were given performance values between 1 and 100. These attributes were GPS accuracy, laptop performance (processor speed, 3-D graphics), battery life, screen visibility, and ruggedness. A survey was sent to representatives from the Law Enforcement and Investigation, Fire and Aviation, Research, and Chief Information Office Mobile Computing Programs asking them to rate the importance of these attributes to their job functions (scores of 1 to 100). The survey results were averaged to give an importance value for each attribute. The importance value was multiplied by the test score of each attribute and the products were added to yield an overall score for each laptop (table 3). The XR-1 laptop's results are based on the new DynaVue screen. **The CF-30 laptop's overall score was 302. The XR-1 laptop's overall score was 274.**

Table 3—Scores based on the Choosing by Advantages procedure. Five attributes were assigned importance values based on results from a survey. Test values were derived from performance testing with the highest performing laptop assigned a value of 100 percent. The total score is the sum of the products of the importance values multiplied by the test scores for each attribute.

			XR-1 Laptop		CF-30 Laptop	
Attribute	Measurement Value	Importance Value (average of survey results)	Relative Test Value	Score (importance value x relative value)	Relative Test Value	Score (importance value x relative value)
GPS	Accuracy (based on average of all tests of GPS accuracies)	31	100 percent	31	50 percent	16
Performance	Benchmark tests (average of three benchmark performance software test scores)	58	100 percent	58	79 percent	46
Battery Life	Battery life tests (average of three Mobile Mark battery life test scores, CF-30 laptop at 1,000 nits)	80	54 percent	43	100 percent	80
Screen Visibility	Brightness and size (subjective score based on screen brightness and size, CF-30 laptop at 1,000 nits)	81	100 percent	81	90 percent	73
Ruggedness	Durability tests	87	70 percent	61	100 percent	87
			Total Score	274		302

Other Considerations

Although life-cycle costs and customer service should be considered when choosing a corporate computing platform, these comparisons were beyond the scope of this project. Personnel from the CIO Mobile Computing Program surveyed Panasonic CF-30 and General Dynamics XR-1 customers to determine their overall satisfaction with both companies and their products. Items considered were the delivery of correct items and quantities, timeliness of deliveries, onsite and other technical support, and whether the customer would purchase or recommend this company's products again. While both companies rated high, General Dynamics had a higher overall score than Panasonic.

During this evaluation, both companies provided excellent technical support. Panasonic had to supply a loaner laptop for testing. They did not supply the laptops ordered for testing until testing was complete. General Dynamics delivered their units on schedule.

Conclusions

The Forest Service Chief Information Office asked MTDC to evaluate two fully rugged laptop computers for the Forest Service's corporate system. The Panasonic Toughbook CF-30 and General Dynamics GoBook XR-1 were evaluated. Both laptops were subjected to a variety of environmental tests, including cold and hot extreme temperatures, moisture/rain, drop/shock, and vibration tests. The laptops also were subjected to performance testing for GPS accuracy, battery life, screen brightness and visibility, WLAN and WWAN throughput, and benchmarking scores.

A questionnaire asked 20 law enforcement officers to evaluate the CF-30 and XR-1 laptops they used in the everyday operations and their impressions on certain features. Overall, the CF-30 laptop rated slightly higher, although the results are within statistical margins of error.

Finally, a process called Choosing by Advantages was used to determine which laptop rated higher based on the Forest Service's fully rugged computing requirements. Typical Forest Service users across several different resource areas were asked to rate (between 1 and 100) the importance of these attributes to their job function. These importance factors were multiplied by performance values of each attribute and added to yield a total score for each laptop. The CF-30 laptop rated higher (301) than the XR-1 laptop (274).

Appendix A—Low Temperature Tests

Purpose

These tests were conducted to determine whether the laptop could start and operate properly at extremely cold temperatures that might be encountered during field use. For instance, a law enforcement officer may leave a laptop in a vehicle for an extended period during cold weather and start the laptop after returning, or a researcher might need to use a laptop outside during cold weather.

Equipment

A 7-cubic-ft freezer was used as the cold temperature environmental chamber (figure A–1). Temperatures were monitored using a Campbell Scientific Model CR-1000 datalogger using a Type K thermocouple programmed to record temperatures every second.

Figure A–1—A commercial freezer (left) was used for the extreme cold temperature tests. Cold startup and operation tests were conducted in the freezer at -15 °F.

Figure A–2—Each laptop was placed in the freezer. The laptops were left in the freezer for 2 hours once they reached a temperature of -15 °F. Then they were started.

Procedure

Tests were conducted under the guidance of MIL-STD-810F (Department of Defense Standard for Environmental Engineering Considerations and Laboratory Tests) Method 502.4—Procedure II (operation). The laptop was cooled to -15 °F and held at that temperature for 2 h. Afterward, the laptop was started and its operation was checked. Once operation tests were complete, the test unit was allowed to warm and a complete visual inspection was conducted.

The freezer was run until it reached a temperature of -15 °F. Then the laptop being tested was placed into the freezer with its screen open (figure A–2). The laptop was plugged into line power but was not operating. The freezer was closed and the temperature was monitored until the air temperature inside the freezer reached -15 °F. After 2 h, the freezer was opened and the laptop was started. PassMark BurnInTest 5.3 (software that tests all the major subsystems of a computer simultaneously for reliability and stability) was run to check the functionality of all the laptop's components. The software tests the CPU (central processing unit), hard drives, CD/DVD drives, CD/DVD burners, sound cards, 2-D graphics, 3-D graphics processor, RAM (random access memory), and video playback.

Results

Both laptops passed all tests:

- **CF-30**: When the CF-30 laptop was turned on after being cooled, a screen appeared stating that the unit must warm up for 32 min. Five min later, the operating system started. The touch screen worked

fine, although the screen was hard to read. It was very white with little color. The BurnInTest software was started and allowed to operate for over an hour with the freezer closed. The temperature remained below 0 °F. All components functioned properly as tested by the BurnInTest software.

- **XR-1**: The XR-1 laptop passed all tests, although the test had to be repeated because of a bad CD-ROM disk that produced an error when the CD/DVD drive was tested. After 2 h at -15 °F, the laptop was started. A screen appeared stating that the unit had to warm up for as long as 12 min (figure A–3). Four min later, the operating system started. The touch screen worked fine, although it was hard to read. It was very white with little color. The BurnInTest software was started and allowed to run for about an hour with the freezer closed. The temperature in the freezer remained below 0 °F.

Figure A–3—Neither laptop started immediately. They displayed a screen like this one (XR-1 laptop) stating it would take time for the laptop to warm up. Both started within 5 minutes.

The first time the test was run, the DVD drive failed the BurnInTest test. The next day after the unit warmed, the BurnInTest software was run again. Again the DVD drive failed. A different CD was used and the DVD drive passed the test. When the low temperature tests were conducted with the new CD, the XR-1 laptop passed the BurnInTest software test.

Conclusions

Both laptops performed similarly in the low temperature tests. Both started after a brief warmup period (about 5 min) after spending 2 h at -15 °F in the environmental chamber. The screens on both machines were readable although much of the color was not displayed. They passed BurnInTest software tests.

Appendix B—High Temperature Tests

Purpose

The high temperature test was conducted to determine whether the laptop would start and whether its components would operate properly at high temperatures. This test simulates, for example, a situation where a law enforcement officer may leave the laptop in a vehicle during hot weather and must start and operate the laptop after returning.

Equipment

An environmental chamber (figure B–1) manufactured by Percival Environmental was used for the high temperature tests. The chamber was programmed to operate at 120 °F. Temperatures were monitored using a Campbell Scientific Model CR-1000 datalogger using a Type K thermocouple.

Procedure

Tests were conducted under the guidance of MIL-STD-810F, Method 501.4—Procedure II (operation). The laptop was heated to 120 °F and held at the temperature for at least 2 h. Afterward, the laptop was started and its operation checked. Once operation tests were complete, the laptop was allowed to cool to ambient conditions and a complete visual inspection was conducted.

The CF-30 and XR-1 laptops were tested at the same time (figure B–2). Each laptop was plugged into line power and started. PassMark BurnInTest software was started and all systems were verified as functioning. The laptops were placed into the chamber and operated for 4 h after the chamber reached 120 °F. The laptops were restarted and unplugged. BurnInTest software was started again for an additional 20 min.

Figure B–1—An environmental chamber was used to conduct the extreme hot temperature startup and operation tests.

Figure B–2—Both laptops were placed in the environmental chamber for two h at 120 °F. Then they were started and tested.

Results

Both laptops passed all tests:

- **CF-30**: The CF-30 laptop passed all BurnInTest software tests while warming up in the chamber and during the 4-h test. The CF-30 laptop successfully restarted. All components successfully passed BurnInTest software tests while the CF-30 laptop was on battery power and operating at a temperature of 120 °F.
- **XR-1**: The XR-1 laptop passed all BurnInTest software tests while warming up in the chamber and during the 4-h test. The XR-1 laptop successfully restarted. All components successfully passed BurnInTest software tests while the XR-1 laptop was on battery power and operating at a temperature of 120 °F.

Conclusions

Both laptops performed similarly in the high temperature tests. Both successfully started at high temperatures (120 °F) and passed the BurnInTest software tests.

Appendix C—Rain/Moisture Tests

Purpose

One of the key features of ruggedized laptops is their ability to resist rain and moisture. This is very important to Forest Service users when they are taking field data in inclement weather. This test was conducted to verify the manufacturers' claims that the laptop is water resistant on all sides. Water should not penetrate the laptop even when it is subjected to simulated rain from all six sides (includes top and bottom).

Tests were conducted under the guidance of MIL-STD-810F, Method 506.4—Procedure II (watertightness), non-operating. Ten-min rain tests were conducted on all six sides of the laptop, including one test with the laptop open and the screen and keyboard exposed (figure C–1). A nozzle sprayed water at a rate of 4 in/h from 48 cm above the laptop.

Figure C–1—The laptops were subjected to simulated rain to test their resistance to moisture. The laptops were sprayed for 10 minutes on each axis with a simulated rain of 4 in/h at 40 mi/h. During one test the laptop was open while the screen and keyboard were sprayed.

This test is not a submersion test. Neither manufacturer claims that its unit will work after being immersed.

Equipment

A spray apparatus was configured to spray water at a rate of 4 in/h at 40 psi. The spray nozzle was 48 cm from the top of the laptop and sprayed it fully.

The following spray equipment was used for the rain/moisture tests:

- Pump: Shurflo, 1.25 gal/min, 12 V DC, 6.0 A
- Battery: 12 volts DC, 7.5 Ah
- Pressure Gauge: Ashcroft, 100 psi, oil-filled
- Nozzle: 90°, full cone, 0.25 gal/min at 40 psi

The nozzle was mounted on a pole attached to a metal frame (figure C–2). The pole could be adjusted to the desired height. Water was pumped from a reservoir through plastic tubing to the nozzle. A pressure gauge monitored pressure. The pressure was adjusted using a valve.

Figure C–2—The nozzle was suspended on a pole mounted to a metal frame. The pole could be adjusted so that the nozzle was 48 cm above the laptop.

Metal grating was placed on two sawhorses for the testing platform. Bookends held the laptop on its ends for the required tests (figure C–3).

Figure C–3—The laptops were placed on a metal grate and held upright using bookends.

Procedure

Six rain/moisture tests were performed on each laptop. Before and after each test, PassMark BurnInTest software was run to make sure all internal components of the laptop functioned. Additionally, the touch screen, touchpad, and keyboard were tested for functionality.

After completion of the six rain/moisture tests, the laptop's cover plates were removed and the sealed doors to its ports were opened. A thorough inspection was completed to see if any water had leaked into the laptop's internal components.

Results

Both laptops passed all the tests without any water leaking in. They both passed all BurnInTest tests. Touch screens, touch pads, and keyboards functioned normally.

Some water got through the CF-30 laptop's first gasket on the power plug cover. A second gasket inside the cover prevented water from getting into the laptop.

Conclusions

Both laptops are fully rain/moisture resistant as tested.

Appendix D—Drop Tests

Purpose

This test evaluates the laptop's resistance to sudden shock or drop, ensuring that laptops can meet shock/drop requirements that reflect typical Forest Service field use.

Tests were conducted under the guidance of MIL-STD-810F, Method 516.5—Procedure IV (transit drop), non-operating—modified to a 36-in drop onto 2 in of plywood. The test was modified to include six drops (one for each axis) rather than 26 as specified in MIL-STD-810F.

Equipment

Two 1-in-thick sheets of plywood were glued together to provide a surface for the drops. A 3-ft-long measuring stick indicated the drop height.

Two video cameras filmed the drops. One camera recorded an overall shot showing the complete drop. The other recorded a closeup of the drop area. A still camera was used to take photos of the laptops and any specific areas of interest.

PassMark BurnInTest software was used to test internal components of the laptops before and after the drop tests. The touch screen, touch pad, and keyboard were functionally tested before and after each drop test.

Procedure

PassMark BurnInTest software was run to test the laptop. The laptop was oriented to the proper test position and held by hand at the 3-ft mark. The video cameras were started and the laptop was dropped.

Still photos were taken of the laptop on the plywood. Additional photos were taken of anything that was particularly noteworthy. The laptop was inspected thoroughly.

BurnInTest software was run and touch screen, touch pad, and keyboard functionality tests were performed.

The procedure was repeated for each axis, a total of six drops.

Results

- **CF30**: The CF-30 laptop passed all drop tests. On the first drop (bottom down), the cover to the hard drive port opened as did the fingerprint scanner cover. The hard drive cover may not have been fully latched properly before testing because it did not open on any subsequent drop tests. The fingerprint scanner cover opened on several of the other drop tests.
- **XR-1:** The XR-1 laptop failed one of the drop tests. The case around the screen cracked when the laptop was dropped on the side with the CD/DVD drive (figure D–1). The laptop still passed all function and BurnInTest tests, although its structural integrity was compromised. It probably would not have been watertight.

Figure D–1—A crack developed on the XR-1 laptop after one of the drops. The XR-1 laptop still functioned properly, but its integrity was compromised. The CF-30 laptop passed all drop tests.

On most of the drops, many of the port covers opened (figure D–2). While this not a cause for concern for most of the components because they are sealed internally, the CD/DVD drive and PC card reader are not. If the laptop was dropped into a stream or lake, open covers would probably allow water to leak into these components and the laptop.

Figure D–2—The covers to drives and ports came open on most of the drops on the XR-1 laptop. This could pose a problem if the laptop were dropped near water or mud. One cover came open of the first drop on the CF-30 laptop. It is unsure if this cover was fully latched before the drop. It did not open on any subsequent drops.

Conclusions

The CF-30 laptop passed all drop tests. One of the port covers came open on the first test. The XR-1 laptop failed a drop test when the case around the touch screen cracked. Additionally, many of the XR-1 laptop's port covers came open on most of the drops.

Appendix E—Vibration Tests

Purpose

These tests were conducted to determine whether vibrations could cause electrical or mechanical problems, particularly if any joints were soldered improperly. Tests were conducted under the guidance MIL-STD-810F, Method 514.5—Procedure I (general vibration), non-operating, 60 min, one axis.

A small, commercial vibration table was used for the tests. Larger vibration tables used for testing electrical components may cost $100,000 or more.

Equipment

The table vibrated at 3,600 vibrations per minute. PassMark BurnInTest software was used to test the laptops' internal components. The touchscreen, touch pad, and keyboard were functionally tested.

Procedure

Before testing, each laptop was tested using the BurnInTest software. One laptop was placed on the table and the table was turned to its highest setting. The laptop was left on the table for 60 min. Then the laptop was started and the touch screen, touch pad, and keyboard were functionally tested. BurnInTest software was run to test the internal components.

Results

After 60 min on the vibration table, both laptops passed all tests.

Conclusions

After 60 min on the vibration table, both laptops passed all tests.

Appendix F—GPS Tests

Purpose

The GPS tests were conducted to determine the expected accuracy of the GPS receivers in each laptop. While these laptops probably would never be used to obtain highly accurate GPS readings, the GPS receivers should be reasonably accurate. Law enforcement officers and research personnel may need relatively good accuracy (within 15 m) when obtaining field data.

The laptops were tested for GPS accuracy in the open and under a forested canopy. MTDC has a test course at the University of Montana's Lubrecht Experimental Forest for testing GPS receivers under a forested canopy. MTDC also has survey markers on its campus to test open-canopy situations.

The National Standard for Spatial Data Accuracy (NSSDA) was used to evaluate and report the GPS receiver's positional accuracy. The Federal Geographic Data Committee specifies that the NSSDA be used to evaluate and report the positional accuracy of geospatial data produced, revised, or disseminated by or for the Federal Government.

The NSSDA reports accuracy values at the 95 percent confidence level. In other words, only 1 out of 20 measurements made with the same receiver and data logging settings under similar forest canopy conditions should have errors larger than those published in this report.

Equipment

ArcPad 7.0 was installed on both laptops to obtain GPS locations. The CF-30 laptop was tested in a vehicle when it was docked and undocked in a vehicle mount. The mount has a pass-through antenna that can be placed on top of a vehicle.

The GPS receivers were configured to use the Wide-Area Augmentation System (WAAS) for improved accuracy. The system did not work on the CF-30 laptop. Panasonic technicians were working on the problem when the tests were conducted. Later they resolved the problem, but preliminary test results showed little difference in the accuracy of the GPS unit in the CF-30 laptop, with or without WAAS.

Procedure

Each laptop was tested both inside and outside of a vehicle. When the laptops were tested outside of a vehicle, they were held over a known, surveyed position. When they were tested inside a vehicle, an offset was determined from the surveyed position to establish the known position. In addition, the CF-30 laptop was tested in a vehicle mount with a connection for an external antenna.

- 60-Position Averages—ArcPad was configured to store a position determined by averaging 60 single positions estimated by the GPS. Ten of these 60-second averages were taken.
- Single-Position Estimates—ArcPad was configured to store a single position (not averaged) estimated by the GPS.

Both 60-position averages and single-position estimates were recorded.

For tests outside the vehicle, the laptops were carried through a test course of seven known positions.

Results

Figures F–1 and F–2 show the results of the GPS accuracy tests.

The XR-1 laptop, which used the WAAS system, typically had more accurate results than the CF-30 laptop.

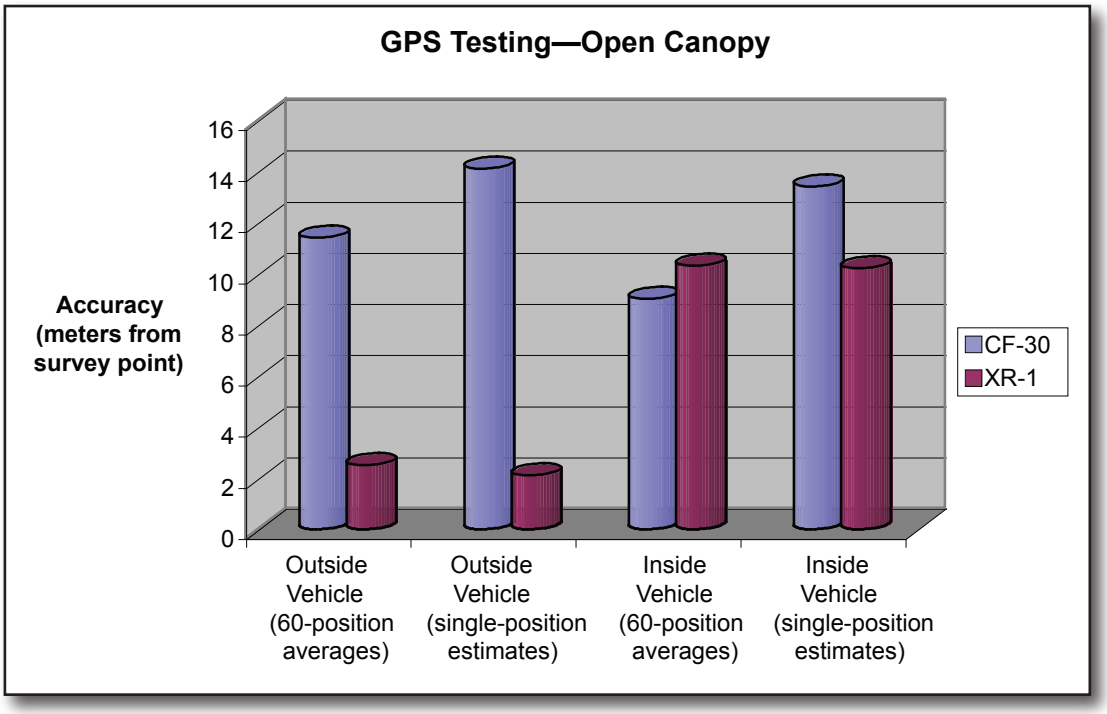

Figure F–1—Results from the open-canopy GPS accuracy tests at the MTDC survey point. Accuracy results are based on National Standard for Spatial Data Accuracy formulas. Lower values mean better accuracy.

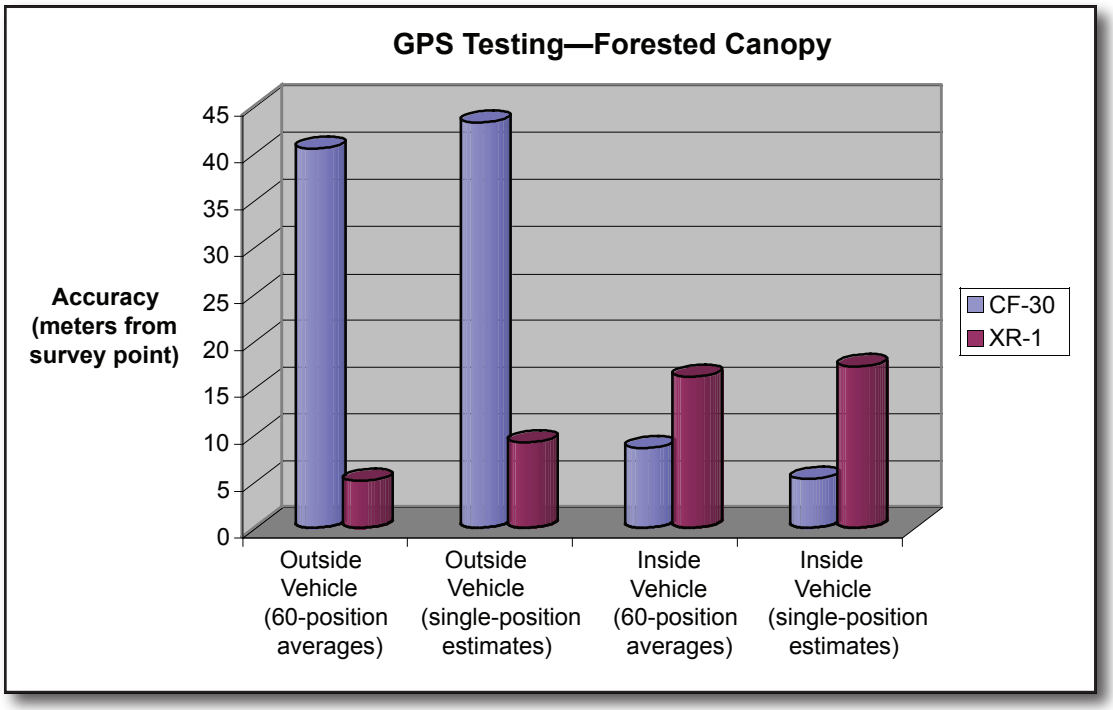

Figure F–2—Results from the forested canopy GPS accuracy tests at the Lubrecht Experimental Forest GPS test course. Accuracy results are based on National Standard for Spatial Data Accuracy formulas. Lower values mean better accuracy.

Conclusions

Results of the GPS tests show that the XR-1 laptop has better GPS accuracy than the CF-30 laptop. For most users, highly accurate positions are not necessary. However, most handheld GPS receivers tested by MTDC have about 15-m accuracy when used under a forest canopy, much better than the 40-m accuracy of the GPS receiver in the CF-30 laptop.

According to Panasonic representatives, the CF-30 laptop should be using the WAAS signal. Two technicians came to Missoula on August 27, 2007, to investigate the problem, but were not able to solve it on location. Later, they resolved the problem. Preliminary test results showed little difference in the GPS receiver's accuracy, with or without WAAS.

Appendix G—Performance Benchmarking Tests

Purpose

Benchmarking tests allow computers' performance to be compared by subjecting them to the same set of tests. These tests provide benchmarks for the performance of the CPU (central processing unit or processor), 2-D and 3-D graphics processors, memory, hard disk, and CD/DVD drives. Forest Service laptop users—especially fire personnel—may require high-performance CPUs and 3-D graphics for some applications.

Equipment

Three different benchmarking software applications were used to conduct the performance tests.

- **3DMark**: 3DMark is the worldwide standard in advanced 3-D performance benchmarking. 3DMark06 uses advanced real-time 3-D game workloads to measure PC performance using a suite of DirectX 9 3-D graphics tests, CPU tests, and 3-D feature tests. 3DMark06 tests include HDR/SM3.0 graphics tests, SM2.0 graphics tests, AI-and physics-driven-single- and multiple-core processor CPU tests.
- **PCMark**: PCMark05 includes 11 system tests—each one is designed to represent a certain type of PC usage. PCMark05 stresses the components in a manner similar to normal usage. The system test suite includes tests measuring different components of a PC. The results of the tests, as well as the total score, depend on all components. PCMark05 tests CPU, system bus, memory, and graphics performance.
- **PassMark Performance Test 6.1:** PassMark Performance Test 6.1 consists of 25 standard benchmark tests including:
  * CPU tests (Mathematical operations, compression, encryption, streaming SIMD extensions, 3DNow! instructions)
  * 2-D graphics tests (Drawing lines, bitmaps, fonts, text, and GUI elements)
  * 3-D graphics tests (Simple to complex DirectX 3-D graphics and animations)
  * Disk tests (Reading, writing, and seeking within disk files)
  * Memory tests (Speed and efficiency of memory allocation and accesses)
  * CD/DVD tests (Speed of the CD or DVD drive)

Procedure

Each of the benchmarking applications was loaded on the laptops. Each application was administered a minimum of three times following the application's specifications. 3DMark06 and PCMark05 were run six times, while PassMark Performance 6.1 was run three times. The benchmarking scores were averaged for each application.

Results

Figure G–1 shows the average results from the three benchmarking applications.

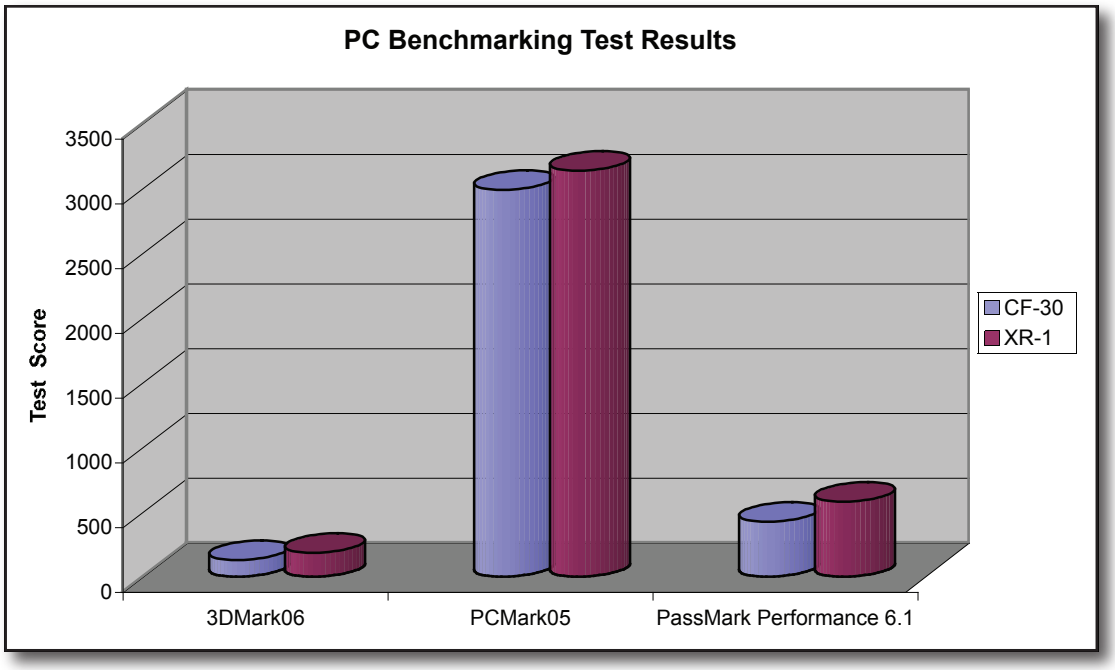

Figure G–1—Three different performance benchmarking software suites were used to test the laptops' processors and components. The XR-1 laptop performed better in all benchmarking tests.

Conclusions

The XR-1 laptop tested higher in all the benchmarking tests. The XR-1 laptop scored 44 percent higher than the CF-30 laptop on the 3DMark06 tests, 5 percent higher than the CF-30 on the PCMark05 tests, and 37 percent higher on the PassMark Performance 6.1 tests. The results are probably due to the XR-1 laptop's faster processor.

Appendix H—Battery Performance Tests

Purpose

Tests were conducted to determine the expected battery life on a single charge when the laptop was subjected to typical usage. Battery life is critical when laptops are used in the field. Longer battery life means field employees won't have to carry as many batteries and won't have to swap or change batteries as frequently. Industry-accepted benchmarking software was used to test the laptops' batteries under several scenarios.

Also, tests determined the expected time to recharge the battery from a full discharge (less than 5 percent battery charge) to full charge (100 percent).

Equipment

MobileMark 2007 is an application that determines expected battery life based on real-world applications. MobileMark has three different testing modules. Each module includes a set of applications that can be run individually to show battery life in a variety of specific scenarios. The productivity module tests the battery life by simulating normal business usage. The DVD module tests battery life while running a DVD. The reader module simulates a person reading a large document on the laptop.

The PassMark Battery Monitor software was used to monitor the battery recharging. It was set to record the battery status every minute.

Procedure

Each of the three MobileMark modules was run on each laptop. The laptops were fully charged before each test. The CF-30 laptop was tested with the screen brightness set to 500 and to 1,000 nits, showing the difference in battery life that might be expected with the brighter screen.

With the battery fully discharged, the laptop was plugged in and the Battery Monitor software was started. A log file was initiated and the laptop was recharged. Logging was stopped when the battery was fully charged (100 percent).

Results

Figure H–1 shows the results of the MobileMark tests.

Figure H–2 shows the results of the recharging tests.

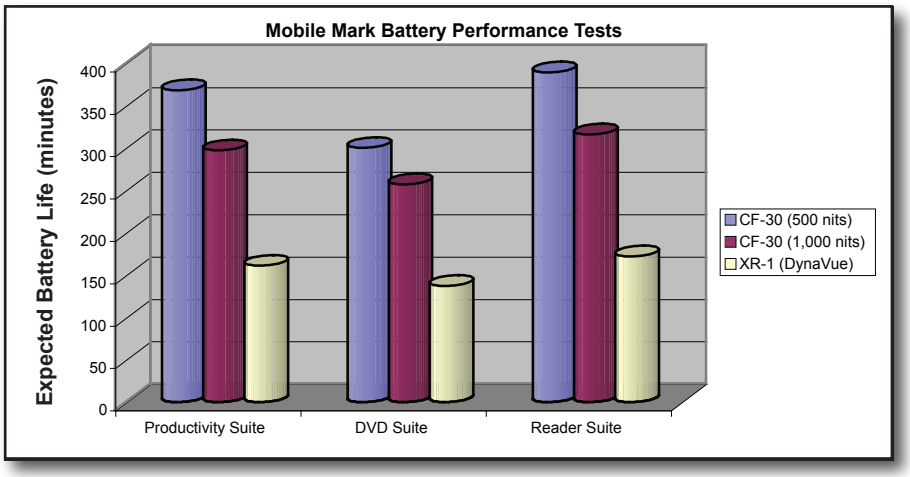

Figure H–1—MobileMark 2007 battery performance software was used to measure battery life. The CF-30 battery lasted nearly twice as long as the XR-1 battery.

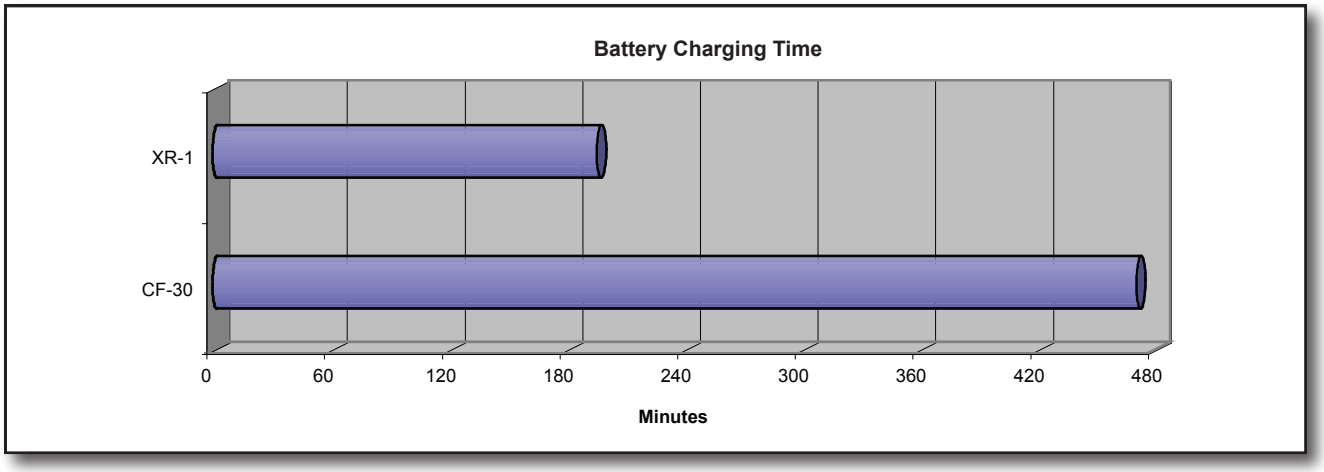

Figure H–2—PassMark Battery Monitor software was used to monitor the battery recharging time for each laptop. It took more than twice as long to charge the CF-30 laptop battery as the XR-1 laptop battery.

Conclusions

The battery life of the CF-30 laptop was more than twice as long as the battery life of the XR-1. A user could expect about 6 h of use with the CF-30 laptop when the screen is set to 500 nits. Battery life drops to about 5 h when the screen is set to 1,000 nits. The XR-1 laptop has a battery life of about 2.5 h under most conditions.

Recharging time is significantly different. The CF-30 battery took nearly 8 h to recharge, compared to just a little longer than 3 h for the XR-1 battery.

Appendix I—Screen Visibility Tests

Purpose

The screen visibility tests determined whether there were any significant differences in the screen visibility in full sun or in the dark. Viewing laptop screens on a bright, sunny day is difficult. They must be very bright. Some screens have special coatings to make it easier to see details. This is very important to all field users, particularly those in law enforcement, firefighting, and field research. Additionally, law enforcement officers sometimes adjust the screen to very low levels so it does not illuminate their position when they are using the laptop in the dark.

Equipment

Digital photos were taken with the laptop screen in full sunlight and in a darkroom at both full and lowest intensity. The photos were taken with the laptops in the same position and location so an overlay could show the photo of each screen next to the other. All camera settings were the same for the photos. Two different screen images were photographed for each test. One was a white background with black lettering. The other image was color palette used by photographers to test image color.

Procedure

Outdoor full sun tests: The laptops were set on a table with the screen facing the sun. A camera was set up facing the screen. The laptops were configured so that the screen was at its brightest. The CF-30 screen was set to 1,000 nits and the XR-1 screen was set to its highest brightness (500 nits). A Wordpad document was opened, displaying black lettering on a white background. Photos were taken. Then a color palette was displayed and additional photos were taken.

Indoor tests: The laptops were adjusted so their displays were at the lowest possible setting that still illuminated the screen. This setting would represent someone using the laptop in the dark with minimal display. Photos were taken of the screens displaying black lettering on a white background and of the color palette. The CF-30 laptop's screen was set at 500 nits.

Results

Figure I–1 shows the photos taken outside. It was difficult to take photos that truly reflected the screen's visibility. The CF-30 screen was much brighter than the XR-1 screen, but the CF-30 screen also had a lot of glare. The XR-

Figure I–1—The laptops were compared side-by-side to determine how well the screen could be seen in direct sunlight. While the CF-30 screen was brighter, the XR-1 with the new DynaVue screen had better contrast and less glare, making it easier to view.

1's new DynaVue screen had superior color contrast, which made the items on the screen much easier to see. Although the XR-1 DynaVue screen was not as bright as the CF-30 screen, it had considerably less glare, improving visibility.

Figure I–2 shows the photos taken inside with the laptops set to their lowest brightness. The XR-1 screen was much darker than the CF-30 screen (but still readable), an advantage to law enforcement officers.

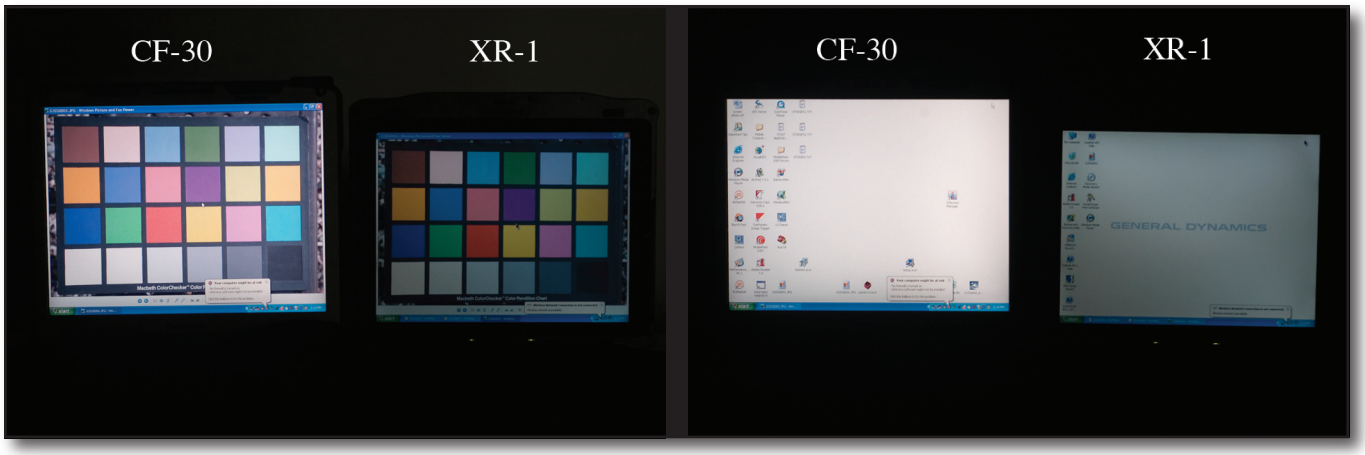

Figure I–2—The laptops screens were also compared in the dark. It is important to law enforcement officers that the screen is not bright enough to compromise their position in the dark. The XR-1 screen was much darker at its lowest setting, but was still readable.

Conclusions

The XR-1 laptop with the DynaVue screen was easier to view in full sunlight. Although the XR-1 DynaVue screen was not as bright as the CF-30 screen, the XR-1 DynaVue screen had considerably less glare, improving visibility. The XR-1 screen was also darker when viewed at the lowest brightness setting, an advantage to law enforcement officers who don't want to give away their position while using the laptop in darkness.

Appendix J—Wireless Networking Tests

Purpose

The WLAN (wireless local area network) tests determined the expected throughput of the WLAN devices in each laptop and compared the laptops' signal strengths when they were side by side. Both laptops used the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standard for wireless networking, often called Wi-Fi.

In communication networks, throughput is the amount of digital data per unit of time that is delivered or passed through a network node. For example, it may be the amount of data that is delivered to a network terminal or host computer, or between two computers. The throughput is usually measured in bits per second (bit/s or bps), occasionally in data packets per second, or data packets per timeslot.

Equipment

Ixia IxChariot software was used to measure the throughput of laptops on a WLAN network. IxChariot is the industry's leading test tool for simulating real-world device and system performance under realistic load conditions. Endpoints are configured and different scripts can be run to simulate typical usage while measuring throughput rates. For these WLAN tests, five different scripts were run to measure throughput:

- Throughput script: Endpoint 1 sends a 100,000-byte file to endpoint 2. Endpoint 2 sends an acknowledgment after receiving the file. This process is repeated 100 times and the throughput is averaged.
- HTTPtext script: This script emulates the transfer of text files from an HTTP server. A 1,000-byte file is sent from endpoint 1 to endpoint 2. Endpoint 2 sends an acknowledgment after receiving the file. This process is repeated throughout the test.
- HTTPgif script: This script emulates the transfer of graphic files from an HTTP server. A 10,000-byte file is sent from endpoint 1 to endpoint 2. Endpoint 2 sends an acknowledgment after receiving the file. This process is repeated throughout the test.
- FTPPut script: This script simulates sending a file from endpoint 1 to endpoint 2 using the TCP/IP FTP application. The file size is 100,000 bytes. The script has three sections, each with its own connection:
  * The first section emulates a user logging on from endpoint 1 to endpoint 2.
  * The second, timed section emulates endpoint 1's request for, and the transfer of, a 100,000-byte file.
  * The third section emulates a user logging off.
- FTPGet script: This script is identical to the FTPPut script except that it emulates receiving a file from an FTP server.

PassMark WirelessMon 2.0 software was used to monitor the Wi-Fi signal strength while driving around a Wi-Fi access point. The PassMark software logs the signal strength and uses the time stamps to compare the signal strength of two laptops.

Procedure

Throughput tests: Three laptops were used for the throughput tests, two XR-1 laptops and a CF-30 laptop. All three laptops were connected to a secure WLAN router. IxChariot software was loaded on one XR-1 laptop and configured as endpoint 1. The other XR-1 laptop and the CF-30 laptop were configured as endpoints 2 and 3. All three laptops were placed side by side at three different locations, simulating different signal strengths (90 percent, 50 percent, and 15 percent). The five scripts described above were run at each of the locations measuring throughput between endpoints 1 and 2, and between endpoints 1 and 3.

Wi-Fi signal strength tests: An XR-1 and a CF-30 laptop were placed side by side on a vehicle dashboard at an unsecured Wi-Fi access point. PassMark WirelessMon 2.0 software was run and configured to log the signal strength and time on both laptops. The vehicle was driven around the parking lot to obtain different signal strengths.

Results

Throughput tests: Figures J–1 through J–3 show the results of the IxChariot throughput tests.

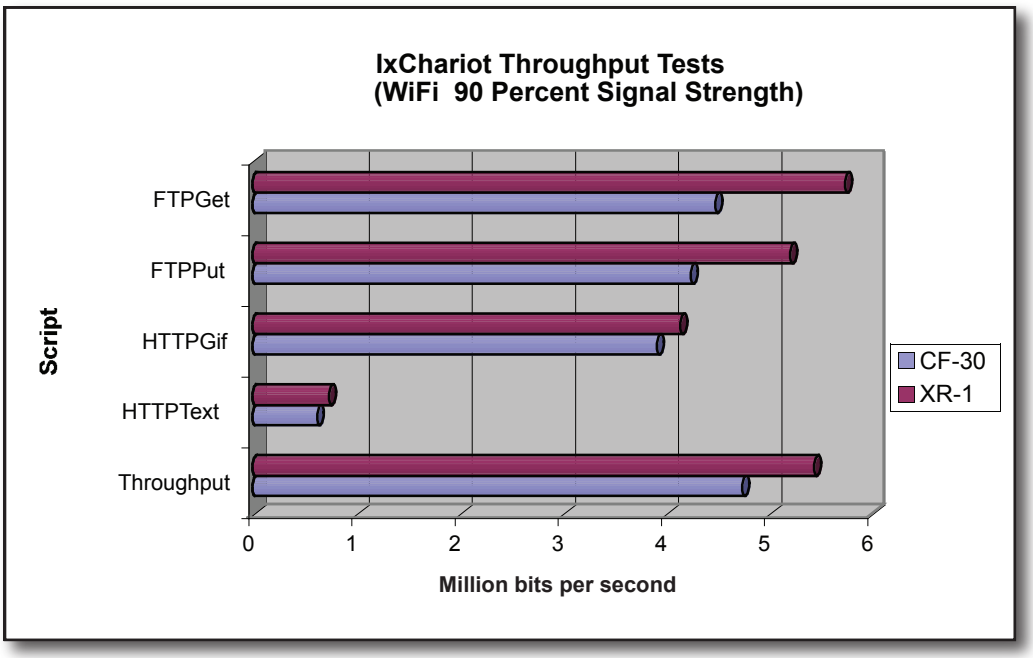

Figure J–1—This graph shows the results from the IxChariot throughput tests using the internal WLAN at 90-percent signal strength. The five tests represent typical Internet usage in a field situation.

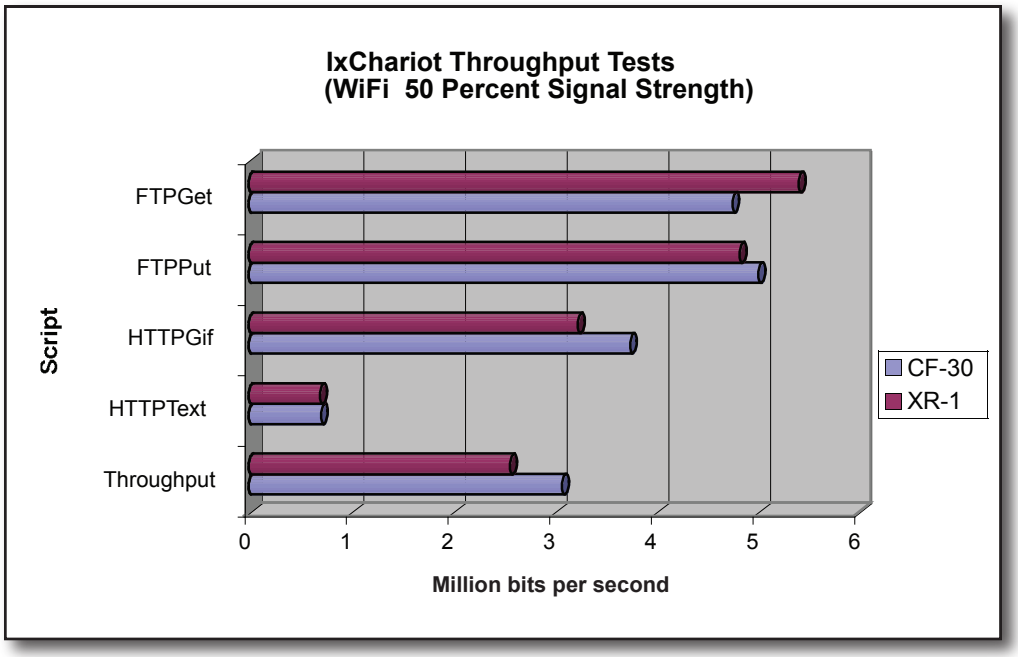

Figure J–2—This graph shows the results from the IxChariot throughput tests using the internal WLAN at 50-percent signal strength. The five tests represent typical Internet usage in a field situation.

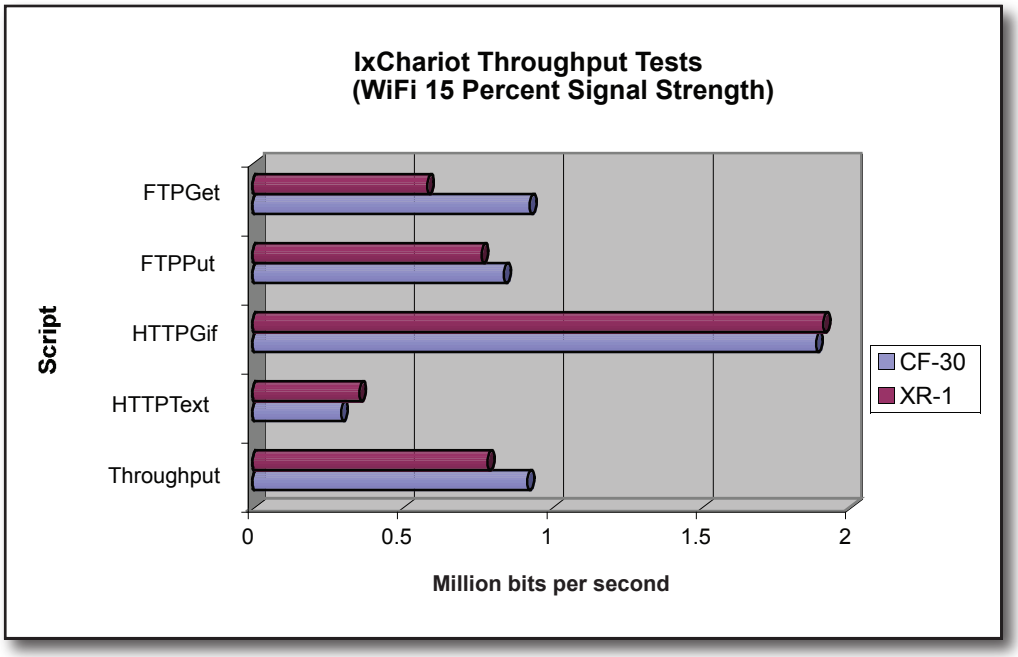

Figure J–3—This graph shows the results from the IxChariot throughput tests using the internal WLAN at 15-percent signal strength. The five tests represent typical Internet usage in a field situation.

Wi-Fi signal strength tests: Figures J–4 and J–5 show the results of the roaming Wi-Fi tests. Figure J–6 is an example of the output from PassMark WirelessMon 2.0 software showing signal strength.

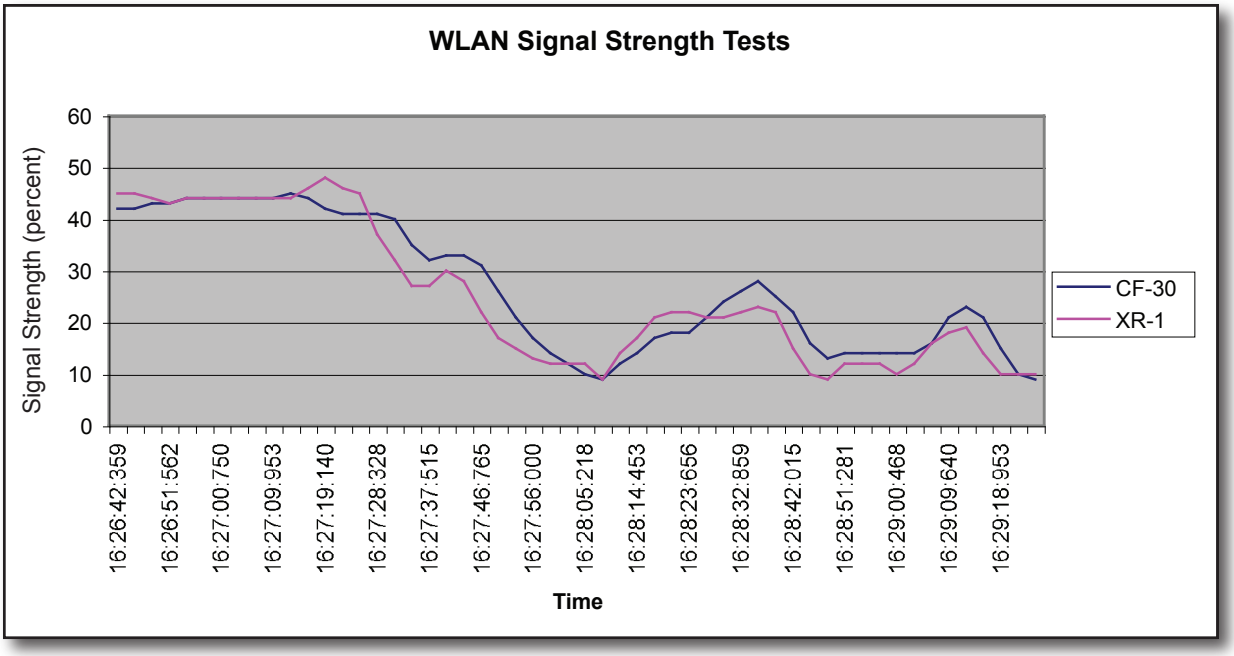

Figure J–4—Results of the WLAN tests for the CF-30 and XR-1 laptops. The results are displayed in signal strength.

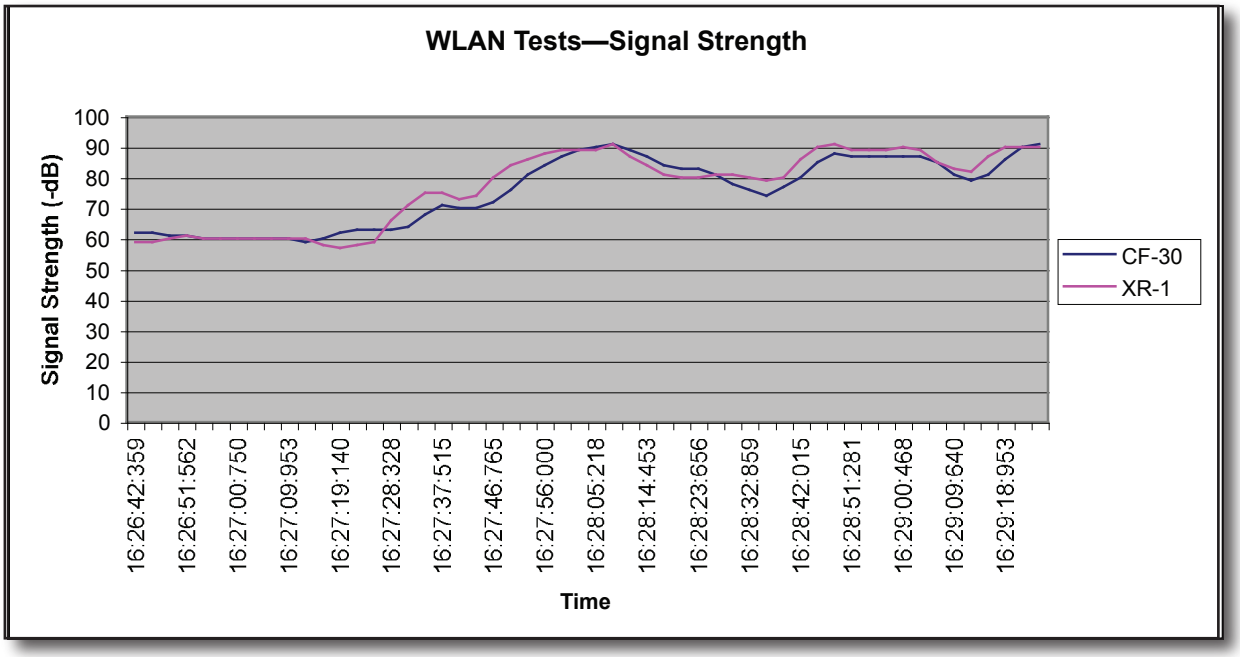

Figure J–5—Results of the WLAN tests for the CF-30 and XR-1 laptops. The results are displayed in –dB levels.

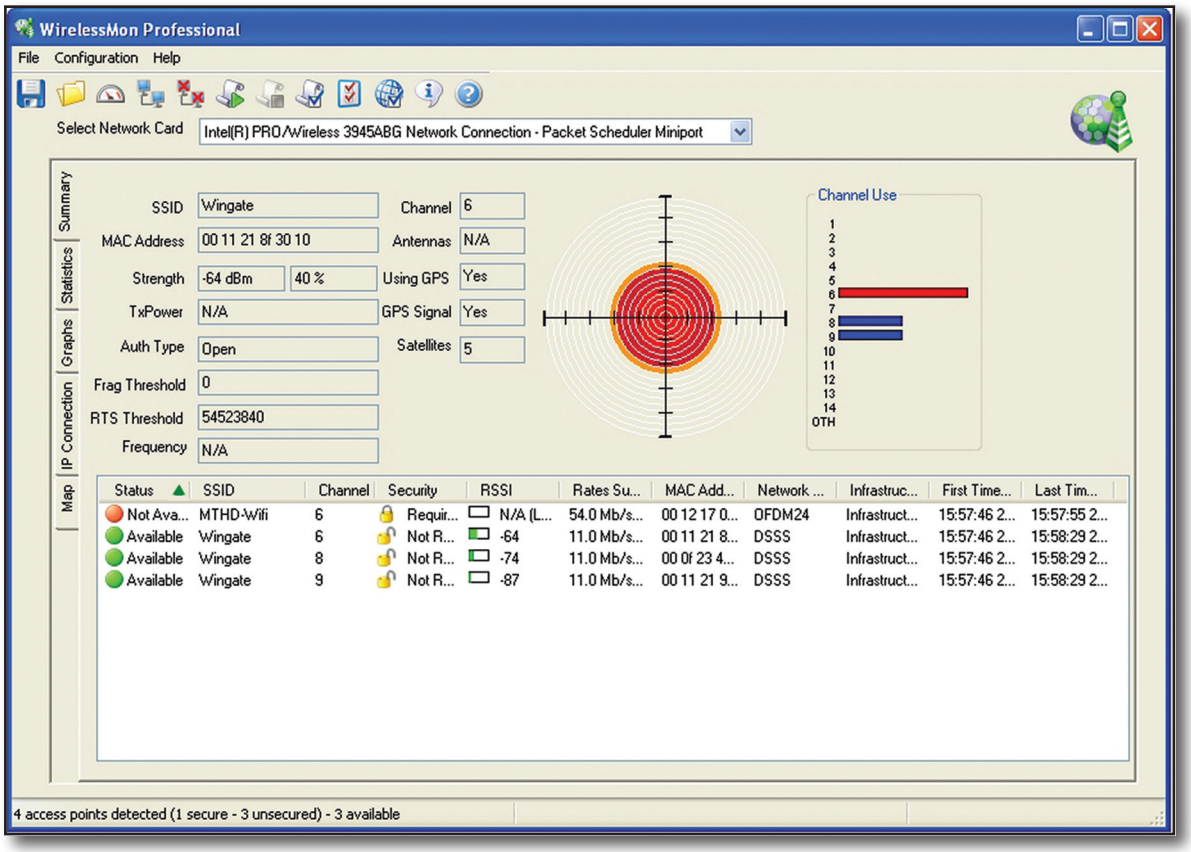

Figure J–6—Typical output from the PassMark WirelessMon 2.0 software showing signal strength and available WLAN access points.

Conclusions

There is very little difference between the internal WLAN (802.11) devices on the CF-30 and XR-1 laptops. The results were almost identical when the two devices were side by side in a vehicle. There was no practical difference between the two laptops when throughput was measured at three different signal strengths.

Appendix K—Cellular Connectivity Tests

Purpose

The WWAN tests determined the expected throughput of the WWAN devices of each laptop and compared the signal strength with the two laptops side by side.

The two WWAN EVDO (Evolution, Data Only) cards were different. The card installed in the XR-1 laptop was the latest model from Verizon Wireless, while the card installed in the CF-30 laptop was an older model.

Equipment

See appendix J for information on Ixia IxChariot software and on the five scripts that were used to test cellular connectivity.

Procedure

Three laptops were used for the WWAN throughput tests, two XR-1 laptops and a CF-30 laptop. All three were connected to a secure WWAN with an internal EVDO aircard. IxChariot software was loaded on one XR-1 laptop and the CF-30 laptop and each was configured as endpoint 1. The other XR-1 laptop was configured as endpoint 2. Endpoint 2 was located at MTDC at the best signal strength possible (-70dB). The other two laptops (one XR-1 and the CF-30) were moved together to different locations to run IxChariot throughput tests at three different signal strengths (-100dB, -70 dB, and -50 dB). Each ran the five throughput scripts independently.

Results

Figures K–1 through K–3 show the results from the WWAN EVDO throughput tests.

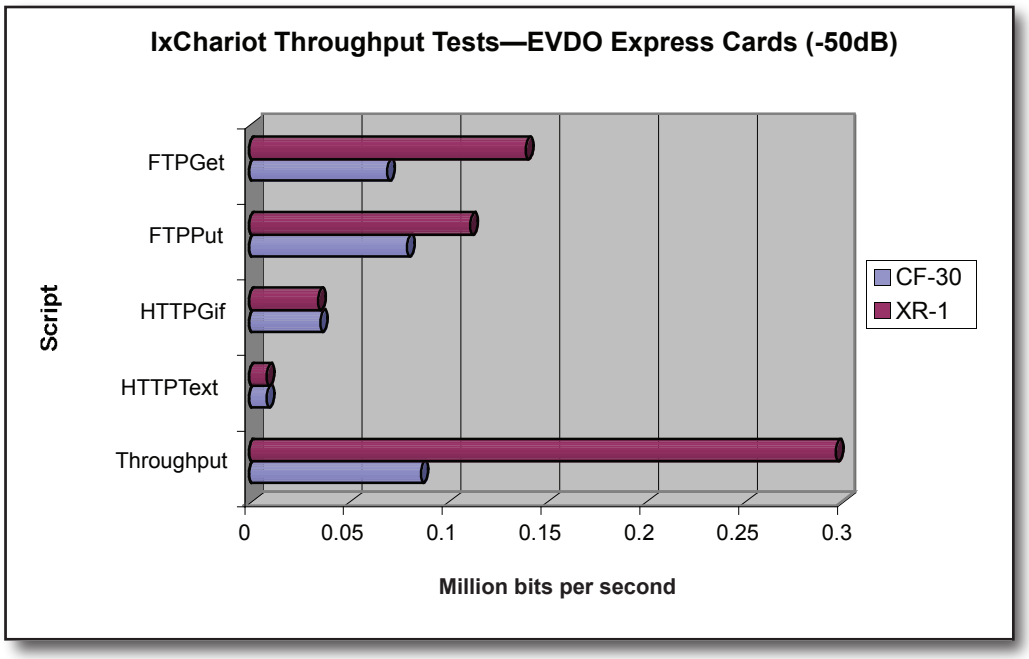

Figure K–1—This graph shows the results from the IxChariot throughput tests using the WWAN EVDO aircard at -50 dB signal strength. The five tests represent typical Internet usage in a field situation.

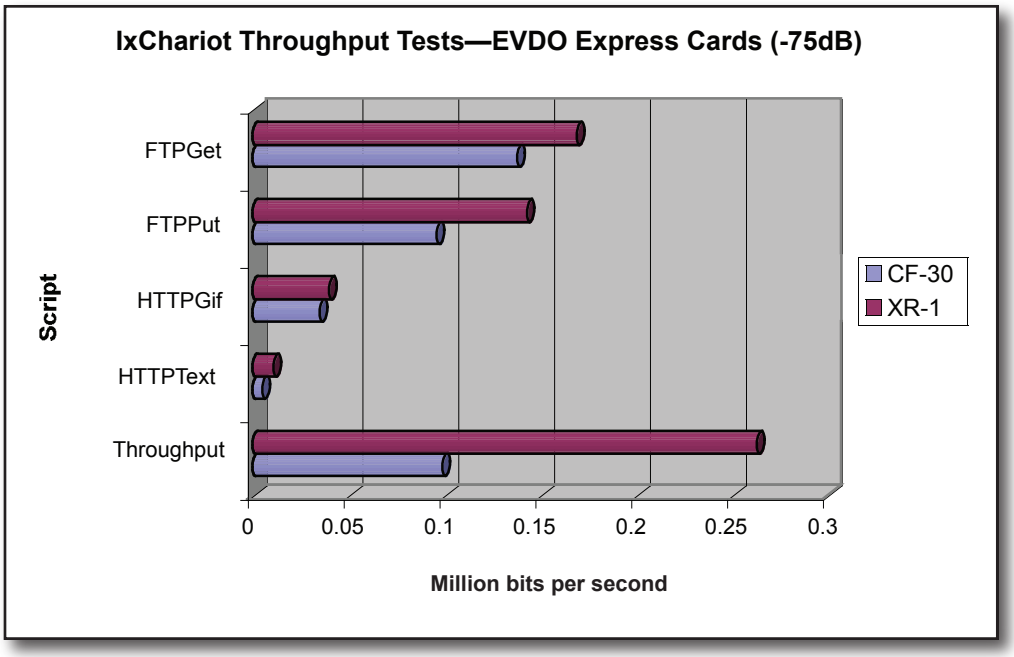

Figure K–2—This graph shows the results from the IxChariot throughput tests using the WWAN EVDO aircard at -75 dB signal strength. The five tests represent typical Internet usage in a field situation.

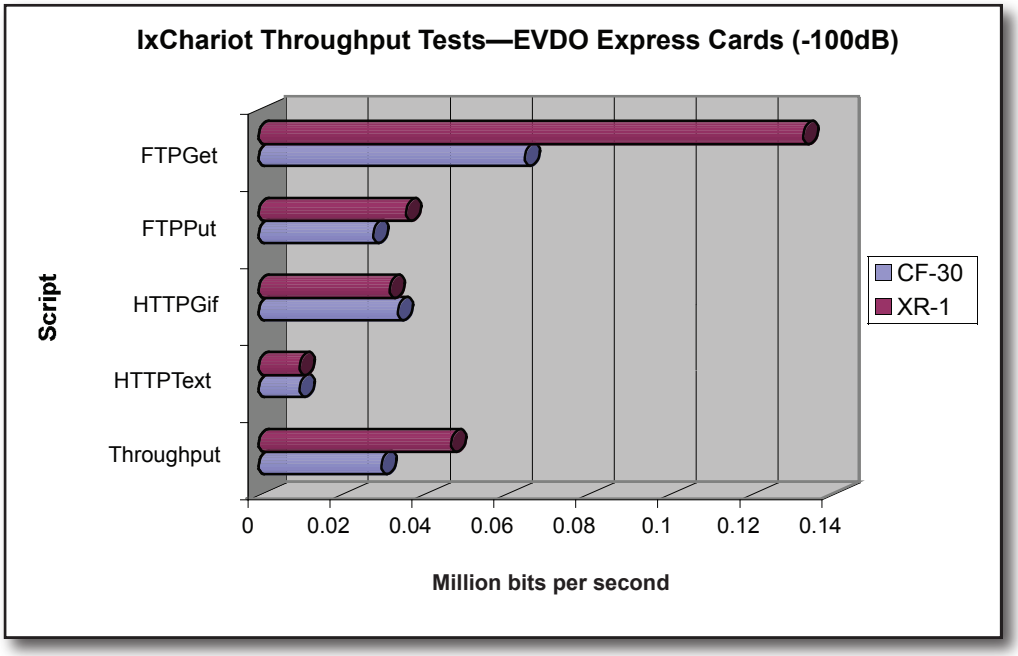

Figure K–3—This graph shows the results from the IxChariot throughput tests using the WWAN EVDO aircard at -100 dB signal strength. The five tests represent typical Internet usage in a field situation.

Conclusions

The WWAN EVDO card in the XR-1 laptop had much higher throughput for nearly all the tests. The throughput was much higher when the signal was stronger (lower dB levels) for the newer Verizon Wireless Aircard in the XR-1 laptop than for the older Verizon Wireless Aircard in the CF-30 laptop.

Appendix L—Questionnaire

A questionnaire was administered to 20 law enforcement officers who were field testing rugged laptops and a new software reporting system. Officers were asked how well the laptop they used performed in the everyday world of law enforcement activities. The questionnaire was divided into five sections:

- Attributes that related to the user interface
- Hardware features
- Use of the laptops in vehicle and office mounts
- General impressions
- Overall ratings

Respondents were also asked to rank the three most important features of a laptop designed for law enforcement field use.

The questionnaire was sent to all 20 participants in the study (10 participants were evaluating the Panasonic CF-30 laptop and 10 were evaluating the General Dynamics XR-1 laptop). Sixteen usable questionnaires were returned for a response rate of 80 percent. Seven responses were received from officers testing the CF-30 laptop and nine responses were received from officers testing the XR-1. Responses were analyzed to determine significant differences in ratings between the two laptops. Because of the small study size, inferences from this study should be treated with caution. A larger trial would be needed for conclusions to be drawn with more confidence.

In the sections of the questionnaire examining user interface, computer hardware, vehicle and office mounts, and general impressions, participants in this trial were presented with a series of statements about their experience working with the laptop. For each statement the respondent indicated whether they "strongly disagreed," "disagreed," "neither agreed nor disagreed," "agreed," or "strongly agreed" with the statements. Respondents also could indicate that they did not know what their response was to the statements.

Regarding the user interface, respondents were presented with 17 statements about the use of the computer: the touch screen, and other input devices such as the touch pad, stylus and keyboard. Fourteen statements about the computer's hardware were offered concerning the computer's battery, the number and accessibility of the USB ports, and the usefulness of the fingerprint reader and the built-in CD/DVD drive. Similarly, 12 statements were offered about the vehicle and office mounts, and 7 were general impression statements concerning the computer's weight, noise, heat, processor speed and accessibility.

A scale from 1 to 5 was developed from the responses where 1 represents a strongly negative evaluation of the user interface attribute, and 5 represents a strongly positive evaluation. As shown in table L–1, the mean scores for interface, hardware, mount, and general impressions differed between the two laptops. However, none of the differences were statistically significant at the $p \leq .05$ level. Any conclusions based on these differences should be made with caution.

Table L–1—A comparison of mean scores for laptop user interface; hardware, vehicle and office mounting capabilities; and general features. The scale is from 1 to 5, where 1 is a strongly negative evaluation and 5 is a strongly positive evaluation.

	Panasonic CF-30			General Dynamics XR-1			
	Mean	Std. Dev.	*N*	Mean	Std. Dev.	*N*	Sig.
Interface	3.6	0.46	7	2.9	1.31	8	0.210
Hardware	3.4	0.47	5	2.5	1.08	9	0.102
Mount	1.9	1.00	6	2.2	1.49	9	0.714
General impressions	3.8	0.59	7	3.1	1.21	9	0.167

Respondents also were asked to provide an overall rating of how easy their laptop was to use and how well the laptop met their needs. Participants rated the ease of use from 1 (very difficult to use) to 10 (very easy to use). Similarly, respondents rated how well the machine met their needs from 1 (did not meet my needs at all) to 10 (completely met my needs). Table L–2 shows the responses. The mean responses for the ease of use were 8.3 for the CF-30 laptop and 6.8 for the XR-1 laptop.

Table L–2—A comparison of how well respondents felt the laptop met their needs and how easy it was to use, based on a scale of 1 to 10.

	Panasonic CF-30			General Dynamics XR-1			
	Mean	Std. Dev.	*N*	Mean	Std. Dev.	*N*	Sig.
How well did the laptop meet your needs?	8.7	1.20	6	6.87	1.81	9	0.058
How easy was the laptop to use?	8.3	0.82	6	6.88	1.73	8	0.820

Both the significance level of these measures and the nearly identical scores for ease of use and usefulness should urge caution before drawing conclusions based on these responses. Respondents might not have distinguished between usability and usefulness. Or, they might simply have used the responses to one of the questions as a guide when filling out the other.

A final measure was used to evaluate the features that respondents considered most important for a laptop used in law enforcement settings. Respondents were presented with a list of 18 attributes and were asked to rank their top 3 (1 for their first choice to 3 for their third choice). Participants could write down attributes that were not included in the original list. Table L–3 shows the number of respondents selecting each attribute as their first, second, or third choice. Ruggedness was the attribute most often selected as important. Processor speed, the availability of a vehicle mount, and a backlit keyboard were also selected as important.

Table L–3—Respondents' choices of specific laptop functions and features as first, second or third most important.

	First Choice	Second Choice	Third Choice	Score*
Ruggedness	8	2		28
Vehicle mount capable	1	3	1	10
Processor speed	2		3	9
Backlit keyboard	1	1	3	8
Keyboard functionality		2	2	6
Touch screen capability	1	1	1	6
Screen size	1		1	4
Office dock capable		1	1	3
Screen brightness		1		2
USB access		1		2
Fingerprint reader functioning		1		2
Battery life			1	1
Touch pad capability			1	1
CD access				0
Number of USB ports				0
Changing battery easily				0
Quietness				0
Port accessibility when docked				0

*The sum of the number of respondents selecting the attribute as their first choice, times three, plus the number of respondents selecting the attribute as their second choice, times two, plus the number of respondents selecting the attribute as their third choice.

About the Authors

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Library Card

Trent, Andy; Miller, Theron. 2007. Evaluation of two fully rugged laptop computers for the Forest Service. Tech. Rep. 0771–2832–MTDC. Missoula, MT: U.S. Department of Agriculture Forest Service, Missoula Technology and Development Center. 42 p.

This report documents the evaluation of the Panasonic Toughbook CF-30 and General Dynamics GoBook XR-1 fully rugged laptop computers for the Forest Service's Chief Information Office Mobile Computing Program. Forest Service law enforcement officers need fully rugged computers, as might firefighters or researchers. The evaluation included a number of tests—many based on military standards—including drop tests, high and low temperature tests, vibration tests, GPS tests, performance benchmarking tests, battery performance tests, screen visibility tests, wireless connectivity tests, and cellular connectivity tests. In addition, the report includes the results of a questionnaire sent to 10 law enforcement officers who field tested the Panasonic Toughbook CF-30 laptop and 10 officers who field tested the General Dynamics GoBook XR-1 laptop.

Keywords: benchmarking, chief information office, General Dynamics, GoBook, law enforcement, mobile computing, Panasonic, testing, Toughbook

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