White paper

Understanding & Evaluating Mobile Printer Performance

How to Identify the Features and Factors That Set Mobile Printers Apart and Add Value in Real-world Operations

Intermec®

Introduction

In a test, a print request for an identical shipping label was sent to two mobile thermal printers over a standard 802.11b wireless connection. Despite the fact both printers had to process the same label format, with the same computer and same network bandwidth, one printer completed the job 2.8 times faster than the other (the faster printer output the label in 3.0 seconds, compared to 8.4 seconds for the slower). When the test was repeated with a retail label format with a large graphic, the job was completed 7.9 times faster (in 3.8 seconds compared to 30). Further testing found the same printer provided an output advantage regardless of what label format was used, whether the print job called for a single label or multiple labels to be printed, or whether the printer connected to the computer wirelessly or through a cable. When different mobile computers were substituted, the faster printer's performance advantage was even greater.[1]

The most surprising result is that both printers tested had the same listed print speed: 4 inches per second (ips). Clearly, there's more to printer performance than what's listed on the product spec sheet.

Businesses need to know when they develop mobile printing applications whether the label, receipt or document will print quickly, or leave the worker waiting for half a minute or more each time output is needed. The answer makes the difference whether the mobile printing process will raise productivity or build delays, frustration and cost into operations.

Three Major Attributes

Speed is one of three major performance attributes that determine the value mobile printers can provide. **Reliability** and **quality** are the others; mobile printers should not only work fast, but work nearly all the time, and produce usable labels, receipts and forms on the first try. This white paper will help identify how features and other variables impact mobile printer performance in real-world operations.

Speed Matters

Speed matters in mobile printing, because businesses turn to mobile printers primarily to improve productivity. Imagine how the printers in the test summarized above would impact real-world operations. Workers for one retailer would waste about 26 seconds each time they printed a price label with graphics, while workers at another retailer using the other printer could complete the job and move on to the next. In a distribution center, the time difference for producing shipping labels would directly impact the number of items that could be shipped each hour, an important productivity metric.

As the test results showed, the inches-per-second rating is not a reliable indicator or differentiator of printer performance. Data from additional tests, which measured various combinations of printers, mobile computers, connectivity options and label formats, are shown in the table below.

Since ips isn't a reliable predictor of performance, it is important to evaluate mobile printers on two other measures: **time to first label**, and **total print time**. Time to first label (also referred to as first label out) is measured as the elapsed time between when a user hits <print> and when the label, receipt or form is presented for use. First label out is essentially a measure of how long a worker will have to wait for materials before he or she can complete the task at hand. Fast first label out performance is important for customer-facing applications so customers aren't kept waiting, and for high-volume operations such as item labeling.

Total print time should be evaluated if operations call for workers to produce multiple labels simultaneously, such as in the test example above in which five shipping labels may be printed at once to label cartons being packed on a pallet. Some printers require a pause between each label produced to process the next print job, while others can print nearly continuously after output begins. The time spent during pauses can be a strong impediment to efficiency. Note the multiple-quantity test results in the table below: Printer Z needs about twice as much time as Printer I to complete a series of five shipping labels.

Testing proves there are major differences in the amount of time printers with the same print speed rating need to complete a print job, but the data does not explain why. Inches per second refers to the maximum theoretical speed a printer can attain, but actual performance depends on multiple other variables, including the amount of graphics, bar codes and variable data required in the printed output, the computer used, connection method, battery level, printer memory, font support, wireless connectivity technology, range from the signal source and security settings. The following sections explain how these factors impact mobile printer performance.

Figure 1: Mobile Printer Time Comparison for Completing Common Labeling Jobs
Note: Each printer's specification sheet lists print speed at 4 ips.

Label Type	Quantity	Communication	Time to First Label (seconds)		Total Print Time (seconds)	
			Printer I	Printer Z	Printer I	Printer Z
Domestic shipping	5	Serial	2.6	7.2	22.8	44.4
Domestic shipping	5	802.11b	3.0	8.4	23.4	50.2
Retail price checker w/large graphic	1	Serial	2.4	26.0	6.2	28.8
Retail price checker w/large graphic	1	802.11b	3.8	30.0	7.2	34.2
GM shipping	1	Serial	2.6	5.8	14.4	18.3

1 Test data referenced in this document is based on tests conducted by Intermec Technologies March - April 2009. For a copy of the test data, please contact Intermec Printer Marketing.

Printer-Computer Combination
One of the biggest variables on printer performance isn't the printer itself, but the device it is paired with. Mobile printers are most commonly used with mobile computers. Even though the devices connect through standard interfaces (e.g. serial cable, Bluetooth or 802.11), the specific mobile computer model is a significant variable to mobile printer performance.

The table below shows test results for the time needed to complete three common shipping labels using different mobile printer and computer combinations. The mobile printers had the same ips ratings and identical label formats were used for all tests. Mobile printers from two manufacturers (designated as I and Z in the chart) were used with mobile computers from two manufacturers (M and I; vendor I manufactures both mobile computers and printers). The impact of the mobile computer used ranged from as little as 10 seconds to two full minutes to complete the three-label print job, as shown below. The same printer was faster when used with each mobile computer, and the mobile printer and computer from the same manufacturer proved to be the fastest overall combination.

Figure 2: Mobile Computer Impact on Mobile Printer Performance

	Computer M	Computer I	Time Difference
Printer I	30	20	10 seconds
Printer Z	150	36	114 seconds
Time Difference	120 seconds	16 seconds	–

You can see a video that highlights the test results and demonstrates the head-to-head performance at www.youtube.com/intermecprinters.

The time differences exist even though standard interfaces are in place because mobile computers and software applications use different drivers and emulations when working with printers, and have several options for how print jobs are processed. The connection between the mobile printer and computer also impacts throughput, as the serial cable and wireless test results presented in Figure 1 showed. Organizations need to test their own print job formats to determine which computer-printer combination is fastest for their operations. Of course, the power of the printer's own processor is also a major speed differentiator.

Output Type
Text-only receipts will print faster than shipping labels that include a company logo, 2D bar code, lot code, carton weight and other variable data. So, when viewing printer demos or otherwise evaluating performance it is important to test your own actual print jobs or samples that are similar. Some printers are not optimized to print bar code symbols and thus take longer to print bar coded output than models that are engineered for the task. Graphics capabilities, font support and international character generation also impact print speed and vary by printer.

Memory
The amount of memory available on a mobile printer indirectly impacts print speed. Printers perform faster when label formats, graphics and data can be loaded directly from memory instead of received from a cable or wireless connection to a host computer or database. Therefore print speed can be improved by storing as many necessary elements on the printer as possible. The more memory a printer has, the more label formats, fonts, graphics and data files it can hold.

Wireless Configuration
When wireless communication is used to send print jobs to a mobile printer, the wireless technology, distance from the signal source, environmental interference, security settings and the printer's ability to support roaming from one access point to another all impact performance. Output depends on the bandwidth of the input, and the printer microprocessor comes also into play. Newer wireless networking and security protocols (e.g. 802.11g, WPA2) consume more bandwidth and processing power than their predecessors (e.g. 802.11b with WEP or WPA security), so legacy printers not originally made to these specifications will not perform as well as those with native support for the new protocols. Remember, 802.11b-compatible devices can be used on 802.11g and 802.11n networks, but will not operate at the newer network speeds.

Battery
Printer batteries usually don't fail suddenly, they wear down gradually, and print speed and quality wear down with them. Printer performance degrades sharply once the battery falls below a certain threshold of its charge capacity. The size of the "sweet spot" where there is little or no performance degradation, how long the battery holds its charge, and the time needed to recharge the battery are among the variables to consider when assessing printer battery performance. Batteries have a bigger impact on printer reliability than on speed or print quality. A slow printer with a good battery is useful, but a fast printer with a dead battery is not.

Assessing Reliability

The value of mobile printing processes comes from their ability to save time and reduce errors compared to having workers walk to a stationary printer. Unreliable mobile printers undermine these benefits. When mobile printers break down, productivity plummets as workers attempt to troubleshoot the device or take time to get a replacement. The alternative is to revert to stationary printing processes, which increase the opportunity for mislabeling and other errors, in addition to reducing productivity. Research has documented that productivity lost from mobile device breakdowns costs organizations more than the devices themselves, and that lost productivity accounts for fully half of mobile computer total cost of ownership (TCO).[2] See Intermec's companion white paper *Time is Money: How to Save Both with Mobile Printing* for user profiles, use-case examples and calculations that show how mobile printer reliability impacts costs and productivity.

2"Total Cost of Ownership (TCO) Models for Mobile Computing and Communications Platforms," VDC Research. July, 2007. For more information and documentation about the relationship between reliability and costs in mobile computing systems, see Intermec's white paper *How Ruggedness Reduces TCO for Mobile Computers*.

As with speed, there are several characteristics of mobile printers that give a good indication of how reliably they will perform. When mobile printers are used in factory, distribution center, retail, delivery, field service and other non-office environments, the printer's ruggedness is the best predictor of its reliability. While ruggedness is most important to reliability, there are other important variables too, including power management, media compatibility, how easily users can troubleshoot the printer themselves and whether it can be corrected remotely through a device management system.

Ruggedness
Printers constructed to withstand drops, vibration and exposure to dust and moisture will have more uptime than models without these design features. Printers that are worn or carried will inevitably be bumped and dropped, and printers mounted in forklifts, vans or other vehicles will experience considerable vibration. To keep these conditions from damaging the printer, rugged construction is essential. When the printer is mounted in a vehicle, a dock designed specifically for the printer will minimize potentially damaging vibration.

Ingress Protection (IP) ratings and drop specifications are the main measures of mobile printer ruggedness. IP ratings are defined by International Electrotechnical Commission (IEC) standards to provide a measure of how well devices are sealed against dirt and moisture. Ratings are typically expressed by the letters "IP" followed by two numbers. The first number indicates the level the device is protected against particles, and the second digit is the protection against water. For example a mobile printer rated IP54 has level five particle protection, which means dust deposits may form on the unit but will not affect performance, and level four water protection, which means the device can function when splashed or exposed to low-pressure spray. IP and temperature ratings are especially important for printers that will be used outdoors or may be stored in vehicles, where temperature and humidity levels can be much higher than those for typical indoor applications. Figure 3 below shows the IP designations that apply to mobile printers.

Figure 3: IP Rating Designations
Source: Underwriters Laboratories

First digit – particle protection level

0	Not protected
1	Protected against penetration by objects larger than 50 mm
2	Protected against objects greater than 12mm
3	Protected against objects greater than 2.5mm
4	Protected against objects greater than 1.0mm
5	Dust protected
6	Dust tight

Second digit – moisture protection level

0	Not protected
1	Protected against dripping water
2	Protected against dripping water when tilted up to 15N
3	Protected against spraying water
4	Protected against splashing water
5	Protected against water jets
6	Protected against heavy seas
7	Protected against the effects of immersion
8	Protected against submersion

Drop specifications refer to how many times the mobile printer can be dropped and keep working. Drop specifications are more difficult to interpret than IP ratings, because they can be subjective. For example, a manufacturer may say its mobile printer is "rugged" or "durable," but there is no objective, widely accepted definition of what these terms mean. In contrast, printers with a MIL-STD specification have been tested and certified according to objective test criteria established by the U.S. Department of Defense. To get MIL-STD-810G certification, devices must remain operable when landing on any face, edge or corner to a "non-yielding" surface such as steel or concrete. Compliance with the standard requires devices to pass this test after being dropped 26 times, which is a more objective and rigorous measure than saying devices will function after "multiple" drops, which is a common marketing claim.

Power Management
Dead batteries bring printing processes to a stop, so the minimum performance requirement for a mobile printer is for the battery to be able to power a full shift of use. A spec sheet can't adequately list the printer's battery performance because printing volume, format of the output, the type of media used with the printer, and connectivity method (wireless communication requires more power) all impact the printer's battery life. Battery performance in specific working conditions can be identified through pilot testing. Besides how long the battery can power the printer, it is also important to consider whether users can easily replace the batteries in their equipment, whether batteries need to be removed from the printer to be recharged, and the time required for recharging. Printers with user replaceable and rechargeable batteries will have lower support and labor costs than those that require tech support to make the change. Recharge time determines how long batteries will be out of service, which in turn determines the number of spares that must be kept to keep the printer population powered.

Media Issues
Many product evaluations underestimate the effect media has on printer performance. The media itself impacts how hard the printer must work to produce an image, how much power is used, the stress on internal components, likelihood of jams, and overall print quality. Time is lost whenever workers need to load media or clear jams. Therefore printers that feature drop-in media that users can easily load themselves, and those that support large capacities, provide a productivity advantage over models that are more time consuming to load and need to be changed more frequently.

Sensors that require a label or receipt to be removed from the printer before the next one is advanced also help prevent jams. Linerless media helps productivity because there is no backing material to discard. Because the value of mobile printers is often determined by the time they save users, media changing time should be considered when comparing products.

Mobile printer lifecycles and reliability can be enhanced by using only media that is recommended for the specific printer model. Although there are only a few common media sizes for mobile printers (e.g. 2-inch, 3-inch and 4-inch) there are hundreds of label, paper and tag options that vary by their thickness, protective coating material, adhesive and resistance to liquid, light and temperature. The differences can't all be seen by the naked eye, but do impact the printer and print quality. Thermal printers produce an image by using their printhead to apply heat

to chemically treated media. The type of media determines how much heat needs to be applied. Media that isn't suited to the printer can cause the printhead to overheat and fail, which results in poor print quality and product downtime. Some printers are not designed to support multiple media types, so that is an important feature to evaluate if the printer may be used to produce different types of labels, tags and tickets.

Problem Resolution
Media loading is an example of how printer design can impact uptime and user productivity. Besides routine media changes, printers should make it easy for users to complete other basic troubleshooting without having to involve IT support staff and take the printer out of service. Once again, printer features make a difference. For example, users will be more likely to solve a problem if the printer has an LCD screen that displays an error message (e.g. paper jam, low battery, etc.) and can provide prompts to fix the problem than if the user has a printer with basic LEDs that only indicate a problem exists.

Mobile printers can provide even more protection against downtime by being compatible with device management systems that enable administrators to monitor performance and remotely perform configuration and troubleshooting. Advanced printers allow administrators to load new label formats, resolve network connectivity problems, adjust printhead temperatures, update firmware, adjust security settings and change other configurations remotely without ever having to handle the printer.

Quality Considerations

Speed and reliability alone don't make for a good mobile printer. Quality is the final critical component. If text isn't readable or bar codes aren't scannable then problems will crop up in the systems and processes that rely on printed output. For example, inventory may not be recorded, products and shelves will need to be relabeled, illegible receipts and invoices will lead to billing and customer service problems, and shipping labels that fail to scan or fall off before they arrive may result in a non-compliance fine from the customer. In fine and chargeback situations, print quality has a direct and strong impact on costs.

Media, print technology, power management and print method are major variables for print quality. Many print quality issues are caused by a poor match between the printer and media, and thus can be avoided by using only media recommended by the printer manufacturer. When preprinted color label stock (i.e. flood coated) is desired, users should always check with their printer supplier for a media recommendation.

Print quality may suffer when the battery charge falls below a certain level. Unless the printer corrects for it, the low charge level may result in light or streaky images, because insufficient power is being delivered to the printhead. Some intelligent mobile printers automatically compensate for low charge levels by reducing print speed to make more power available to maintain print quality.

Thermal printing provides exceptional print quality and is the dominant technology used in mobile printing applications that require bar code, graphics and other high-quality output. For bar codes to be readable, the bars and spaces must be produced to very exact width specifications and must provide sufficient contrast between dark and light elements. Thermal is the dominant technology used for bar code printing because it is capable of producing very crisp lines and images, and because many thermal printers have native support for bar code symbols and do not treat them as fonts or bitmap images, which reduces quality.

Deployment Differentiators
A mobile printer's value depends largely on the amount of time it takes to print and the amount of time it is in service producing quality output. But there is another time variable in the value equation: the time required to configure, deploy and maintain mobile printers and related applications. The faster a printer can be taken out of the box, configured, interfaced to a mobile computer or other host, loaded with print formats and applications, the sooner it can begin returning value. System administrators should evaluate and rate mobile printers based on their ease of configuration, supported device interfaces, development resources, support for enterprise connectivity and security standards, and compatibility with preferred device management methods. Mobile printers create value by trimming minutes or even seconds from work processes; saving hours during deployment can really raise the return on investment.

The simplest mobile printers to deploy come with a bar coded menu sheet that can be scanned to set configuration settings. Others require IT support staff or systems integrators to program the printer firmware or use management software applications to initialize the device and adjust settings. Printers labeled with their MAC and/or Bluetooth device address also save time during deployment.

For printers that will connect to wireless networks, native support for enterprise connectivity and security protocols is essential. Although printers may be nominally 802.11b/g certified, that does not mean they are fully compatible with corresponding enterprise networks. For example, 802.11-standard networks are very flexible as to the types of security that can be used, so the printer should support the exact protocols the enterprise has in place (e.g. WPA, WPA2, 802.11i, FIPS, AES, TKIP, LEAP, etc.). If the wireless network has a Cisco backbone, printers with CCX compatibility provide integration advantages.

Compatibility with the legacy printer environment and management systems can have a major impact on deployment time and costs. There is no standard control language for thermal printers, which means label formats and printer programming can't be reused with another brand of printers, or sometimes even different models from the same manufacturer. This limitation can effectively lock organizations into a single printer manufacturer, because the time and cost required to redevelop formats and

printing applications may not be worth the advantages by upgrading to newer printers from another vendor. Printers that provide emulations for other printer languages eliminate this problem and let users leverage their legacy development work when introducing new makes and models of printers. Because emulation enables printers to be installed immediately into legacy environments without requiring label formats to be redeveloped or other integration work, it is a very valuable feature.

Similarly, printers that are compatible with enterprise IT management systems, or include their own, provide value by simplifying integration and saving time for support staff. Because uptime is so important to operations and printer value, printers should be monitored so they can be managed proactively and problems (e.g. out of paper) can be corrected quickly. Some printers can automatically issue alerts if they lose power or network access or other error conditions exist, and have their own management environment that allows administrators to provision, troubleshoot and update printers remotely. Printers may also be compatible with third-party systems that are used to monitor other printers, computers and IT assets. Even the most reliable printers will run out of media or will need periodic updates, so remote management capabilities are practical, and are often a differentiator among models that offer similar printing performance.

Conclusion

Print speed, size, weight and power requirements are all listed on printer spec sheets. "Performance" "productivity" and "value" are not. Understanding how the former contribute to the latter is essential for finding the mobile printer that best fits the usage requirements. The true differentiators among mobile printers are how quickly and reliably they perform in real-world environments. The time to first label and total print time – not listed print speed – have a direct impact on how much mobile printing processes will improve worker productivity. Durability determines how long the printer will reliably remain in service, and thus is an important component to total cost of ownership. Other factors that impact the cost and value associated with integrating and using mobile printers include support for enterprise networking, security and management protocols, and compatibility with the legacy printing environment.

Intermec offers a complete range of mobile printers to meet different performance needs. They are built to provide fast, reliable label, receipt and form printing in industrial, retail, distribution, field service and other environments. Intermec mobile printers are also designed to integrate with the mobile computers, data collection devices and enterprise IT systems used in these environments, and include native support for wireless security and mobile device management. Intermec mobile printers are extremely rugged and are available in a variety of form factors and configuration options to meet different needs.

Intermec has been developing ruggedized mobile computers and peripherals for more than 40 years and together with our extensive network of partners have successfully integrated hundreds of thousands of devices into demanding industrial, warehouse, field service, delivery, logistics, retail and other environments. Intermec mobile computers and mobile printers are rugged and are designed for use in challenging environments.

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123.456.7890
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