Planning a DoD UID Bar Code Marking System

A practical guide to program requirements, marking options and printer selection

A ZEBRA **BLACK&WHITE** PAPER

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Executive Summary

The U.S. Department of Defense Unique Identification (UID) program was launched in 2003 to make the business processes associated with tracking DoD personnel, roles, real property, and personal property more efficient. A subset of the DoD UID program—the Item Unique Identification (IUID) program—focuses on DoD personal property. The IUID program aims to improve asset management by marking items delivered to the DoD with unique item identifiers. This is accomplished by assigning a Unique Item Identifier (UII) to an item, making it distinctive from all other items. According to the DoD, a UII "identifies an item with a set of data that is globally unique and unambiguous." With few exceptions, contractors must mark goods delivered to the DoD with the UII encoded into a Data Matrix two-dimensional (2-D) bar code symbol. The Data Matrix 2-D bar code can be marked directly on the item surface, or affixed by a label or data plate to the item, as long as it remains permanent through the life of the item and not damaged or destroyed in use. It's up to contractors to determine the best way to mark their products. This white paper will help, by:

- Summarizing the IUID program requirements;

- Explaining the leading options for compliance marking;

- Presenting the advantages and limitations of using data plates, label printing, and direct part marking techniques, including ink jet marking, chemical etching, dot peening, laser bonding and laser etching; and

- Providing an overview of what to look for in a IUID label printing system.

IUID marking will become a business-critical operation for DoD contractors and DoD agencies who need to mark legacy items. In fact, the DoD has launched a multi-faceted business transformation process that relies on UID, Wide Area Workflow (WAWF), and radio frequency identification (RFID) tagging to provide total asset visibility for shipments and assets. (WAWF is an electronic, paperless contracting application; by eliminating paper-based, labor-intensive tasks from the contracting process, it helps speed payment of government vendors.) These programs provide the foundation to enhance item visibility, improve life cycle item management and accountability, and support clean financial audits. All DoD suppliers need to be aware of how these programs can impose new requirements on them. Compliance for IUID programs isn't necessarily complex and can be done very cost-effectively if organizations fully understand the capabilities of different marking methods. Thermal label printers, for example, are suitable for marking about 80 percent of items provided to the DoD and are the lowest-cost and easiest-to-use option available.

UID Requirements

The DoD requires contractors to include a permanent two-dimensional mark on items so they can be accurately identified and tracked throughout their lifetime. The information is used to manage inventory, maintain maintenance records, and support logistics, as well as for many other operations. Encoding the information in a 2-D Data Matrix bar code enables the DoD to capture and access information automatically, with minimal user intervention and no manual data entry required. Unique identification is a mission-critical element of many DoD operations, so the Department includes most items, parts, and supplies in the program.

DoD policy requires a Unique Item Identifier for items that meet one of the following criteria:

1. Cost $5,000 or more;

2. Are managed by serial number;

3. Are considered mission-critical;

4. Are part of controlled inventory; or

5. Any consumable or material where permanent identification is necessary.

A UII is required if any of these conditions are met. As a result, most items provided to the DoD require a unique serial number that can never be duplicated by the contractor or any other supplier. Supplier ID numbers (e.g. CAGE codes), part numbers and other data can be used to provide unique and unambiguous serialization. Within DoD agencies, program and item managers are responsible for implementing IUID marking for legacy items that meet the criteria. This includes items undergoing maintenance, repair or overhaul, and in inventory. The UID process itself must conform to several ISO and military standards. The UID program Web site, www.acq.osd.mil/dpap/pdi/uid/index.html, contains specific guidance and includes links to the full policy and related documents, and has many valuable resources to aid compliance.

There are several acceptable ways to construct the UII, but all require that the information be expressed in a Data Matrix two-dimensional bar code symbol with Error Correction Code 200 (ECC 200). There are exact specifications on the element size for this Data Matrix, resulting in a finished symbol size only about 1/2-inch square. Determining the most efficient way to apply Data Matrix symbols to items is therefore one of the most important considerations when developing a IUID marking system.

Marking Options

Contractors can opt to outsource their IUID marking to subcontractors, so the first decision is whether to do so or to develop in-house compliance capabilities. Outsourcing is a good short-term solution while in-house compliance systems are being developed, or for contractors who supply the DoD very infrequently. Another option is to order preprinted UII labels and data plates and apply them as necessary. Organizations with ongoing marking needs will find it much more cost-effective to bring marking operations in house.

The next decision is to determine the optimal marking method. The three principle options are to apply labels or data plates to the item, or to create a bar code on the item itself by direct part marking (DPM). There are five main direct part marking techniques: ink jet printing, chemical etching, dot peening, laser bonding, and laser etching.

DPM has caused considerable confusion and concern among DoD contractors that Zebra has worked with. There is a misperception that DPM is a requirement; it is not. DPM may be the only way to apply to a UII to some items, but it is a niche method. Adhesive labels produced

> **Excerpts from "Cost Benefit Analysis of Unique Item Identification (UID)"**
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> The UID Program Office is unaware of any small business that cannot afford to comply with the UID policy….We anticipate that most small vendors will be able to comply using labels and data plates readily and inexpensively available in the commercial market.
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> Source: The Office of the Under Secretary of Defense for Acquisition Technology and Logistics. The complete report and other resources are available on the Defense Procurement and Acquisition Policy Web site, www.acq.osd.mil/dpap/pdi/uid/index.html.

with thermal-transfer printers are sufficient to mark a significant percentage of all items that require a UII, with the exception of heavy duty equipment or machinery that may require other permanent marking techniques because of their physical properties. Before finalizing its policy, the DoD studied this issue out of concern that DPM would create an undue burden on its suppliers, particularly small businesses (see sidebar). The DoD found no cause for concern because **most UID requirements could be met with inexpensive labels and data plates.** The following sections profile the in-house UII marking methods.

Label Printing

On-demand bar code label printers are all most DoD suppliers and agencies will need to satisfy their marking requirements for items where a permanent adhesive label can be affixed to the item. Direct-thermal and thermal-transfer on-demand printers are the technology of choice for mission-critical bar code labeling applications in manufacturing, logistics, aerospace, and most other industries. Direct-thermal printers, which are more common, use no ribbon and apply heat directly to chemically treated media. Thermal-transfer printers work by using a printhead to apply heat to a ribbon, which melts the image onto the label material. They create a longer-lasting image than direct-thermal models. Thermal-transfer printers are ideally suited to meet IUID requirements because they work with a wide range of durable media and provide outstanding print quality for Data Matrix symbols, especially for small items.

Advantages:

Thermal-transfer printers are designed specifically to create long-lasting bar code labels. They cost the least to purchase and offer the lowest cost to operate of any in-house marking option. There are many styles of thermal-transfer printers, ranging from compact desktop units to high-speed industrial models that can be used on packaging lines to automatically apply labels in high-volume environments. Receiving print commands with part numbers and other variable data to encode the UII should not slow down label printing or otherwise reduce printer efficiency. Many models have native support for Data Matrix, so no upgrades or additional software are required. Thermal-transfer printers are compatible with a wide range of synthetic media suitable for lifetime identification, including Kapton® labels that can withstand temperatures up to 600° F. Because thermal-transfer printers are purpose-built for labeling, there is virtually no media waste and it is easy for operators to load media themselves, with minimal downtime.

Limitations:

Thermal-transfer printers are limited by capabilities of label media. For example, printers can create Data Matrix symbols at the DoD-required sizes, but to fit in the printer, the label material itself generally must be at least 1 inch wide. UII marks that will be exposed to temperatures above 600° F or other extreme conditions typically require direct part marking or a specialty data plate.

For more information about thermal printing, see Zebra's white paper "The Business Case for Using Bar Code Label Printers," available at www.zebra.com.

Data Plates

Data plates can be created in-house using expensive equipment, or ordered from a supplier. If preprinted data plates are ordered, the user will have to create tight processes to ensure plates are applied to the correct items, or risk recording UII numbers incorrectly.

Advantages:

Data plates are available in a variety of plastics and metals, which make them very durable and able to withstand exposure to specific chemicals and other hazards. Data plates can be applied with rivets, screws, or other fasteners, so they can be used in environments that adhesives can't withstand.

Limitations:

The equipment to produce data plates is fairly expensive, ranging from about $5,000 for a low-volume plastic plate machine (more than double the cost of a high-end thermal-transfer printer) to $20,000 for laser markers, according to DoD estimates[1]. Adhesives are not always effective for applying data plates, especially when metal plates need to be attached to metal objects. Fasteners are often required, which adds time, labor, and expense to the marking process and raises the radar profile of the plated item. Data plates also cost approximately 10 times as much as labels, according to the DoD.

Direct Part Marking

Direct part marking processes stamp or etch a symbol directly on the item being marked. The process used depends on the composition of the item and its structural tolerances. One reason Data Matrix was selected as the symbology standard for UID is that DPM equipment can produce it more easily than other 2-D bar code symbols. Some DPM marks are not read optically, so they can still perform if covered by paint or dirt.

Advantages:

Durability and space efficiency are the strengths of bar code symbols produced by direct part marking. DPM is sometimes the only option for marking items that will be exposed to extreme environmental conditions. The bar code becomes part of the item, and will last as long. Bar code marking is a one-step process, with no additional action required to apply a label or data plate.

Limitations:

The marking process is extremely slow, with throughput often expressed by the number of minutes required to produce a symbol. Thermal-transfer printers, in contrast, can generally output several labels per second. Although there are no supplies to manage with DPM, waste can be an expensive problem. If the symbol is applied incorrectly or is unreadable, it's the item that is wasted, not an inexpensive label or data plate. Because of these limitations and high equipment costs, DPM is used very selectively and should be considered the marking method of last resort.

The following chart summarizes the equipment and operating costs for UID marking methods.

Relative Costs of In-house UID Marking Methods

Marking Method	Equipment Cost	Cost per UID Marking
Thermal-transfer label printing	$2,000 printer + $700 software	$0.05 polyester label;
		$0.05 resin ribbon
Data plate—plastic	$5,000	$0.50 plate
Data plate—metal	$20,000	$0.50 plate
DPM—ink jet	$10,000	$0.50 mark
DPM—chemical etching	$2,000 printer + $300 chemtech	
	+ $700 software	$0.50 mark
DPM—dot peening	$10,000	$0.10 mark
DPM—laser bonding	$15,000	$0.30 mark
DPM—laser etching	$25,000	$0.20 mark

1. Office of the Under Secretary for Defense Acquisition Technology & Logistics report "Cost Benefit Analysis of Unique Identification (UID)," March, 2005.

Thermal-transfer printers are highly valued for IUID marking because they create quality Data Matrix symbols on very cost-effective media. There are many models available, and the variations among them often result in major differences in total cost of ownership and the value the print system provides. The following sections explain key printer features and performance capabilities and how they relate to marking operations. This information will help you understand your specific print systems requirements so you can select printers that meet your needs most efficiently.

Print Method

The term "thermal printers" is commonly used as a catch-all to describe direct-thermal and thermal-transfer models. Thermal printer manufacturers often offer direct-thermal and thermal-transfer versions of the same base model. Thermal-transfer should always be selected for IUID printing. It provides superior long-lasting images and is the preferred method for lifetime identification in multiple industries and industrial environments.

Media Compatibility

Label material and ribbons should be matched to the specific printer make and model for optimal bar code quality and printer performance. Bar code printing solution providers can recommend printer-media-ribbon combinations based on the item to be marked, the labeling process, and the item's storage and usage conditions.

Thermal-transfer printers and supplies are not fully interchangeable. When evaluating printers, it is important to determine if they can accommodate the media sizes required for labels. It is also imperative to make sure the printer vendor can supply label stock with the required heat, chemical, and abrasion resistance in the correct sizes.

The problems that result from using non-optimized media are not always immediately apparent. The greatest danger is that the Data Matrix symbol will fade over time and become unreadable. Label adhesives and protective coatings may also fail. Incompatible media can also cause the thermal printhead to work harder and lead to premature failure. These problems more than offset any money that might be saved by trying to use incompatible or bargain media for IUID printing.

To ensure optimum performance, Zebra Technologies offers extremely durable label synthetic materials designed to provide lifetime identification even for items exposed to challenging, hazardous environments. Zebra's UID supplies solutions are independently tested and certified to meet the DoD's requirements for UID labeling under MIL-STD-130, MIL-STD-129, and MIL-PRF-61002A.

Performance

Many printers can't produce variable-data Data Matrix symbols at the top-end print speeds listed on their spec sheets. It is important to test printers to ensure they can meet your label throughput requirements, especially for high-volume printing and when automatic label applicators are used. The printer's onboard processor, available memory, plus the labeling software and host IT system all impact throughput.

Symbol size and print resolution also differentiate printer performance. The standard resolution for most thermal-transfer printers is 203 dots per inch (dpi), which is sufficient for most IUID labeling needs. Some printers offer resolution of 300 dpi or higher, and there is a misperception that 300-dpi is the minimum resolution required to produce Data Matrix bar codes at small sizes. Higher-resolution printheads are available as options, but this adds to the printer cost. The potential added cost should be factored when comparing printers. Testing will determine which printers and printhead resolutions can satisfy an organization's specific UID marking needs. As a rule of thumb, 300-dpi resolution for thermal printers is not necessary unless the Data Matrix symbol is smaller than a quarter inch square. For generating an A-rated 2-D bar code in a small size, Zebra Technologies offers thermal-transfer printers with options for 300-dpi and 600-dpi printing. Laser printers should have higher than 300 dpi resolution even for larger Data Matrix symbols because of how they produce individual elements.

Ease of Use

Printer design and management capabilities determine the amount of time and labor required for operation, and therefore are important components of total cost of ownership. IUID labeling will be a mission-critical operation for many DoD contractors. Printer downtime is a potential business disruption. Printers that enable operators to easily load labels, change ribbons and clear simple errors promote productivity and reliability. Thermal-transfer printers may also have features that simplify management and maintenance tasks for system administrators. Advanced models can issue proactive notices when media is running low and send instant alerts for error messages or if printing is stopped for any reason. Administrators can take advantage of networkable printers that support remote configuration to perform troubleshooting and upgrades from a central location. These features save considerable labor time, minimize downtime and help organizations get the most from their printer assets.

Host System Compatibility

Remote management is only one of the ways connectivity support impacts printer value. Printers with native support for enterprise standards for networking, security, host computer platforms, ERP, database, and other software applications prevent the need for custom development and enable easy-to-maintain printing architectures. Host compatibility is especially important for UID operations, because data for the IUID label may be shared with applications for Wide Area Workflow reporting or DoD-compliance case and pallet labeling.

A single printer can often produce case, pallet and UII labels, including radio frequency identification (RFID) smart labels that the DoD is requiring of its suppliers. Organizations should consider their current or future RFID labeling requirements while planning their UID systems. It may be practical to select a printer that can be upgraded for RFID smart label encoding. This approach will meet UID requirements and support future needs without causing the organization to purchase additional printers. Visit www.rfid.zebra.com for more information about smart label printing (including the variety of RFID printer/encoders and upgradeable RFID Ready printers available through Zebra) and DoD programs.

Conclusion

In most cases, thermal printers are the easiest and most efficient option for IUID printing. They are the leading choice for bar code printing throughout many industries and excel at producing Data Matrix symbols for use in challenging environments. Thermal bar code label printers and RFID smart label printer/encoders provide an opportunity to improve business-process efficiencies as well as meet the UID mandate. DoD contractors with ongoing labeling needs should commit to taking control over their IUID marking operations by implementing an in-house thermal printing system.

In-house printing is the best long-term IUID marking solution. Printers that support an organization's operational needs and IT infrastructure provide the most value and superior total cost of ownership. Media support, throughput, connectivity, and ease of use should be carefully considered when planning a UID labeling system.

Zebra Technologies Corp. (NASDAQ: ZBRA) is a leading provider of thermal printing solutions and offers a broad range of printers, supplies, software, and connectivity tools to support IUID labeling. Zebra delivers innovative and reliable on-demand printing solutions for business improvement and security applications in 100 countries around the world. More than 90 percent of Fortune 500 companies and many government agencies use Zebra-brand printers. A broad range of applications benefit from Zebra-brand thermal bar code, "smart" label, receipt, and card printers, resulting in enhanced security, increased productivity, improved quality, lower costs, and better customer service. The company has sold more than six million printers, including RFID printer/encoders and wireless mobile solutions, and also offers software, connectivity solutions and printing supplies. Information about Zebra® bar code and RFID products can be found at www.zebra.com.

Additional Resources

There is a wealth of resources available to provide background on the UID program, how to create UII numbers, marking options, relevant standards documents, and more. The best place to start is the UID program Web site, www.acq.osd.mil/dpap/pdi/uid/index.html. Also be sure to visit www.zebra.com/uid or call Zebra's UID hotline at +1 866 515 2488.

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