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Special
SCAN: The DATA CAPTURE Report
Reprint

Here Comes The Judge...The 2D Judge™

PIPS, Inc. selected by GS1 US to produce Data Matrix conformance test cards and operate the 2D Judge™ high-resolution metrology instrument.

The technical side of the AIDC industry recently achieved a new milestone—the announcement and delivery of the 2D Judge, which, simply put, provides a way to verify 2D verifiers. **Product Identification & Processing Systems, Inc.** (**PIPS**) has been awarded a multi-year contract by **GS1 US** to manufacture its next-generation calibrated conformance standard test card (CCSTC) for use with Data Matrix and other 2D symbologies. The contract also calls for PIPS to operate, maintain, and help to further develop the 2D Judge.

In a recent interview with George Wright IV, vice-president of technology and business development at PIPS, he explained that the 2D Judge is a unique, high-resolution imaging system used to precisely measure and certify the reflectance and dimensional accuracy of bar codes on calibrated conformance standard test cards. These cards are used to calibrate and test verifiers for conformance to ensure accurate, repeatable grading. The Data Matrix two-dimensional (2D) bar code CCSTC is the first of a series of expected test cards of a variety of symbologies that will be certified by the 2D Judge.

George Wright IV, vice-president of technology and business development at PIPS,

"PIPS has lobbied for more than five years on behalf of 2D bar code users in every market sector for the development of 2D bar code conformance test cards and a suitable metrology device to certify them," said Wright. "We worked closely with GS1 US, **Ohio University**, **Pitney Bowes**, and other members of a consortium working on the project. PIPS made important contributions to the development of the Data Matrix test card and to the 2D Judge **National Institute of Standards & Technology** (**NIST**)-traceable metrology system itself. These contributions, and our history of supporting and implementing rigorous, standardized linear and 2D bar code verification systems for more than 15 years, were key factors in the GS1 US decision to award the contract to PIPS."

CCSTCs have reference bar code symbols of exact dimensional and reflectance values. The 2D Judge combines a high-resolution digital camera and telecentric lens with image analysis and symbology decode algorithm software faithful to the ISO/IEC

standards for Data Matrix, 2D bar code verification methodology and bar code verifier conformance. The calibrated cards are sold by GS1 US to verifier manufacturers, resellers and users of bar code print quality verifiers, who use them to challenge their instruments and determine whether they are accurate. If the verifier reports symbol quality grades for the symbols on the CCSTC beyond the allowed tolerances, then corrective action must be taken. This may be as simple as recalibration of the verifier. Or, the verifier may need to be repaired or replaced.

[*Editor's note: Cards are serialized and have a two-year in-service life.*]

The 2D Judge and Data Matrix CCSTC development project was sponsored by GS1 US under the direction of Rich Richardson with volunteer support from an ad hoc work group of **AIM's** Technical Symbology Committee (TSC) under the chairmanship of Sprague Ackley of **Intermec**. The 2D Judge robotic image capture system was built at Ohio University's AIDC Lab by director Kevin Berisso, PhD.

The original "Judge" was several years in the making, but has withstood the test of time.

The 2D Judge image analysis and decode algorithm software was developed by technologists at Pitney Bowes under the leadership of principal scientist Claude Zeller, PhD. Wright served on the AIM ad hoc work group and was a principal architect of the Data Matrix calibrated conformance standard test card. Major bar code verifier manufacturers and other technologists on the ad hoc team also contributed.

An interesting history

The 2D Judge didn't just appear out of the blue. Long ago, the AIDC industry realized the need for a way of verifying verifiers for linear (1D) bar codes. "The linear bar code industry suffered for years," Wright told *SCAN/DCR*. "There was simply no way to accurately confirm that verifiers were doing their job properly. Then, Sprague Ackley, a young and talented engineer at Intermec, decided to tackle the problem."

Reminiscing, Ackley told *SCAN/DCR*, "In early 1985, David Allais, then president of Intermec and my boss, asked me how to solve the problem of commercial verifiers. The problem was getting repeatable results and having those results correlate with scanning performance. I suggested off the top of my head that all we needed to do was to create a device that was 10 times more repeatable than commercial verifiers. He encouraged me to do exactly that and we gathered all the printing and scanning experts at Intermec to analyze existing measurement methods and to generate a recommendation.

"It was no easy task," Ackley continued. "I worked on this

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project for over a year trying to develop a machine to meet the requirements we had set for ourselves. **CodeScan** had developed a device to measure the width of the bars in a bar code, but it did not measure predictability of scans. The **Symbol Technologies** LaserCheck was performing statistical scans to prove bar codes were accurate. A 100 scans would be made to see if the results were the same. We needed something much more accurate. After more than 12 months of work, I came up with a method that would identify any errors up to one six-millionth of an inch."

Sprague Ackley, Intermec Technologie, AIDC 100 charter member.

Ackley, serving as a historian of sorts, outlined the following milestone chart in the development of The Judge:

■ 21 August 1985 - Intermec Measurement Task Force publishes a design for a "Measurement Machine" which should be capable of making bar code symbol measurements that were 10 times more repeatable than commercially available verifiers. The optics consisted of a simple one-to-one projected aperture scanner with a 16-bit A/D converter for the voltage and a laser interferometer to measure position. The device turned out to be a very high-resolution scanning microdensitometer with a part cost of about $30K.

■ 27 January 1986 - Begin assembly of components.

■ 6 August 1986 - First software written to calculate edge positions on scan profiles covering five edges. Because initial measurements of element widths showed the bars to be about 20% bigger than the spaces, I was encouraged to continually "fix" the machine. This constant refinement to lower the noise never changed the original result, which is that the bars are bigger to a scanner than to the naked eye (i.e. measurements made on an optical comparator). The net result was a machine that exhibited typical element-width repeatability with a standard deviation of 8 millionths of an inch.

■ 30 October 1986 – "Edge Finder" software finds profile edges using four different methods.

■ 10 February 1987 - First meeting of the **ANSI** X3A1.3 ad hoc committee. The meeting was held in Dayton, OH at **Monarch Marking Systems** and established a first goal of determining where the edge was. The ad hoc continued to meet about every two months. Machine and software development proceeded at the direction of the ad hoc.

■ 22 October 1987 - The "Edge Finder" software stabilizes around the "float" algorithm and work on ANSI X3.182 contrast begins. The software is whimsically renamed "The Judge".

■ 30 June 1988 - "The Judge" software version F2RevH is published which includes the final algorithms to be used in ANSI X3.182.

■ 7 November 1990 - "ANSI X3.182 Bar Code Print Quality Guideline" is published with the following special task force members credited: "H. S. Ackley, G. Ahlquist, C. E. Biss, M. Brosnan, A. Gilligan, M. Hileman, A. Longacre, P. J. Traglia, N. R. Weiland, and R. Ulinski." They were Gary Ahlquist of **Kodak**, Chuck Biss of **PSC**, Mike Brosnan of **HP**, Allan Gilligan of **AT&T**, Marty Hileman of **Standard Register**, Andy Longacre of **Welch Allyn**, Pat Traglia of **IBM**, Norm Weiland of **Monarch Marking**, and Richard Ulinski of **RJS**.

■ 2 April 1993 – **Uniform Code Council** (**UCC**—now GS1 US) Measurement Machine process documented. "The Judge" version F2RevQ published and machine delivery completed to **Applied Image** in Rochester, NY.

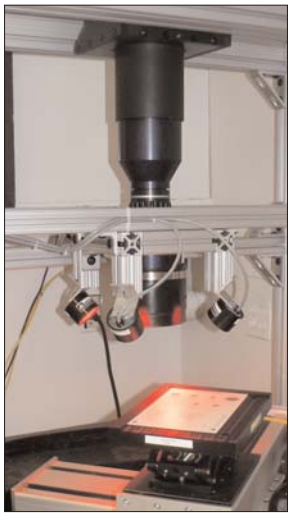
■ 19 October 1994 – "UCC Quality Specification for the U.P.C. Printed Symbol," including a reference decode algorithm and a measurement method based on the ANSI X3.182 process, is published.

■ 15 August 2000 - "ISO/IEC 15416 Information technology - Automatic identification and data capture techniques - Bar code print quality test specification - Linear symbols", which employs a nearly identical method to ANSI X3.182, is published and remains today the sole method in the world for evaluating 1D bar code print quality.

"On the topic of problems with bar code print quality verification in the years following the introduction of verifiers and the development of what became known as calibrated conformance standard test cards, in the August 1993 issue of *SCAN Newsletter* (forerunner of *SCAN: The DATA CAPTURE Report*), the late editor George Goldberg wrote:

"Although there was no common standard available, the verifiers generally conformed to published specifications for symbologies...and while it was generally recognized that the

verifiers were imperfect—results often varied from device to device, certain inks and substrates caused problems—in general, checking a bar code after printing achieved the desired results: poorly printed symbols were isolated and the causes of the problems were usually identified." Quoting Hal Juckett, executive secretary of the Uniform Code Council, "the Council has spent 'hundreds of thousands of dollars' in a program...to develop special targets to be used as a common benchmark or standard by all UPC verification manufacturers."



The new "2-D Judge" will solve a verification problem that has hampered 2-D symbology use for a decade.

These targets are calibrated conformance standard test cards, which today are still the accepted means by which a bar code verifier is judged to be accurate and in conformance with ISO/IEC specifications." [*end SCAN Newsletter quote*]

"This was such a fun project," Ackley confided. "We started with a blank slate…no one knew the answer to the problem. You had all these great minds working together. And, our work [The Judge] has certainly withstood the test of time."

The CCSTCs

Both Ackley and Wright are what we refer to as "techies." They can tear apart any symbology and have fun doing so. You can hear it in their voices when they stroll down memory lane and talk about things that happened more than 20 years ago. They were almost sentimental when telling us about how the CCSTCs were created.

"These cards were hand mastered," said Ackley. "They were incredibly beautiful cards." Wright added, "There are 4-6 symbols on the linear symbologycards, and each CCSTC cost hundreds of dollars. But, these cards have proven invaluable over the years. The new 2D cards are sure to become equally indespensible to good bar code quality assurance procedures."

Major contributions

As it can be seen from Ackley's milestone chart above, the contribution to the original Judge was immense and from a wide variety of companies and engineers. Of course, all this help lead to the development of the 2D Judge.

"...each CCSTC cost hundreds of dollars. But, these cards have proven invaluable over the years."

"Our industry has been hampered for over a decade by the lack of a Judge-like device for Data Matrix and other 2D symbologies," said Wright. "GS1 US really stepped up to the plate and invested six figures toward the development cost of the 2D Judge project. It must also be noted that Pitney Bowes-a leader in global mailing applications that use Data Matrix symbologies-contributed huge amounts of IP in Data Matrix decoding software. Without its contributions, hard dollar development costs for the 2D Judge could easily have tripled. This is a huge gift."

Closing

Wright, who is also a member of AIDC 100 and a GS1 US certified bar code consultant concluded, "PIPS is proud of the contributions we made to the development of these long-awaited bar code quality assurance tools and to have had the privilege of working with the talented and dedicated people and organizations that made the project a success. It is an honor to house the 2D Judge and provide CCSTCs on behalf of GS1 US."

Comment: We want to thank Wright and Ackley for sharing their years of wisdom with us. These are two men who truly fall into the category of "pioneers." They have made huge contributions to the AIDC industry and made our trip down memory lane a rewarding experience.

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