The Global Language of Business

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1 Introduction

Globally, stakeholders are transitioning to 2D barcodes that contain more data encoded in different syntaxes at a rate never before seen. Details on scanning system capabilities and best practices are currently unclear. Unbiased, independent data is required to support improving this understanding and answer key questions that are critical to users looking to implement scaled, interoperable solutions to leverage 2D barcodes.

GS1 is conducting tests to quantify the performance of 2D barcodes in retail point-of-sale (POS) scenarios, using both GS1 syntaxes (i.e., plain, GS1 element string, GS1 Digital Link URI) and non-GS1 encodings (e.g., unformatted data, generic marketing QR Code with a URI, etc.).

The University of Memphis Automatic Identification Lab has been engaged to conduct this unbiased, independent testing using robotic equipment and representative POS scanners. To establish common baselines of performance and unbiased test data, a series of tests were performed on a variety of barcodes to understand how they scan. The first tier of testing focused on barcodes with only a Global Trade Item Number (GTIN) contained within them, to compare against current EAN/UPC scanning. Barcodes containing GTIN with additional data elements will be tested in Tier 2 of the test plan. These tests assess the impact of including additional data that will unlock many of the use cases enabled by 2D barcodes. All tiers of testing analyse variables including barcode orientation, barcode print technology, speed, angle and distance from the scanner. This report is the full Tier 1 test results.

2 Executive summary

This 2D in Retail - Tier 1 scanner test report is the result of the collaborative efforts of printing and scanning solution providers, the University of Memphis and GS1. These scanner tests are designed to support solution providers preparations for the future when retailers welcome multiple types of barcodes through the POS. This comprehensive Tier 1 baseline testing of scanning ability of 1D and 2D barcodes that contained only the Global Trade Item Number (GTIN) data were executed in a lab environment. This testing was performed on five commercial retail point-of-sale (POS) systems from four different manufacturers. Tier 1 testing will lay the groundwork for initial scanner improvements and answer the following questions:

- How quickly can different barcodes be scanned with accuracy?

- Can 2D barcodes (e.g., QR code and Data Matrix) encoded with GTIN be scanned at retail check speeds (40 IPM)?
  - The results proved that in a controlled environment 2D barcodes encoded with only GTIN can meet today's retail requirement of ~40 items per minute. All 2D can be scanned with accuracy, however as the barcode traversing speed increases the scan rate for 2D is lower than the scan rate for 1D. This make sense, as scanner manufactures having been optimising 1D scan algorithms for over 45 years.
- How does the number of barcode decode algorithms that are switched on (barcode types turned on in a scan engine) impact relative scanning performance?
  - Testing showed that barcode direction and the number of barcode types (decode algorithms) enabled does not adversely affect scanner throughput on the tested barcodes, as seen by the average decode time per scanner readings having no significant increase in time.
- Is GS1 guidance for 2D barcode's quality and size appropriate for imaged-based bi-optic POS scanners? See GS1 General Specification Section 5.12 Barcode production and quality assessment
  - The testing showed that the current GS1 standards for barcode dimensions work with a representative sample of today's most popular scanning systems.

The next two tiers of testing will answer these additional questions:

- How does encoded data (amount, type) impact scan speed and accuracy?

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- If there are multiple barcodes on a pack (such as an EAN/UPC and a QR Code), how well do scanning systems find the right information they need?
- How should barcodes be placed in relation to each other for optimised scan results?

Important: The solution providers, the University of Memphis and GS1 all agree that retail store pilots are needed to continue the learning and vetting of POS scanner improvements.

3 Methodology

This section outlines the process followed in the development and execution of the testing.

The primary considerations made during the test design include:

1. The Tier 1 group of barcodes encode only the GTIN in the format required by the symbology and syntax. Barcodes were printed on standard width 4X3 inch labels using known major production printing technologies
   a. Continuous ink jet (CIJ)
   b. CO^2 laser
   c. Thermal ink jet (TIJ)
   d. Thermal transfer (TT)
   e. High resolution laser jet
2. Use of current generation retail scanners. All scanners were set to factory defaults settings
   a. Datalogic
   b. Honeywell
   c. NCR Realscan 7879
   d. Zebra

   Note: In this report the scanners are given Greek aliases (Alpha#. Beta#, Delta#, …)
3. Data must be as statistically robust

3.1 Test profile overview

Tier 1 test scenarios (called 'profiles' within this document) were determined using a series of beta tests, historic tests, GS1 specifications, including barcode size, quality, test velocity, distance from the scanner surface, rotational and angular distances and other parameters. Twenty-three test profiles were designed to understand how barcodes would be read when the parameters were altered.

The variation of parameters in the test setup and the varying of barcode characteristics are both important to understanding how a range of barcodes will perform outside of the lab environment. Below is an outline of the parameter variations that were used in the Tier 1 testing. A detailed spreadsheet of the barcodes is available as an appendix to this report. (see section 6)

Test profiles were varied in:

1. Distance (~25, 55, 85 mm from scan horizontal and vertical surfaces)
2. Speed (from 150 mm/s to 1,200 mm/s)
3. Pause (traverse @ 1500mm/s with 0.250s stop)
4. Tilt angle from horizontal (0,30,45,75,90)
5. Clockwise rotation in plane (0, 45, 90, 180)

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6. Activated symbologies
    a. 1D barcodes only (EAN-13, EAN-8, UPC-A, UPC-E, GS1 DataBar Omnidirectional)
        i. Stage 1: EAN/UPC, GS1 DataBar Omnidirectional
    b. 1D and 2D barcodes (EAN-13, EAN-8, UPC-A, UPC-E, GS1 DataBar Omnidirectional, GS1 DataMatrix, GS1 QR Code, Data Matrix (GS1 DL URI) QR Code (GS1 DL URI))
        i. Stage 2: EAN/UPC, GS1 DataBar Omnidirectional, Data Matrix and QR Code
        ii. Stage 3: EAN/UPC, GS1 DataBar Expanded Stacked, GS1 DataBar Omnidirectional, Data Matrix, QR Code, ITF-14, PDF417, Code 128, ISBN, watermark

Barcodes varied by:

1. Symbology
2. Data encoded
3. X-dimension
4. Print technology used to produce
5. Print quality (various levels of contrast)
6. Error correction level (for QR Code only)

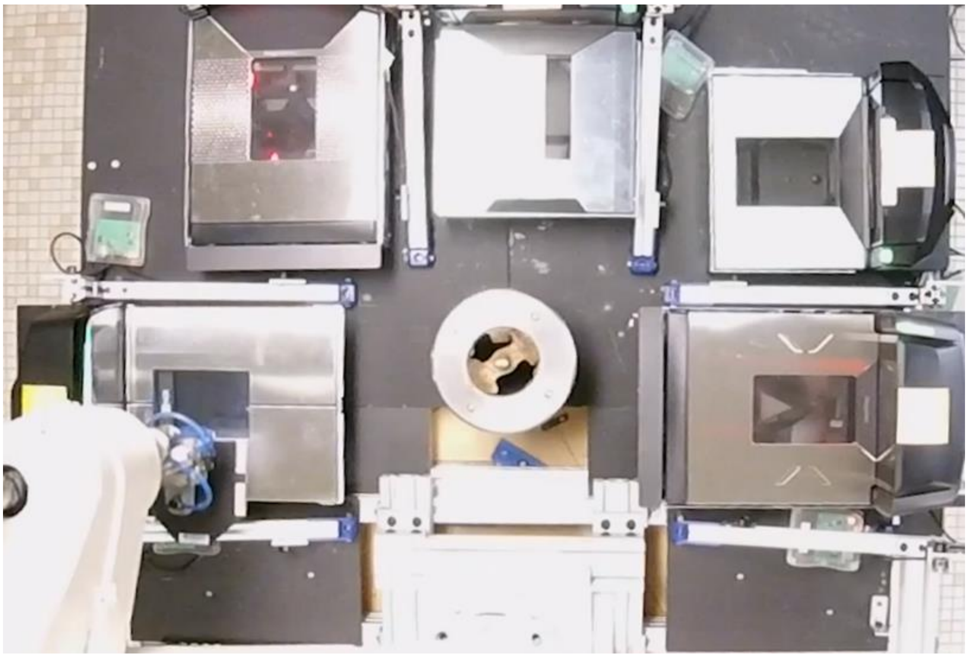
3.2 Test rig design

A test rig was constructed with a robotic arm. Five tabletop imager-based scanners were used for the test.

Custom Microsoft .NET software and a simple database were developed for collecting scan data. All scanners were configured with physical RS-232 serial connections and a computer with multiple serial ports.

To address timing requirements, photoeye sensors were tied to a programmable logic controller and the custom software was configured to capture the photoeye events. The leading edges of the scan windows and sensors were optimised for each scanner/sensor combination. Finally, the scan path for the samples was adjusted to comply with specific test profiles.

Figure 3-1 Scanning setup with robotic arm and POS scanners



3.3 Sample preparation

All test barcodes were mounted on fibre-board test cards. Unique identifiers were associated to each barcode to allow for the definitive identification (ID) of the test cards themselves. Barcodes were verified to report their print quality of the for correlation with scan results. (see section 7)

Figure 3-2 Example of barcodes on test cards

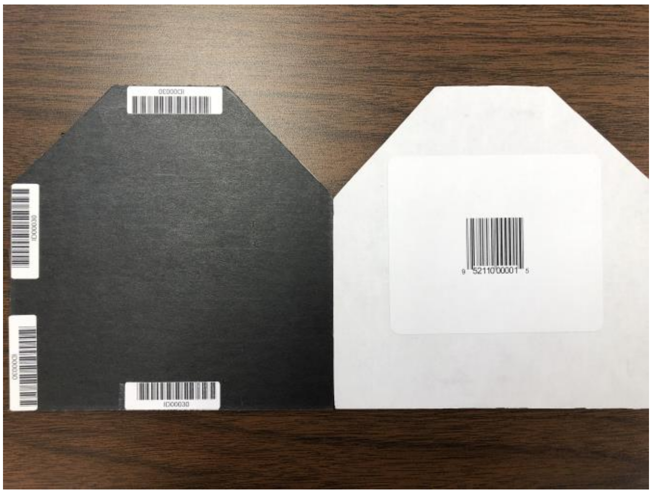


Figure 3-3 Example of barcodes on test cards

3.4 Testing process

Testing was conducted by a single robot that would pick up each single carrier, scan the unique identification on the card, and then pass the symbol over each of the five bi-optic POS scanners.

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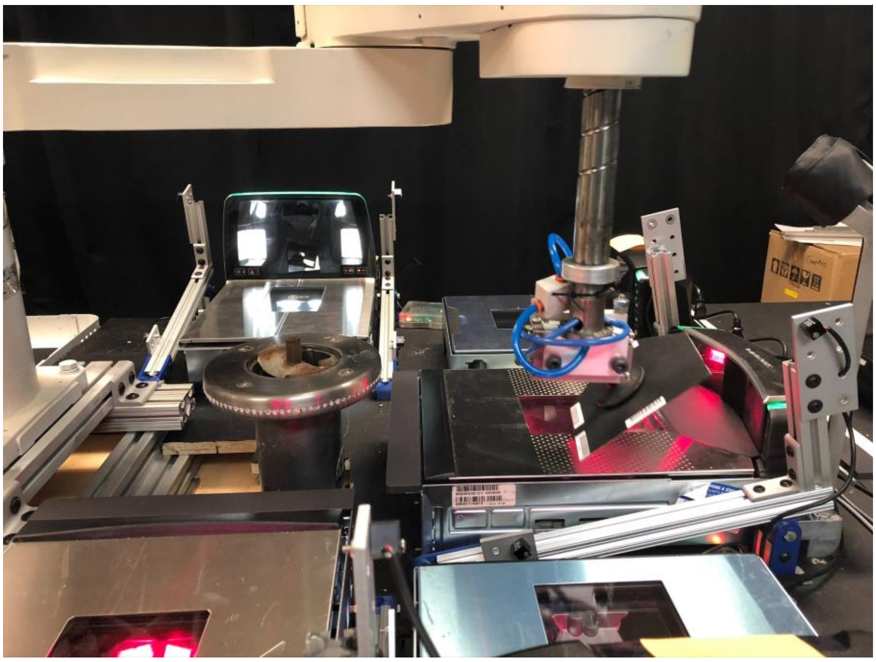
Scanning speed was maintained by the robot and the scan path was repeatable to within about 0.01mm at any given point. The robot ran at the defined speed required for each test profile. All samples were ran between ten and fifty times for each test scenario, to maximise our ability to analyse the resulting data and to ensure that we could identify any anomalous runs.

Figure 3-4 Presentation scanner with card presented at 45° angle from horizontal



The programmed robot was responsible for managing the test profiles, including card pick-up, rotation and tilt angle. Optical photoeye sensors detected the card entering the scanner and triggered the data acquisition system timer.

The scan count, scan time (time from trigger to data transmission time) and scanner decode data was all captured. Decoded data was compared to the expected data, based on the identification of the test card's carrier ID. All data was stored on test lab local servers, to avoid some of the effects of the limitations defined below in the next section.

3.5 Limitations

There were two sources of uncertainty within the system as it was deployed for this test. If/when this testing is expanded or repeated, these items should be addressed.

- It was determined that, when the PC doing the data collection was connected to the university network, there were occasions where the network traffic and/or the inherent latency that Windows imparts resulted in the occasional loss of photoeye trigger event.
  - Within a cycle of only 1,000 scans this seemed, on average, to cause two or three lost events.
  - However, even this small number of events may have been the cause for less than 100% first pass read rates.
  - Post-hoc testing showed that the lost events did not distribute evenly, which made it difficult to quantify the impact of the PC being connected to the university network.
- The level of inconsistency in symbol positioning on the test cards.
  - When initially viewed, it seemed that the location of the barcodes on the carriers was sufficiently consistent and any variation that existed would be absorbed by the individual scanner's fields of view.

- However, simple post hoc testing/analysis showed that shifting the symbol did in fact seem to impact the first pass read rates for a limited number of barcodes, implying that if/when this testing is done, or even if similar testing is done, that much more attention will need to be paid to the location of the barcodes on the test cards.
- A smaller card design will be used in the Tier 2-3 tests.

Important: Despite the issues mentioned above these limitations did not impact the output of Tier 1 and the results maintain integrity and statistical relevance.

4 Test results and observations

Over 45 years of EAN/UPC scanning history and scan algorithm optimisation was clearly evident in the strong results for all 1D barcode decoding:

- EAN-8, EAN-13
- UPC-A, UPC-E
- GS1 DataBar Omnidirectional

With few exceptions, all 1D barcodes decoded correctly on all tests. Bi-optic scan algorithms have been optimised to be capable of decoding a small sliver of a 1D barcode with very high rates of success.

Scanners need to see complete 2D barcodes to decode them reliably. The 2D barcodes tested in Tier 1 were:

- GS1 DataMatrix (GS1 element string syntax)
- GS1 QR Code (GS1 element string syntax)
- Data Matrix (GS1 Digital Link URI syntax)
- QR Code (GS1 Digital Link URI syntax)

In addition to analysing read rates, the tests were designed to understand whether translation between data syntaxes (e.g., GS1 Digital Link URI data structures to GS1 element string syntax) adversely effected the relative scanner decode time. Two scanner manufacturers provided a first iteration of a GS1 Digital Link URI parser/translator. For the systems of these two scanner manufacturers, 2D barcodes were translated correctly on all tests whenever the barcodes were successfully decoded, regardless of translation between syntaxes being part of the process or not.

Both 1D and 2D scan rates dropped as speeds increased beyond 400mm/s-600mm/s. At 1200mm/s. 1D scan rates were in the 70% range and 2D scan rates were in the 45% range. The higher velocity range is far above the industry Item Per minute rates and also far above the Guinness World Record for the fastest time to scan and bag 50 items by a team of two, which is 48.15 seconds, or ~62 IPM, achieved in 2014. If the 1D or 2D barcode tests are limited to those speeds that are considered normal (or best-in-class) retail scan speeds, the scan rates are between 90%-100% for all Tier 1 barcodes.

All 1D barcodes were decoded faster than any 2D barcode. The processing speed for decoding is expected to be faster for 1D barcodes than for 2D barcodes, as the processing times are closely tied to the level of scanner decoding algorithm optimisation. It should be noted that QR Codes decode times were only ~100 milliseconds (ms) slower than 1D decode times, which is likely attributable to the barcode's prominent finder pattern. In contrast, the decode times for Data Matrix symbologies were ~150 to 200 ms slower than the decode time for 1D symbologies. In the most fast-paced environments, when scanners are equipped with newly-developed decoding algorithms, these decode processing times for Data Matrix codes may create throughput challenges. Over time, decoding algorithm optimisations are expected to reduce the decode processing times required for all 2D symbologies.

We have heard a concern expressed by some constituents that an increase in the number of barcode decoding algorithms that are enabled on a scanner could slow down processing speeds of the POS scanner. In these Tier 1 tests, we did not find a correlation between the number of decoding algorithms that were enabled and the decode time of the barcodes under test, even with

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fourteen barcode decoding algorithms enabled at the same time. This is not to say that these results will be repeatable when the tests become more complex (e.g., with multiple symbols, etc).

As noted earlier, two scanner manufactures delivered a GS1 Digital Link URI ←→ GS1 element string solution for GTIN-only encoded barcodes. The ability for the scanning system to do this translation is important to retailers, as it removes the requirement to make any changes to the POS backend systems within a particular retail environment. The GS1 Digital Link URI ←→ GS1 element string conversions has three steps:

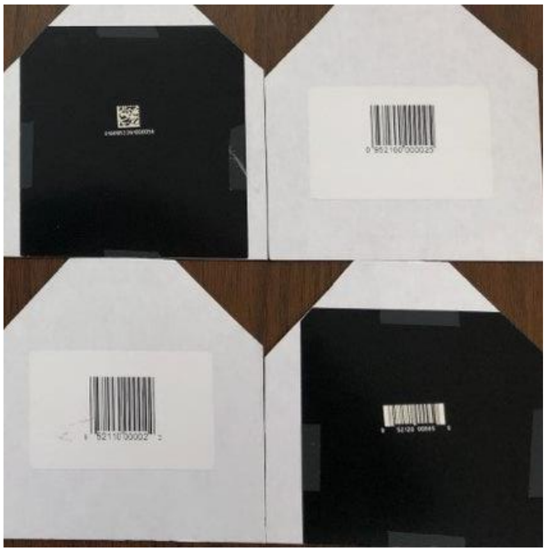
1. GTIN-only conversion
2. GTIN plus attribute data
3. Co-located barcodes

No appreciable delay was identified between units with the GS1 Digital Link URI parser/translator and those without.

All barcodes were created to meet the GS1 General Specifications barcode quality standards. The X-dimension (i.e., bar or module size) was varied with in the tolerances of the standard. Both 1D and 2D barcodes from minimum to maximum X-dimension as prescribed in the GS1 General Specifications decoded correctly on all tests. This is an important milestone in 2D scanning on bi-optic POS scanners. It is also an important leading indicator for future work that might allow for reduction of the minimum X-dimension on 1D barcodes that are allowed in the GS1 General Specifications.

Printing technologies were varied across the tests, to produce a representative population of the types of print technologies that are currently scanned in retail environments. All printing technologies could produce a code that could be decoded by bi-optic scanners.

Figure 4-1 Example of reverse reflectance test cards

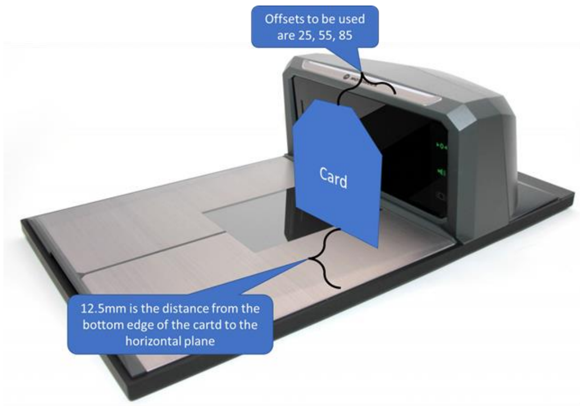


One scanner had issues decoding the reverse reflectance test symbols (i.e., white on black) that were generated by laser printing.

Continuous inkjet-printed symbologies performed marginally lower, which is likely the result of lower resolution and round module generation (i.e., ink drop design), both which are known as characteristic of this printing technology.

The minimum and maximum horizontal and vertical offset did affect scan rates for most barcodes. It is expected for scanning systems to be challenged with barcodes at the outer limit of their focal distance, however the observed challenges of scanning at the minimum horizontal distance were unexpected. The primary reason for the scanners not decoding the "close up" barcodes is the position of the barcode. The barcode test card design caused the barcode to be close to the upper edge of the bi-optic scanners vertical camera. This is an important finding and fact that will feed into the 2D in Retail mission specific work group's work on barcode location.

Figure 4-2 Vertical offset reference



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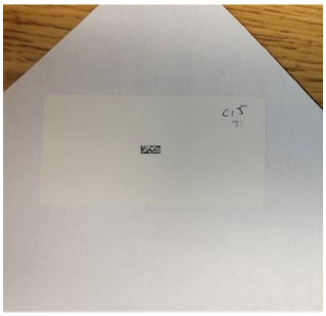
The barcode test card scan rate was affected by the card velocity, offset distance and tilt angle (e.g., there were maximum speeds, distances and tilt angles that resulted in performance drop-offs). In contrast, barcode direction or the barcode test card rotation in plane had no appreciable effect on the scan rate. The minimum and maximum horizontal and vertical distance did affect scan rates for most barcodes. The maximum scanning distance is not a common practice in real-world retail environments and was expected to be challenging with barcodes at the outer limit of their focal distance. The minimum horizontal distance was unexpected. The primary reason for the scanners not decoding the "close up" barcodes is the position of the barcode. The barcode test card design caused the barcode to be close to the upper edge of the bi-optic scanners vertical camera. This is an important finding and fact that will feed into the 2D in Retail Mission Specific Work Group's barcode location discussions.

Figure 4-2.1 Rectangular GS1 DataMatrix card location



Barcode test card tilt angle was determined to be impactful to scan rates, with larger angles reducing the scan rate for all the bi-optic scanners under test. Interestingly a 30-degree tilted barcode caused the largest reduction in scan rates for most scanners.

4.1 Items per minute (IPM) data subset

Based on a scan of available data, GS1 estimates that a range of 40 IPM to a maximum of 60-70 IPM is a very robust estimate of practical scanning speeds in store. Using 70 IPM and assuming the average item size + a practical scanning gap of 250mm, the resulting barcode/package velocity is ~315mm/s. At the low end of the range (40 IPM), the resulting barcode/package velocity is ~167mm/s.

Within these speed ranges, the scanners all performed extremely robustly on both 1D and 2D symbologies.

The robotic cell manages the barcode test card velocity as it traverses across the bi-optic scanners. The IPM calculation assumes the barcode test cards are presented in a back-to-back manner, as could happen in a typical retail environment. All tests assume a minimum gap between products of 250mm (average distance to scan window + barcode location on product), which is seen as a very robust and aggressive estimate of throughput.

Relating speed of the robot (mm/s) to IPM calculations (IPM), the following reference table is established:

- 150mm/s → 36 IPM
- 300mm/s → 72 IPM
- 400mm/s → 96 IPM
- 600mm/s → 144 IPM
- 800mm/s → 192 IPM
- 1200mm/s → 288 IPM
- 1500mm/s + 250ms (0.25 seconds) pause between products → 240 IPM

Within normal retail speeds and when barcodes pass directly in front of the scanner's camera surfaces, the result shows acceptable scanner performance for both 1D and 2D barcodes, as shown in Table 4-1 below.

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Table 4-1 Average retail IPM scan rate in percentage

Bi-Optic Scanner	Horizontal plane			Vertical plane		
Barcode type	36 IPM 150mm/s	72 IPM 300mm/s	96 IPM 400mm/s	36 IPM 150mm/s	72 IPM 300mm/s	96 IPM 400mm/s
EAN-13	100	100	100	90	90	98
UPC-A	97	95	91	90	90	90
GS1 DataBar	100	100	98	90	93	96
GS1 DataMatrix	99	89	87	97	91	86
GS1 DataMatrix Rectangular	99	92	84	96	93	87
GS1 QR Code	98	91	89	99	93	88
Data Matrix (GS1 DL URI)	97	91	85	99	91	83
QR Code (GS1 DL URI)	95	85	80	93	84	79

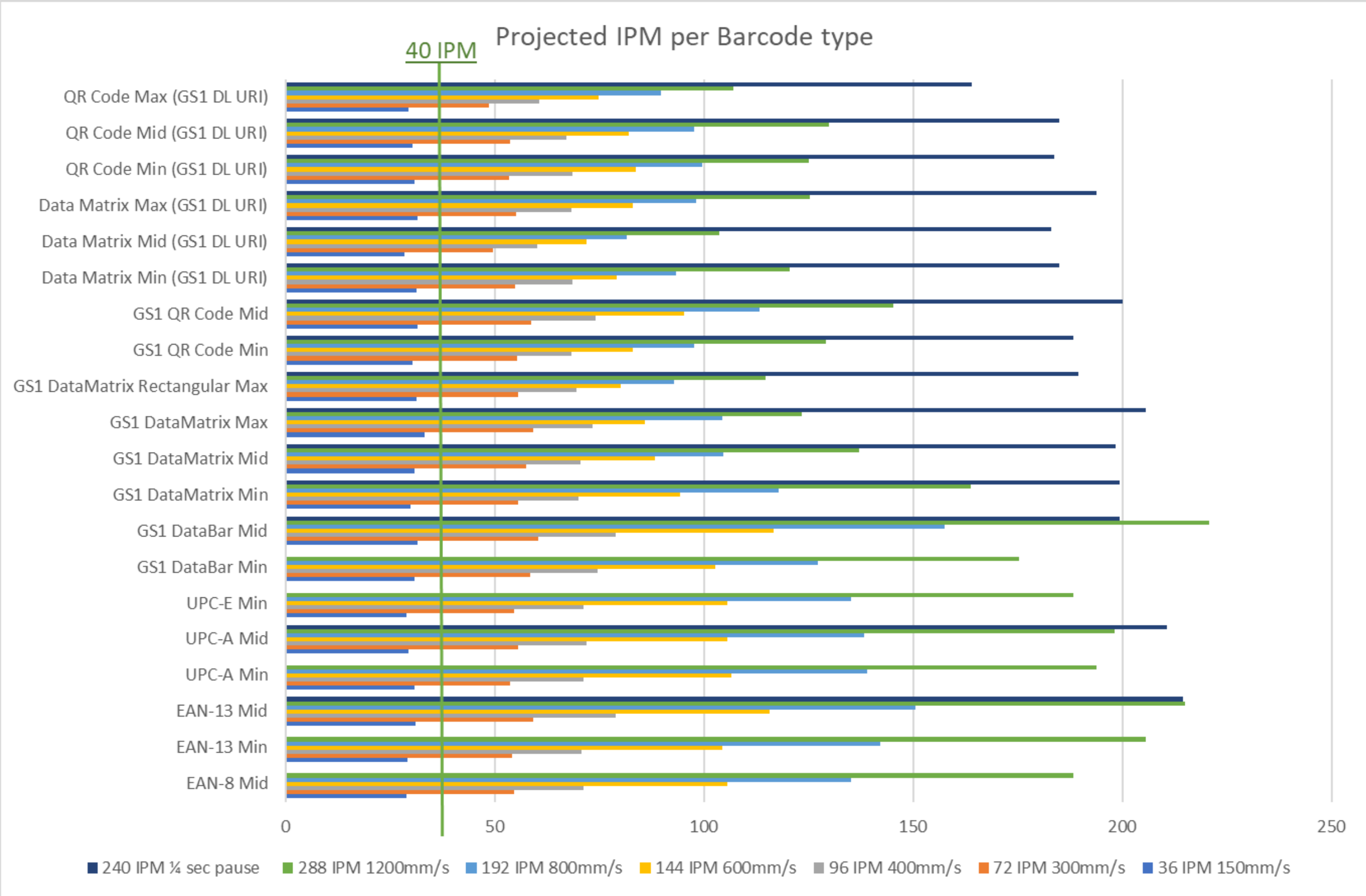
4.2 Items per minute (full suite of test)

As noted earlier, this test is design to identify opportunities for scanner improvements. The below chart shows the projected IPM based on the scan percentage for the full suite of tests as described in section 3.

The chart below visualises the mathematical throughput of what the scanning systems are currently capable based on all factors that effected the Tier 1 scan rates. The projection of the maximum items per minute scanned can be calculated by using the average scan rate at each scan speed multiplied by the speed → IPM table conversion values.

The barcodes are sorted based on their size (minimum to maximum X-dimension see section 4.9). The chart shows that barcodes printed based on GS1 General Specification limits perform similarly across all tests and that the higher barcode test card speeds well exceed the current retail norms. It also shows that the 0.250 second pause was a significant performance improvement.

Figure 4-3 Projected IPM per barcode type



4.3 Average total scan time

This test measures the time required for a scan system to deliver the decoded barcode data to the AIDC test lab data acquisition system. The time start is triggered with the leading edge of the test card entering the bio-optic scanner station. The average scan times in table 4-3 are the sum of all the below elements of time:

- Optical sensor trigger time (start)
- Time of test card passing scan surfaces
- Bi-optic scanner capture and processing time for images of test card
- Decode process of located barcode(s) on captured images
- Data conversions performed by the scanner system
- Data transmission time

Table 4-2 Average total scan time (milliseconds)

Barcode type	150mm/s (ms)	300mm/s (ms)	400mm/s (ms)	600mm/s (ms)	800mm/s (ms)	1200mm/s (ms)	¼ sec pause (ms)
EAN-8/13	445	268	222	190	177	176	129
UPC-A/E	464	279	230	246	160	168	140
GS1 DataBar	449	272	204	159	141	125	151
GS1 DataMatrix	596	392	347	287	260	242	356
GS1 DataMatrix Rectangular	639	411	365	299	274	263	372
GS1 QR Code	523	328	282	222	201	183	269
Data Matrix (GS1 DL URI)	617	411	359	297	269	249	365
QR Code (GS1 DL URI)	547	340	293	234	212	193	282

4.4 Number and type of barcode decoding algorithms enabled

The bi-optic scanner gives the user the ability to set what barcodes the scanning system will detect or ignore. This is enabled by allowing a set of barcode decoder algorithms to be switched on any particular scanner. This test was designed to measure the effect of an increased number of barcode decoder algorithms being enabled for 1D and 2D barcodes on scanner performance.

Barcodes are randomly arranged so the any combination of barcode could be next to cross the scanners field of view. For example, a QR Code (GS1 DL URI) could be followed by an EAN-13 or GS1 DataBar or GS1 DataMatrix. We tested the following scenarios:

- 1D barcode decode algorithms enabled (EAN-13, EAN-8, UPC-A, UPC-E, GS1 DataBar Omnidirectional)
  - **Test 1:** EAN/UPC, GS1 DataBar Omnidirectional
- 1D and 2D barcode decode algorithms enabled (EAN-13, EAN-8, UPC-A, UPC-E, GS1 DataBar Omnidirectional, GS1 DataMatrix, GS1 QR Code, Data Matrix (GS1 DL URI) QR Code (GS1 DL URI))
  - **Test 2:** EAN/UPC, GS1 DataBar Omnidirectional, Data Matrix and QR Code
  - **Test 3:** EAN/UPC, GS1 DataBar Expanded Stacked, GS1 DataBar Omnidirectional, Data Matrix, QR Code, ITF-14, PDF417, Code 128, ISBN, watermark

The result of this set of tests is that there is little measurable effect on total scan time as a result of the number of enabled barcode decoder algorithms. This result is valid for the set of tests run on single barcodes present on the Tier 1 test cards and may be different when we execute Tier 2 or Tier 3 tests in which multiple symbols encode with more data are presented to the scanners within the same scan window.

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Table 4-3 Total scan time vs. number of barcode decode algorithms (in milliseconds) by barcode

Barcode type	Test 1 (ms)	Test 2 (ms)	Test 3 (ms)
EAN-8/13	189	205	187
UPC-A/E	211	205	200
GS1 DataBar	213	216	203
GS1 DataMatrix	*	380	397
GS1 DataMatrix Rectangular	*	418	428
GS1 QR Code	*	311	309
Data Matrix (GS1 DL URI)	*	396	412
QR Code (GS1 DL URI)	*	331	323

Note: The "*" indicates that the 1D barcode only test (Test 1) does not apply.

4.5 Data Conversion (GS1 Digital Link URI → GS1 element string)

A comparison of the additional time required to convert the data extracted from a Data Matrix or QR Code that is encoded with GS1 Digital Link URI into a GS1 element string structure was performed and the data is in Table 4-4. The bi-optic scanner models names have been given aliases (e.g., Alpha#, Beta#, Delta#). The scanner manufactures receive their data to support future development if required.

For example if a QR Code or Data Matrix is encoded with a URI (https://example.com/01/09501101530003/10/AB-123?17=241021), scan system Delta 0 and Delta 1 will facilitate the conversion to (01)09501101530003(10)AB-123(17)241021. All other scanners are with the factory default software and settings.

The ability for the scanning system to do this translation is important to retailers, as it removes the requirement to make any changes to the POS backend systems within a particular retail environment. No appreciable delay was identified between units with the GS1 Digital Link URI → GS1 element string conversion and those without.

Note: The bi-optic scanner models names have been given aliases (Alpha#, Beta#, Delta#). The scanner manufactures receive their data to support future development if required.

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Table 4-4 Data conversion in millisecond

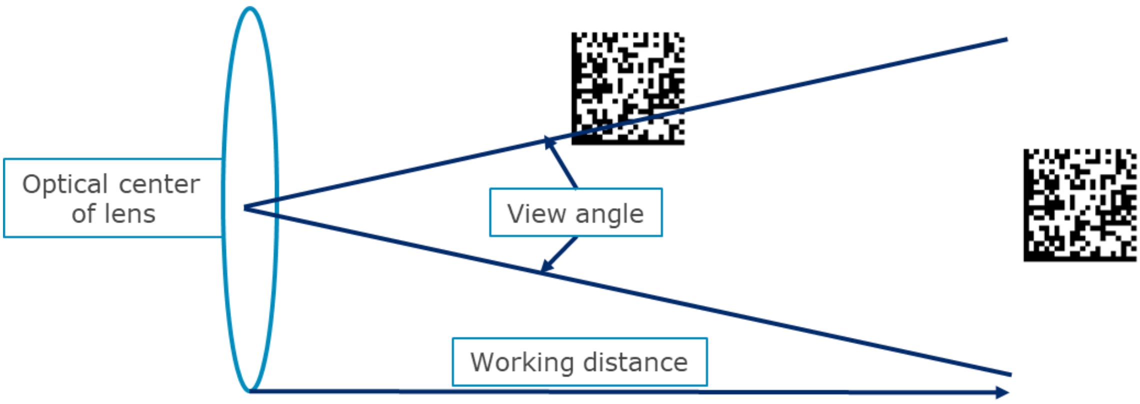
Barcode type	Alpha2 (ms)	Alpha5 (ms)	Beta3 (ms)	Delta0 (ms)	Delta1 (ms)
GS1 DataMatrix	228	469	407	553	241
GS1 DataMatrix Rectangular	248	493	413	560	255
GS1 QR Code	220	281	403	447	239
Data Matrix (GS1 DL URI)	234	500	399	581	248
QR Code (GS1 DL URI)	239	301	430	455	246

4.6 Distance from scanner surface

The minimum to maximum distance from the scanner surface was determined for each scanning system, based on scanner system specifications. A safety margin was added to the lower limit to avoid any test cell robot collisions. The test was design to identify any concern with the distance from the barcode being scanned to the scanner itself. Ranges were tested from minimum specified range (+safety margin) to maximum specified range.

Barcode test card design caused the barcode to be on the edge of the scanner imager's view angle when at the minimum distance to the vertical camera. This is an important finding and supplies requirement for barcode placement. The combination of speed and distance also resulted in reduce scanner decode rates. The major reason for the 10%-15% is related to the barcode test card being on the edge of the scanner imager working distance or view angle.

Figure 4-4 Distance from scanner angles



The barcode test samples were produced to approximate the minimum, median and maximum size (X-dimensions) and is explained in the next section.

Table 4-5 Barcode to scanner distance (scan rate %)

Barcode type	Min-vertical distance (%)	Mid-vertical distance (%)	Max-vertical distance (%)	Min-horizontal distance (%)	Mid-horizontal distance (%)	Max-horizontal distance (%)
EAN-8 Mid	89	88	86	58	83	61
EAN-13 Min	99	100	96	53	79	51
EAN-13 Mid	85	100	66	61	71	59
UPC-A Min	99	96	75	48	79	52
UPC-A Mid	97	89	64	69	86	66
UPC-E Min	96	68	10	49	49	21
GS1 DataBar Min	88	97	74	57	42	50
GS1 DataBar Mid	95	98	82	77	92	77
GS1 DataMatrix Min	59	82	80	59	78	68
GS1 DataMatrix Mid	56	67	54	53	63	46
GS1 DataMatrix Max	61	77	84	62	76	68
GS1 DataMatrix Rectangular Max	60	78	79	55	72	59
GS1 QR Code Min	69	85	63	57	75	53
GS1 QR Code Mid	70	86	77	63	81	63
Data Matrix Min (GS1 DL URI)	63	82	66	62	74	52
Data Matrix Mid (GS1 DL URI)	60	80	52	55	69	48
Data Matrix Max (GS1 DL URI)	65	83	78	64	75	70
QR Code Min (GS1 DL URI)	65	83	66	58	76	55
QR Code Mid (GS1 DL URI)	67	85	70	64	80	58

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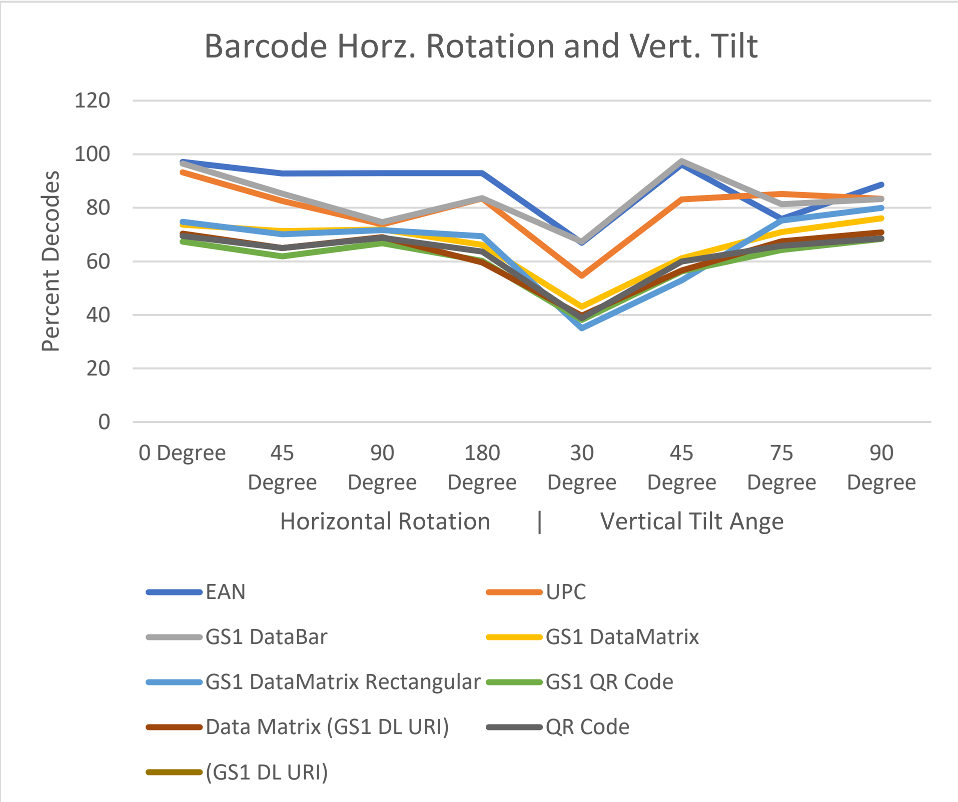
Barcode type	Min-vertical distance (%)	Mid-vertical distance (%)	Max-vertical distance (%)	Min-horizontal distance (%)	Mid-horizontal distance (%)	Max-horizontal distance (%)
QR Code Max (GS1 DL URI)	53	68	76	39	67	61

4.7 Rotation in plane and tilt angle comparison

The effect of barcode rotation in plane and tilt angle towards vertical camera were explored. The barcode rotations and tilt angles were tested at surface offset and velocity settings. This test was designed to isolate and identify any concern with the direction or tilt of the barcode as it passes over the scanner.

Rotating the barcode test card in plane did not appear to impact the scan rate, however barcode test card tilt angle was determined to be impactful to scan rates, with larger angles reducing the scan rate for all the bi-optic scanners under test. Interestingly a 30-degree tilted barcode caused the largest reduction in scan rates for most scanners.

Figure 4-8 Barcode rotation and tilt scan rate in percentage



Note: Barcode rotation and tilt scan rate in percentage

4.8 Printing technology comparison

Five printer manufacturers produced the test card barcodes using current production printing technologies. Each barcode was encoded to be unique and identify the printing technology. The below table shows the relative scan rates per technology across all card velocities

One scanner manufacture had issues decoding the reverse reflectance test symbols (i.e., white on black) that were generated by created by laser printing. Continuous inkjet-printed symbologies performed marginally lower, which is likely the result of lower resolution and round module generation (i.e., ink drop design), both which are known as characteristic of this printing technology.

Table 4-6 Printing technology scan rate with full test suite in percentage

Print type	150mm/s (%)	300mm/s (%)	400mm/s (%)	600mm/s (%)	800mm/s (%)	1200mm/s (%)	¼ sec pause (%)
CIJ	77	71	68	59	54	47	74
Laser	86	74	69	62	56	50	86
Laser Jet	79	71	68	60	56	51	73
Thermal Transfer	83	75	72	62	59	52	76
TIJ	84	78	73	64	59	53	81

4.9 Barcode size (X-dimension) comparison

The range of 1D and 2D barcode sizes allowed at retail POS size is defined in GS1 General Specifications section 5.12.3.1 Symbol specification table 1 (shown below). The testing limited the X-dimension for all barcodes to be compliant with this table, insofar as was possible for each of the chosen printing technologies. The barcode test samples were produced to approximate the minimum, median and maximum X-dimensions wherever possible for each printing technology.

Figure 4-5 . GS1 symbol specification table 1

Main symbol(s) specified	X-dimension mm (inches)			(**) Minimum symbol height for given X mm (inches)			Quiet Zone		Minimum quality specification
	(*) Minimum	Target	Maximum	For minimum X-dimension	For target X-dimension	For maximum X-dimension	Left	Right	
EAN-13	0.264 (0.0104")	0.330 (0.0130")	0.660 (0.0260")	18.28 (0.720")	22.85 (0.900")	45.70 (1.800")	11*X*	7*X*	1.5/06/660
EAN-8	0.264 (0.0104")	0.330 (0.0130")	0.660 (0.0260")	14.58 (0.574")	18.23 (0.718")	36.46 (1.435")	7*X*	7*X*	1.5/06/660
UPC-A	0.264 (0.0104")	0.330 (0.0130")	0.660 (0.0260")	18.28 (0.720")	22.85 (0.900")	45.70 (1.800")	9*X*	9*X*	1.5/06/660
UPC-E	0.264 (0.0104")	0.330 (0.0130")	0.660 (0.0260")	18.28 (0.720")	22.85 (0.900")	45.70 (1.800")	9*X*	7*X*	1.5/06/660
GS1 DataBar Omni-directional (****)	0.264 (0.0104")	0.330 (0.0130")	0.660 (0.0260")	12.14 (0.478")	15.19 (0.598")	30.36 (1.195")	None	None	1.5/06/660
GS1 DataBar Stacked Omni-directional (***) (****)	0.264 (0.0104")	0.330 (0.0130")	0.660 (0.0260")	25.10 (0.988 ")	31.37 (1.235")	62.70 (2.469")	None	None	1.5/06/660

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GS1 DataBar Expanded	0.264 (0.0104")	0.330 (0.0130")	0.660 (0.0260")	8.99 (0.354")	11.23 (0.442")	22.44 (0.883")	None	None	1.5/06/660
GS1 DataBar Expanded Stacked (*****)	0.264 (0.0104")	0.330 (0.0130")	0.660 (0.0260")	18.75 (0.738")	23.44 (0.923")	46.86 (1.845")	None	None	1.5/06/660
GS1 DataMatrix	0.375 (0.0148)	0.625 (0.0246)	0.990 (0.0390)	Height is determined by the X-dimension and data that is encoded			1X on all four sides		1.5/08/660
GS1 QR Code	0.375 (0.0148)	0.625 (0.0246)	0.990 (0.0390)	Height is determined by the X-dimension and data that is encoded			4X on all four sides		1.5/08/660

Figure 4-6 Symbol specification table 1 addendum 2 for GS1 Digital Link

Symbol(s) specified	X-dimension mm (inches)			Minimum symbol height for given X mm (inches)			Quiet Zone	Minimum quality specification
	Minimum	Target	Maximum	For minimum X-dimension	For target X-dimension	For maximum X-dimension	Surrounding Symbol	
Data Matrix (ECC 200) (*)	0.396 (0.0150")	0.495 (0.0195")	0.743 (0.0293")	Height is determined by X-dimension and data that is encoded			1X on all four sides	1.5/12/660
QR Code (*)	0.396 (0.0150")	0.495 (0.0195")	0.743 (0.0293")	Height is determined by X-dimension and data that is encoded			4X on all four sides	1.5/12/660

Within normal retail speeds and when test barcodes pass directly in front of the scanner's camera surfaces, the result showed acceptable scanner performance for both 1D and 2D barcodes, however when we add all the test factor (e.g., maximum barcode distances, barcode tilt angles, higher speeds, print technologies, …) the percentage of successful scans drops. The major reason for the 10%-15% is related to the barcode test card being on the edge of the scanner imager working distance or view angle

Table 4-7 Barcode scan rate with full suite of tests (%)

Barcode type	36 IPM 150mm/s	72 IPM 300mm/s	96 IPM 400mm/s	144 IPM 600mm/s	192 IPM 800mm/s	288 IPM 1200mm/s	240 IPM ¼ sec pause
EAN-8 Mid	80	76	74	73	70	65	*
EAN-13 Min	81	75	74	72	74	71	*
EAN-13 Mid	86	82	82	80	78	75	89
UPC-A Min	86	75	74	74	72	67	*
UPC-A Mid	82	77	75	73	72	69	88
UPC-E Min	80	76	74	73	70	65	*
GS1 DataBar Min	86	81	78	71	66	61	*
GS1 DataBar Mid	88	84	82	81	82	77	83

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Barcode type	36 IPM 150mm/s	72 IPM 300mm/s	96 IPM 400mm/s	144 IPM 600mm/s	192 IPM 800mm/s	288 IPM 1200mm/s	240 IPM ¼ sec pause
GS1 DataMatrix Min	83	77	73	65	61	57	83
GS1 DataMatrix Mid	86	80	73	61	55	48	83
GS1 DataMatrix Max	92	82	77	60	54	43	86
GS1 DataMatrix Rectangular Max	87	77	72	56	48	40	79
GS1 QR Code Min	85	77	71	58	51	45	78
GS1 QR Code Mid	88	82	77	66	59	50	83
Data Matrix Min (GS1 DL URI)	87	76	71	55	49	42	77
Data Matrix Mid (GS1 DL URI)	79	69	63	50	43	36	76
Data Matrix Max (GS1 DL URI)	87	76	71	58	51	44	81
QR Code Min (GS1 DL URI)	86	74	71	58	52	43	77
QR Code Mid (GS1 DL URI)	84	75	70	57	51	45	77
QR Code Max (GS1 DL URI)	81	68	63	52	47	37	68

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5 Conclusions and recommendations

The scanner solution providers agreed that the rigors of this set of tests would uncover opportunities for improvements in decoding and locating algorithms. The tests were determined to be a good and challenging lab representation of the retail POS scan environment.

However, GS1, the University of Memphis and the solution providers also agreed that retail store pilots are needed to continue the learning and vetting of POS scanner improvements. As stated earlier, we have had over 45 years to optimise scanners for 1D barcodes and will need the stakeholders to collaborate to improve 2D scanning performance for all scanners that have been tested.

Tier 1 testing was used to set the baseline for improvements and, therefore, no 2D setting optimisation was done to any bi-optic scanner company. The barcode test cards were purposely limited to GTIN-only data strings and use barcodes approved for use in the GS1 system.

The results show that 2D barcodes encoded with only GTIN can meet today’s retail throughput requirement of ~40-70 items per minute in a controlled environment. It is important to note that the tests performed in these Tier 1 tests did not include any additional “noise” surrounding the barcodes (label graphics, reflective surfaces, curved surfaces, etc). It is also important to note that a lab robot cannot simulate human motions and that lab testing cannot fully replicate a retail environment. Therefore, retail pilots are essential as a complement to the results captured in these lab tests.

The lab tests have shown that the current GS1 standards for barcode dimensions work with a representative sample of today’s most popular scanning systems. Future tests will need to be done to understand how earlier generations and other manufacture’s bi-optic scanner solutions decode the Tier 1 barcode test cards. Once this bi-optic test complete, presentation and handheld scanners testing is also planned, to understand the impacts and potential changes to these retail scanning tools.

The Tier 1 tests showed that barcode direction and the number of barcode types (decode algorithms) enabled do not adversely affect the throughput, as the average decode time were not meaningfully different when these variables were changed.

Barcode test card distance to the scanning surface and tilt angle did impact the barcode scan rate. Scanning at the maximum distance caused double scans at slower velocities and missed decodes at higher velocities. The subsequent tiers of 2D testing will remove the maximum distance as a tested range (as we know the cause and effect, and as this scanning distance is not a common practice in real-world retail environments).

The combination of barcode test card design (size of card) caused the barcode to be on the edge of some imager’s field of view. To minimise these negative results, GS1 and the Memphis lab have redesigned a smaller test card that still accommodates the barcode test samples and lowers the barcode further into the scanner’s field of view.

Barcode test card tilt angle was determined to be impactful to scan rates, with larger angles reducing the scan rate for all the bi-optic scanners under test. Scanner manufactures have delivered new scanner setting recommendations to improve the overall 2D scan rate and, therefore, the expected IPM performance. The robot traversing velocities, card rotations and or tilt angle will remain the same to quantify if the updated scanner settings improve the results.

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A Annex: Tier 1 barcodes

During the Tier 1 test, thirty-nine barcodes were tested. The barcodes varied in:

- Barcode type
  - EAN/UPC family
  - GS1 DataBar family
  - GS1 DataMatrix
  - GS1 QR Code
  - Data Matrix (GS1 Digital Link URI)
  - QR Code (GS1 Digital Link URI)
- Data encoded
- Size (X-dimension)
- Print technology used to produce
  - Thermal transfer printing
  - Laser printing
  - Continuous inkjet (CIJ)
  - Thermal inkjet (TIJ)
- Print quality (various levels of contrast)
- Error correction level (for QR Code only)

Below image show a sample of the barcodes created for the test on the test card carriers. No barcode from outside of the GS1 system (e.g., Code 39, MaxiCode, JAB Code, etc.) were used in this testing

Figure A-1 Barcode test cards

The table below shows the different barcodes and the characteristics of the barcodes. Note that the data encoded was a GTIN unless the barcode was a QR Code or Data Matrix, in which case a GS1 Digital Link URI was encoded to comply with the minimum requirements.

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Table A-1 Tier 1 test card barcodes

Symbologies	*URL*	*Data (GTIN)*		*Error Correction*	*X-dimension (mm min, target)*	*Print Tech (Thermal, CIJ, TIJ, Laser)*
EAN-13		**095210000001**	8		0.264 (0.0104")	Laser Jet
		095210000002	5		0.330 (0.0130")	Thermal
		095240000003	9		0.330 (0.0130")	CIJ
		095230000004	7		0.330 (0.0130")	TIJ
		095220000005	5		0.330 (0.0130")	LASER
EAN-8		**2345025**	**7**		0.264 (0.0104")	Laser Jet
		9521000	**1**		0.330 (0.0130")	Thermal
UPC-A		**95211000001**	5		0.264 (0.0104")	Laser Jet
		95211000002	2		0.330 (0.0130")	Thermal
		95214000003	0		0.330 (0.0130")	CIJ
		95213000004	0		0.330 (0.0130")	TIJ
		95212000005	0		0.330 (0.0130")	LASER
UPC-E		**04010000130**	**9**		0.264 (0.0104")	Laser Jet
		04010000144	6		0.330 (0.0130")	Thermal
GS1 DataBar OmniDirectional		**0095213100001**	8		0.264 (0.0104")	Laser Jet
		0095213100002	5		0.330 (0.0130")	Thermal
GS1 DataMatrix		**0095216100001**	9		0.375 (0.0148)	Laser Jet
		0095216100002	6		0.375 (0.0148)	Thermal
		0095246100003	0		0.625 (0.0246)	CIJ
		0095236100004	8		0.625 (0.0246)	TIJ
		0095226100005	6		0.625 (0.0246)	LASER
		0095216100008	8		0.99 (0.0340)	Thermal
GS1 DataMatrix (rectangular version)		**0095219100001**	0		0.375 (0.0148)	Laser Jet
		0095219100002	7		0.375 (0.0148)	Thermal
		0095249100003	1		0.625 (0.0246)	CIJ
GS1 QR Code		**0095215100001**	2	L	0.375 (0.0148)	Laser Jet
		0095215100002	9	Q	0.375 (0.0148)	Thermal
		0095245100003	3	L	0.625 (0.0246)	CIJ
		0095235100004	1	M	0.625 (0.0246)	TIJ
		0095225100005	9	L	0.625 (0.0246)	LASER
QR Code (DL URI)	https://dalgiardino.com	0095217100001	6	L	0.625 (0.0246)	Laser Jet
	https://dalgiardino.com	0095217100002	3	Q	0.396 (0.0150")	Thermal
	https://dalgiardino.com	0095247100003	7	L	0.495 (0.0195")	CIJ
	https://dalgiardino.com	0095237100004	5	M	0.625 (0.0246)	TIJ
	https://dalgiardino.com	0095227100005	3	L	0.625 (0.0246)	LASER
	https://dalgiardino.com	0095217100008	5	L	0.99 (0.0340)	Thermal
Data Matrix (DL	https://dalgiardino.com	0095218100001	3		0.625 (0.0246)	Laser Jet
	https://dalgiardino.com	0095218100002	0		0.396 (0.0150")	Thermal
	https://dalgiardino.com	0095248100003	4		0.495 (0.0195")	CIJ
	https://dalgiardino.com	0095238100004	2		0.625 (0.0246)	TIJ

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B Annex: Test profiles

Twenty-three different test profiles (summarised in the table below) were run to analyse and understand the read rates of different barcodes. The parameters that were adjusted are explained as follows:

A. The number of enabled barcode decode algorithms varied from a limited profile, only looking for expected bar codes, to the full suite of test, which included the enabling of all decoding algorithms for all barcodes turned on within the scanner. The following symbologies were enabled as the full suite of test in all scanners: Data Matrix, QR Code, GS1 DataBar Expanded Stacked, GS1 DataBar Omnidirectional, EAN/UPC, ITF-14, PDF417, Code 128, Code 39, ISBN, watermark
B. When the barcode symbol was passed in front of the scan window, the height or distance from the scan window was tested at 25, 55, and 85 mm.
C. The barcodes were passed in front of the scan window at the following speeds: 150 mm/s, 300 mm/s, 400 mm/s, 600 mm/s, 800 mm/s, 1200 mm/s and at 1500mm/s + a 250ms pause.
D. The barcodes were presented at different angles from parallel to the scan window: 0°, 30°, 45°, 75°, and 90°.
E. Within the parallel presentation to the scan window, the barcodes were rotated clockwise: 0°, 45°, 90°, and 180°.

Table B-2 Test Matrix

Barcode decode algorithms	Distance from Scan window	speed	*Tilt Angle from Horzontal*	*CW Rotation in Plane*	Test ID
linear only	all (25, 55, 85 mm)	all	0	0	test0
				45	test1
				90	test2
				180	test3
			30	0	test4
			45	0	test5
			75	0	test6
			90	0	test7
test set	all (25, 55, 85 mm)	all	0	0	test8
				45	test9
				90	test10
				180	test11
			30	0	test12
			45	0	test13
			75	0	test14
			90	0	test15
full set	all(25, 55, 85 mm)	all	0	0	test16
				45	test17
				90	test18
				180	test19
			30	0	test20
			45	0	test21
			75	0	test22
			90	0	test23

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C Annex: Barcode verification data

All barcodes used in the testing were validated on a barcode verifier to discover the barcodes quality based on the GS1 General Specification Section 5.12 Barcode production and quality assessment. Only barcodes that received a 1.5 (C) and above were acceptable for testing.

Table C-3 Verification table

Symbology	Data	Acceptance Criteria	Overall Grade SYMBOL ANSI GRADE	ANSI Letter Grade	ANSI Numeric Grade
EAN8	95210001	GS1 Acceptance Criteria PASS	A(4.0/06/660)	A	4
EAN8	95210001	GS1 Acceptance Criteria PASS	A(4.0/06/660)	A	4
UPCA	952100000025	GS1 Acceptance Criteria PASS	A(4.0/06/660)	A	4
UPCA	952110000022	GS1 Acceptance Criteria PASS	A(4.0/06/660)	A	4
GS1 DataBar	0100952131000025	GS1 Acceptance Criteria PASS	A(4.0/06/660)	A	4
DataMatrix	<F1>0100952161000026	GS1 Acceptance Criteria PASS	B(3.0/08/660/45)	B	3
DataMatrix	<F1>0100952191000027	GS1 Acceptance Criteria PASS	B(3.0/08/660/45)	B	3
QR	<F1>0100952151000029	GS1 Acceptance Criteria PASS	B(3.0/08/660/45)	B	3
QR	https:/dalgiardino.com/01/00952171000023	GS1 Acceptance Criteria PASS	B(3.0/08/660/45)	B	3
DataMatrix	https:/dalgiardino.com/01/00952181000020	GS1 Acceptance Criteria PASS	A(4.0/08/660/45)	A	4
QR	https:/dalgiardino.com/01/00952171000023	GS1 Acceptance Criteria PASS	B(3.0/08/660/45)	B	3
QR	<F1>0100952151000029	GS1 Acceptance Criteria PASS	C(2.0/08/660/45)	C	2
DataMatrix	<F1>0100952191000027	GS1 Acceptance Criteria PASS	A(4.0/20/660/45)	A	4
DataMatrix	<F1>0100952161000026	GS1 Acceptance Criteria PASS	B(3.0/08/660/45)	B	3
DataMatrix	<F1>0100952261000056	GS1 Acceptance Criteria PASS	B(3.0/20/660/45)	B	3
QR	<F1>0100952251000059	GS1 Acceptance Criteria PASS	A(4.0/08/660/45)	A	4
DataMatrix	https:/dalgiardino.com/01/00952281000050	GS1 Acceptance Criteria PASS	A(4.0/08/660/45)	A	4
QR	https:/dalgiardino.com/01/00952271000053	GS1 Acceptance Criteria PASS	B(3.0/08/660/45)	B	3
UPCA	952120000050	GS1 Acceptance Criteria PASS	A(3.7/06/660)	A	3.7
UPCA	952100000018	GS1 Acceptance Criteria PASS	A(4.0/06/660)	A	4
UPCA	952110000015	GS1 Acceptance Criteria PASS	A(4.0/06/660)	A	4
GS1 DataBar	0100952131000018	GS1 Acceptance Criteria PASS	A(4.0/06/660)	A	4
DataMatrix	<F1>0100952161000019	GS1 Acceptance Criteria PASS	B(3.0/08/660/45)	B	3
DataMatrix	<F1>0100952191000010	GS1 Acceptance Criteria PASS	B(3.0/08/660/45)	B	3
QR	<F1>0100952151000012	GS1 Acceptance Criteria PASS	C(2.0/08/660/45)	C	2
QR	https:/dalgiardino.com/01/00952171000016	GS1 Acceptance Criteria PASS	C(2.0/08/660/45)	C	2
DataMatrix	https:/dalgiardino.com/01/00952181000013	GS1 Acceptance Criteria PASS	C(2.0/08/660/45)	C	2
GS1 DataBar Expanded	0100952141000015 1010ABC<F1>17271231	GS1 Acceptance Criteria PASS	A(3.9/06/660)	A	3.9
GS1 Data Matrix	100952161000064	GS1 Acceptance Criteria PASS	A(4.0/12/660/D)	A	4.0
Data Matrix	https:/dalgiardino.com/01/00952181000068	GS1 Acceptance Criteria PASS	A(4.0/12/660/D)	A	4.0
GS1 QR Code	100952151000081	GS1 Acceptance Criteria PASS	A(4.0/32/660/D)	A	4.0
GS1 QR Code	100952351000041	GS1 Acceptance Criteria PASS	A(4.0/19/660/D)	A	4.0
UPCA	952400000039	GS1 Acceptance Criteria PASS	A(4.0/10/660/D)	A	4.0
QR Code	https:/id.gs1.org/01/009952471000037	GS1 Acceptance Criteria PASS	F(0.0/11/660/D)	F	0.0
GS1 QR Code	100952151000067	GS1 Acceptance Criteria PASS	A(4.0/20/660/D)	A	4.0
GS1 Data Matrix	100952161000071	GS1 Acceptance Criteria PASS	A(4.0/12/660/D)	A	4.0
QR Code	https://dalgiardino.com/01/00952171000085	GS1 Acceptance Criteria PASS	A(4.0/32/660/D)	A	4.0
Data Matrix	https://id.gs1.org/01/009952481000034	GS1 Acceptance Criteria PASS	B(3.0/07/660/D)	B	3.0
GS1 QR Code	100952451000033	GS1 Acceptance Criteria PASS	D(0.9/12/660/D)	D	0.9
UPC-A	952130000040	GS1 Acceptance Criteria PASS	A(3.7/10/660/D)	A	3.7
GS1 QR Code	100952151000074	GS1 Acceptance Criteria PASS	A(4.0/20/660/D)	A	4.0
Data Matrix	https://dalgiardino.com/01/00952181000075	GS1 Acceptance Criteria PASS	A(4.0/12/660/D)	A	4.0
QR Code	https://dalgiardino.com/01/00952171000078	GS1 Acceptance Criteria PASS	A(4.0/20/660/D)	A	4.0
QR Code	https://id.gs1.org/01/00952371000045	GS1 Acceptance Criteria PASS	B(3.0/11/660/D)	B	3.0
UPC-A	952300000047	GS1 Acceptance Criteria PASS	B(3.4/10/660/D)	B	3.4
GS1 Data Matrix	100952161000088	GS1 Acceptance Criteria PASS	A(4.0/20/660/D)	A	4.0
Data Matrix	https://dalgiardino.com/01/00952181000082	GS1 Acceptance Criteria PASS	A(4.0/20/660/D)	A	4.0
QR Code	https://dalgiardino.com/01/00952171000061	GS1 Acceptance Criteria PASS	A(4.0/20/660/D)	A	4.0
Data Matrix	https://id.gs1.org/01/00952381000042	GS1 Acceptance Criteria PASS	A(4.0/08/660/D)	A	4.0
GS1 Data Matrix	100952361000048	GS1 Acceptance Criteria PASS	A(4.0/13/660/D)	A	4.0
UPC-A	952400000039	GS1 Acceptance Criteria PASS	A(4.0/10/660/D)	A	4.0
QR Code	https://dalgiardino.com/01/00952472000081/	GS1 Acceptance Criteria PASS	F(0.0/08/660)	F	0
Data Matrix	^0100952461000085 1010ABC^17271231243123	GS1 Acceptance Criteria PASS	F(0.0/08/660)	F	0
QR Code	https://dalgiardino.com/01/00952472000081/	GS1 Acceptance Criteria PASS	F(0.0/08/660)	F	0
Data Matrix	https://dalgiardino.com/01/00952482000088/	GS1 Acceptance Criteria PASS	F(0.0/08/660)	F	0
QR Code	https://id.gs1.org/01/009952471000037	GS1 Acceptance Criteria PASS	F(0.0/11/660/D)	F	0.0
DataMatrix	01<F1>00952291000057	GS1 Acceptance Criteria PASS	F(0.0/20/660/45)	F	0
Data Matrix	(01)00952491000031	GS1 Acceptance Criteria PASS	F(0.0/06/660/D)	F	0.0

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