QR Code

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A *QR* code (in English, *QR* code) is a two-dimensional barcode, meaning a system for encoding information arranged in a square matrix (International Organization for Standardization [ISO], 2024).
The matrix consists of small elements, called **modules**, generally dark on a light background.
The arrangement of the modules allows information, such as text or web addresses, to be represented and decoded using a smartphone camera or a dedicated reader.



The QR Code was developed in Japan in 1994 by DENSO WAVE, then a division of DENSO Corporation, to improve the management and traceability of components in the automotive industry (DENSO WAVE, n.d.-a).
Its use subsequently spread rapidly to many other sectors. The name *QR* comes from Quick Response, meaning “quick response”, and recalls one of the project's main objectives: to enable fast reading of the encoded information (DENSO WAVE, n.d.-a).

As we have said, the *QR* Code matrix consists of small square elements called modules, However, not all modules have the same function. Some areas contain data, while others are structural elements needed to enable the reader to locate, orient and correctly decode the *QR* Code (ISO, 2024).
For this reason, some parts of the code must not be removed, covered or modified indiscriminately.

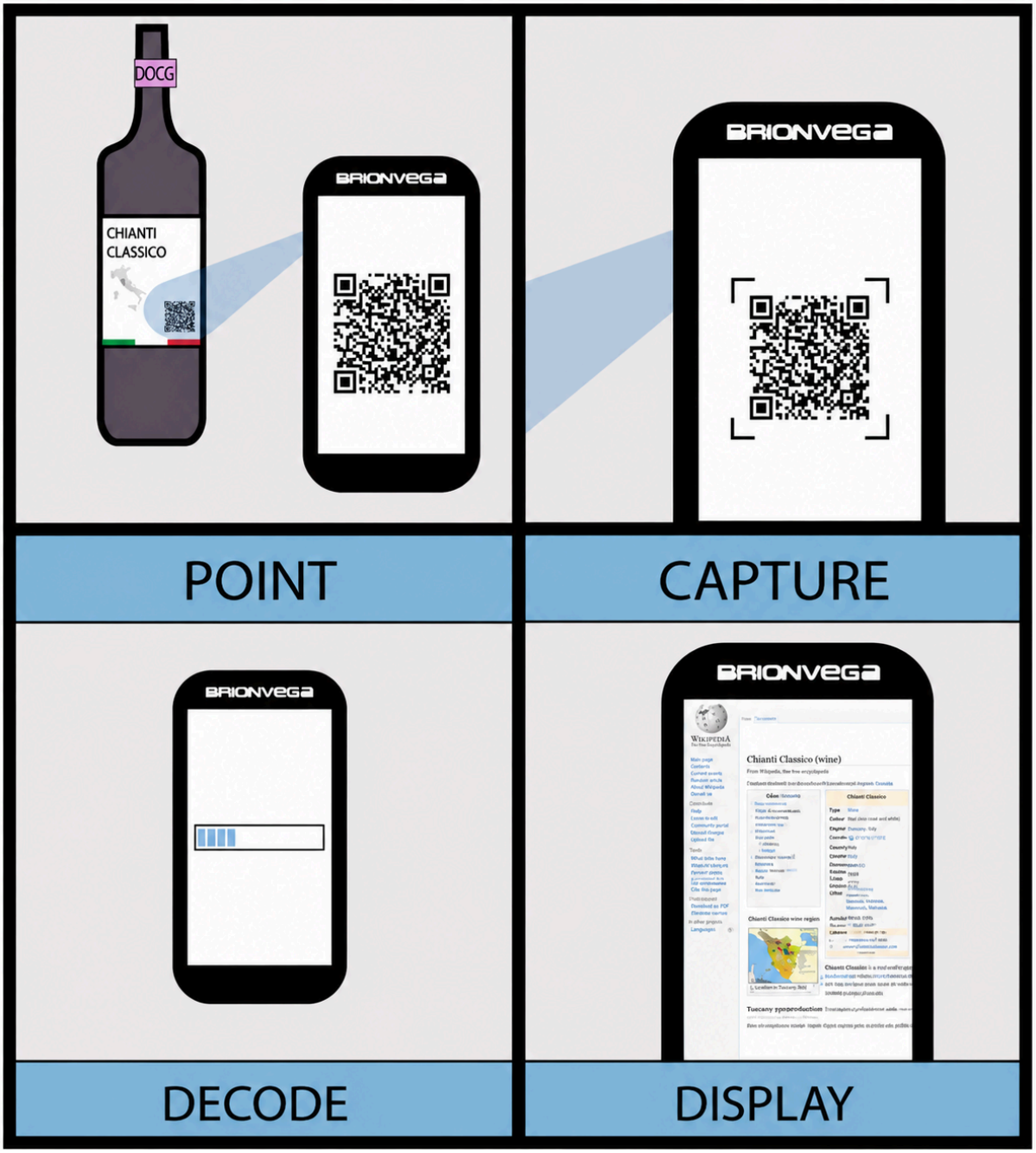
Generating a *QR* Code is now a simple operation and can be done using numerous software tools and online services.
For example, web addresses, text, contact information, Wi-Fi configurations and other data can be encoded within it. Once captured by a smartphone camera or a dedicated reader, the content is decoded and interpreted by the device (ISO, 2024).

Creating a QR Code is very simple; for example, this is a good website that allows you to create one:

https://me-qr.com/qr-code-generator

How it works

QR codes can contain different types of data, such as web addresses, text, telephone numbers, email addresses and contact information. Reading them requires a device with a camera and software capable of recognizing and decoding the code. On modern smartphones, this function is generally integrated directly into the camera application (ISO, 2024).



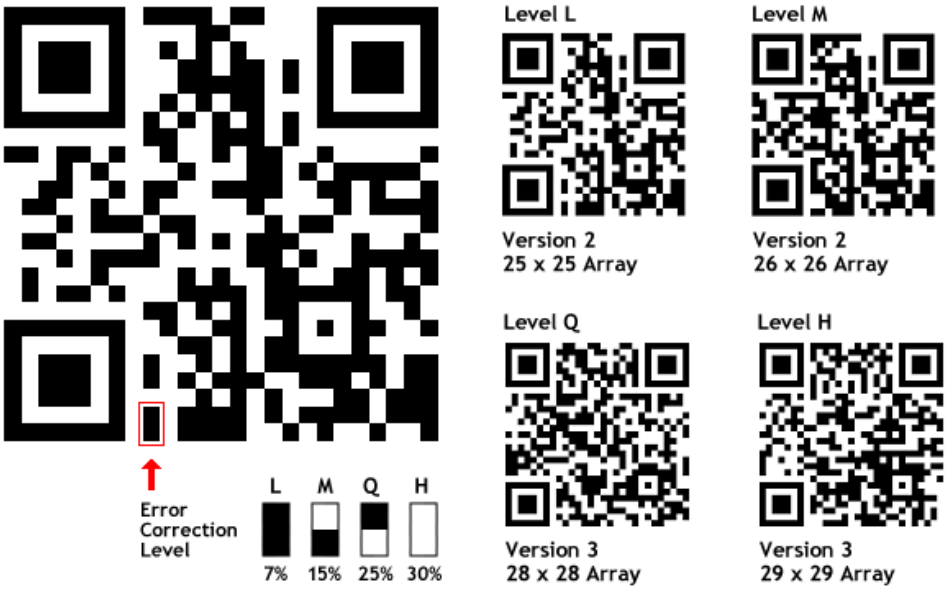
Each *QR* Code belongs to a particular version, which determines the dimensions of its matrix and therefore the number of available modules (DENSO WAVE, n.d.-b).
There are 40 versions: Version 1 uses a matrix of 21 × 21 modules, while Version 40 reaches 177 × 177 modules (DENSO WAVE, n.d.-b).
Each version increment adds four modules per side. A larger matrix generally allows a greater amount of data to be encoded, but also produces a denser QR Code (DENSO WAVE, n.d.-b).

QR Codes also use an error correction system that allows some of the data to be recovered even when certain modules are damaged, covered or difficult to read, for example because of scratches, dirt or printing problems (ISO, 2024; DENSO WAVE, n.d.-g).

Four error correction levels are available (DENSO WAVE, n.d.-g):

- Level L: allows approximately 7% of damaged data to be recovered.
- Level M: allows approximately 15% of damaged data to be recovered.
- Level Q: allows approximately 25% of damaged data to be recovered.
- Level H: allows approximately 30% of damaged data to be recovered.

A higher correction level makes the QR Code more resistant to damage, but also requires more space to store the information needed for error correction (DENSO WAVE, n.d.-g).
Consequently, for the same version, increasing the correction level reduces the amount of data that can be stored (DENSO WAVE, n.d.-g).



QR Codes can use different encoding modes, chosen according to the type of data to be represented (ISO, 2024).
The four main modes are numeric, alphanumeric, byte and Kanji. The mode used affects the amount of information the code can contain: simpler data, such as numerical digits alone, can be represented more compactly (DENSO WAVE, n.d.-g).
In the maximum-capacity configuration, namely a Version 40 QR Code with error correction level L, it is possible to encode up to (DENSO WAVE, n.d.-g):

- Numeric: 7,089 digits.
- Alphanumeric: 4,296 characters.
- Byte: 2,953 bytes.
- Kanji: 1,817 characters.

The actual capacity of a QR Code therefore depends on three main factors: encoding mode, version and error correction level (DENSO WAVE, n.d.-b).

Elements of a QR Code

Visually, a QR Code consists of several functional areas, meaning regions that perform different tasks in reading and decoding the symbol. Not all modules therefore have the same function: some contain data, while others allow the reader to recognize, orient and correctly interpret the code (ISO, 2024).

The three large squares positioned in three corners of the symbol are called **finder patterns** or **position detection patterns**. They enable the reader to quickly locate the *QR* Code, recognize its orientation and distinguish it from the background or other graphic elements on the page (ISO, 2024).
A clear band called a **quiet zone** must also surround the entire QR Code (DENSO WAVE, n.d.-e).
This empty space is essential because it allows the device to visually separate the code from its surroundings and correctly identify its edges.



Many versions of the QR Code also contain one or more **alignment patterns**, small alignment markers that help the reader correct perspective distortions or printing irregularities, for example when the code is applied to curved surfaces or scanned from an angle that is not perfectly frontal. The number of alignment patterns increases in larger versions of the code (ISO, 2024).



Between the finder patterns there are also **timing patterns**, alternating sequences of light and dark modules arranged horizontally and vertically. These lines help the reader recognize the grid structure and correctly determine the position of the modules in the matrix (ISO, 2024).



Some small areas of the symbol contain format information, meaning technical information needed to read the code. In particular, they indicate the error correction level and the masking pattern used (ISO, 2024).



Larger versions, starting with Version 7, also include version information, a portion of the symbol that indicates the QR Code's version number (ISO, 2024).



Most of the remaining modules form the area intended for data and error correction codes. These areas store the actual information contained in the QR Code, together with the data needed to recover its content even in the event of minor damage or reading imperfections (ISO, 2024).



Types

There are several variants of the QR Code, developed to meet specific needs (DENSO WAVE, n.d.-i).
This is because the *QR* Code is not a single rigid format, but a family of two-dimensional codes designed for different trade-offs between capacity, size, shape and use.

Micro QR Code
It is a more compact version of the traditional QR Code, designed for situations where the available space is very limited and the amount of data to be stored is small. It uses a single finder pattern instead of the three in the standard QR Code and requires a quiet zone of only two modules. There are four versions, from M1 to M4, with matrices ranging from 11 × 11 to 17 × 17 modules (DENSO WAVE, n.d.-d).

rMQR Code
It is a rectangular variant designed for use in long, narrow spaces where a square QR Code would be unsuitable. It offers greater capacity than the Micro QR Code while remaining compact and is particularly useful for labels, components and surfaces with little available space (DENSO WAVE, n.d.-h).

iQR Code
It is a high-density variant that can store more information than a traditional QR Code. At the same size, it can contain up to approximately 80% more information or, for the same data, occupy approximately 30% less space. It can also be square or rectangular and can be used with inverted modules or special industrial marking techniques (DENSO WAVE, n.d.-c).

SQRC
It is a variant designed to restrict access to certain information. It can contain both a public portion of data and a private portion, readable only by compatible, authorized devices. Visually, it can appear identical to a normal QR Code. This function restricts access to the

data (DENSO WAVE specifies that it does not in itself constitute a cryptographic guarantee of their security) (DENSO WAVE, n.d.-i).

Frame QR

It is a variant containing a specific graphic area, called the canvas area, where images, logos, text or other visual elements can be inserted without interfering with the parts of the code needed for reading. It is particularly suitable when the QR Code needs to be integrated into the visual identity of a product or promotional material (DENSO WAVE, n.d.-i).



Content types

A QR Code can encode different types of data. When it is scanned, the device interprets the content and, where possible, automatically suggests a corresponding action, such as opening a website, adding a contact or connecting to a Wi-Fi network (ISO, 2024).
The following table shows the different types of data a *QR* Code can contain.

CONTENT TYPE	**DESCRIPTION**
Link/*URL*	Contains the address of a web resource. After scanning, the device may suggest opening it in the browser.
Text	Directly contains text, which can be displayed even without an Internet connection.
WiFi	Contains the information needed to connect to a Wi-Fi network, such as the network name, security type and password.
vCard	Contains contact information, such as name, telephone number, email address and website, which can be added to the address book.
Email	Can contain an email address and, optionally, a subject and message body, allowing a new email to be prepared.
Telephone	Contains a telephone number and allows the device to suggest starting a call.
SMS	Can contain a telephone number and a predefined message, preparing an SMS for sending.
Payment	Can contain structured data used by compatible applications to prepare a transaction, for example through certain payment systems or cryptocurrencies.

Static and dynamic QR Codes

Based on how the destination is managed, we can distinguish between static and dynamic QR Codes (ISO, 2024; Fielding et al., 2022).

Static QR Code
A static *QR* Code directly contains the data to be read, such as a URL, text or contact information. Once generated, the content encoded in the QR Code cannot be modified: changing the information requires creating a new code (ISO, 2024).

Static *QR* Codes are simple and do not necessarily require external services to work. They are therefore suitable when the content needs to remain stable over time.

However, compared with dynamic *QR* Codes, they have certain limitations: they do not allow the code's destination to be changed later and, on their own, do not provide scan-tracking features. For this reason, they are less flexible in communication or marketing campaigns where content needs to be updated frequently or usage statistics collected (Fielding et al., 2022).

Dynamic QR Code
A dynamic *QR* Code is a *QR* Code that contains a redirect *URL* instead of the final address of the resource to be reached (Fielding et al., 2022).
The *QR* Code itself therefore remains unchanged; what can be modified is the destination associated with the *URL* contained in the code (Fielding et al., 2022).

Its operation can be represented as follows:
QR Code → redirect *URL* → final content

When the user scans the *QR* Code, the browser opens the *URL* stored in the code.
The server managing that address then performs an *HTTP* redirect to the final destination, such as a web page, a document or other online content (Fielding et al., 2022).

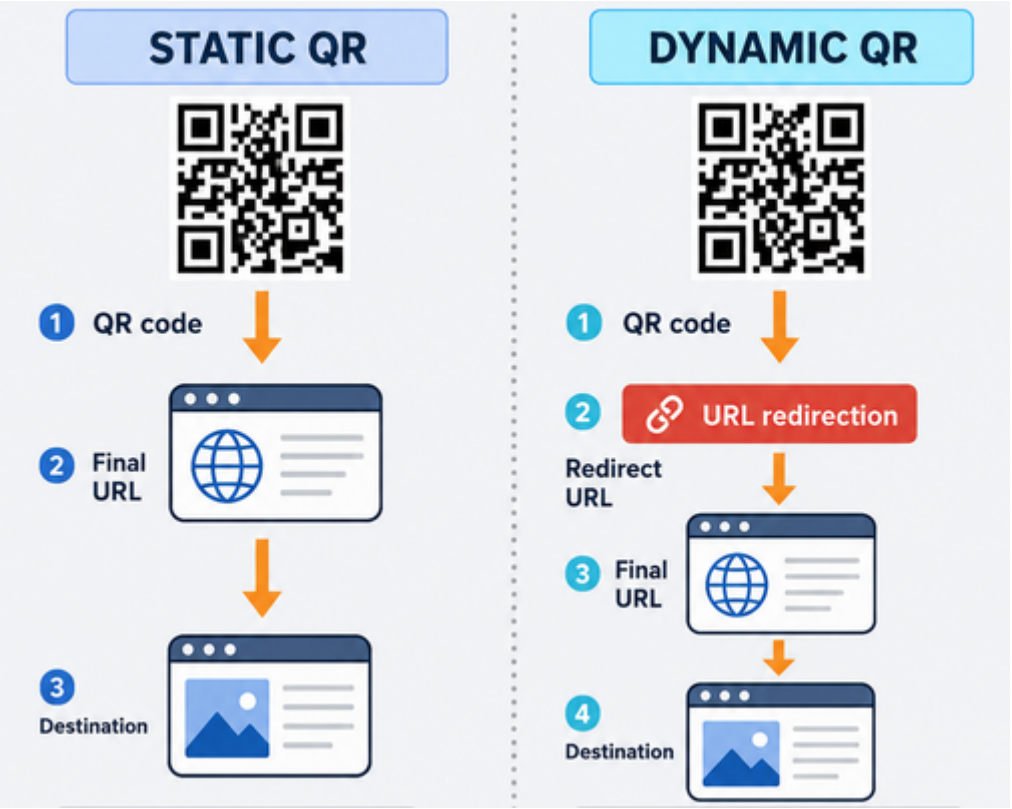
The final destination can be changed over time without modifying the *QR* Code already printed. For example (Fielding et al., 2022):

- Before: *QR* Code → miosito.it/qr1 → Page A.
- After: *QR* Code → miosito.it/qr1 → Page B.

The address stored in the *QR* Code, miosito.it/qr1, remains the same; only the destination to which the server redirects is changed.

Dynamic *QR* Code services can also integrate scan analytics systems. Since each access passes through the redirect server, the service can record information such as the number of accesses, the date and time the redirect *URL* is accessed, the type of device used and, where technically available, an approximate geographical location. However, these functions do not belong to the *QR* Code itself: they are provided by the Web system that manages the redirect (Fielding et al., 2022).

Therefore, a dynamic *QR* Code is not technically a different *QR* Code from a static one (ISO, 2024; Fielding et al., 2022).
Its “dynamic nature” is provided by the Web infrastructure to which the code points (Fielding et al., 2022).



Many commercial dynamic *QR* Code services charge a fee because they have to maintain the redirect service and, where included, the infrastructure needed to collect and process statistics.
However, payment is not a necessary feature of a dynamic *QR* Code.

If you have your own Web space, you can build an equivalent system yourself (Fielding et al., 2022):

- Create a *URL* on your website that redirects to the desired destination.
- Generate a normal *QR* Code containing the redirect URL.
- Change the redirect destination later when necessary.

In this way, the QR Code can continue to be used without being regenerated or reprinted. If your server logs accesses, it is also possible to implement statistics and monitoring systems without necessarily using an external commercial service (Fielding et al., 2022).

QR Code design

In this section, we will see how to design and customize a QR Code while maintaining its readability (ISO, 2024).
The main aspects are color, module shape, size, logo placement and printing surface.

Color
A *QR* Code does not necessarily have to be black on a white background: it can be made using different colors, provided a clear difference is maintained between the dark modules and the light background (ISO, 2024).

However, the most reliable solution remains the traditional one: dark modules on a light background. Some color combinations can reduce the contrast perceived by the reading system and make the code difficult or impossible to recognize. For this reason, using very light modules on dark backgrounds or color combinations with very similar brightness is generally discouraged (ISO, 2024).

Shades or gradients can also be used, but they must maintain sufficient contrast throughout the code area. Color customization should also not compromise the quiet zone or make the individual modules hard to distinguish (ISO, 2024).

Contrast checkers used for text accessibility can be useful as a general indication, but they do not on their own guarantee the readability of a QR Code (ISO, 2024).
The most important check is therefore to test the code under real conditions of use, using different devices and considering size, print medium, lighting and reading distance (ISO, 2024).
You can check whether the two colors have good contrast using the application on this website.



Module shape
The modules of a QR Code do not necessarily need perfectly square corners. For graphic design purposes, they can be rounded or replaced with different shapes, such as circles, diamonds or other geometric elements, provided the overall structure of the code remains clearly recognizable (ISO, 2024).

However, excessive customization can reduce QR Code readability because it makes the individual modules harder to distinguish correctly (ISO, 2024).

It is therefore advisable to mainly modify the appearance of the data modules, paying particular attention to functional elements such as finder patterns, timing patterns and alignment patterns (ISO, 2024).

Finally, any customized *QR* Code should be tested with different devices and reading conditions before printing or publication (ISO, 2024).



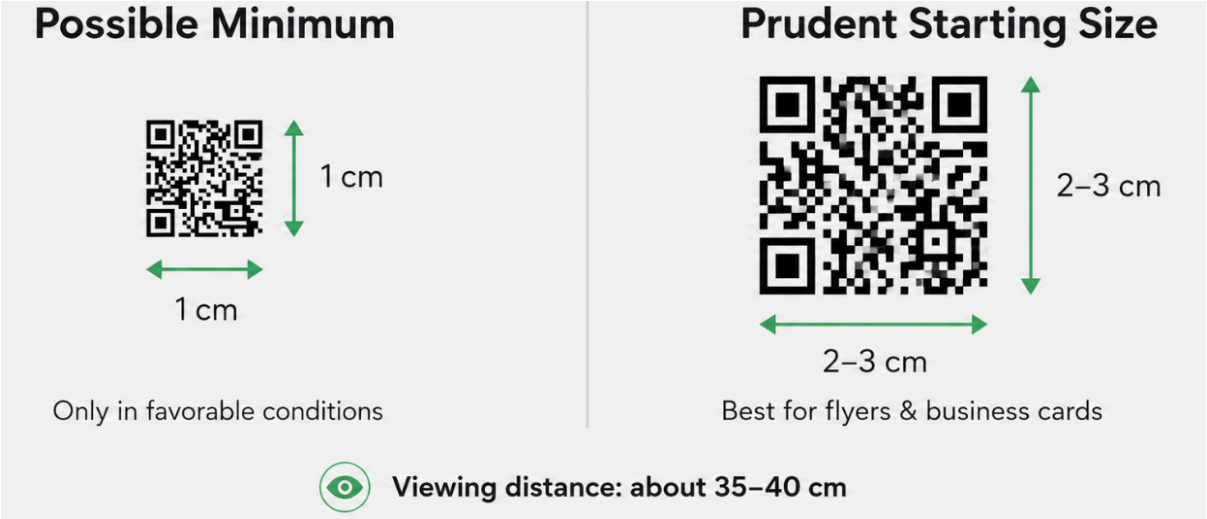
Size
To be read correctly, a *QR* Code must be sufficiently large in relation to the density of the matrix, print quality and the characteristics of the device used for scanning (DENSO WAVE, n.d.-f).

There is therefore no universal minimum size valid for all *QR* Codes (DENSO WAVE, n.d.-f). The physical size of the symbol depends mainly on its version and the size of the individual modules that make up the matrix (DENSO WAVE, n.d.-f).
Increasing the amount of data generally also increases the number of modules needed, making the QR Code denser (DENSO WAVE, n.d.-b).

Reducing the code too much also means making the individual modules smaller, which may prevent them from being reproduced accurately enough by the printer or recognized by the camera or reader (DENSO WAVE, n.d.-f).
For this reason, for the same available space, it is preferable to limit the amount of encoded data and use the smallest possible version compatible with the content (DENSO WAVE, n.d.-f).

As a design guideline, it is advisable to print the *QR* Code as large as the layout allows, especially when it needs to be read quickly or in uncontrolled conditions. DENSO WAVE recommends choosing the module size by considering both print resolution and the capabilities of the reading device (DENSO WAVE, n.d.-f).

For common applications, such as flyers or business cards viewed from approximately 35–40 cm away, a size of 2–3 cm per side can be a cautious starting point. Under favorable conditions, smaller QR Codes, down to approximately 1 cm per side, can also be used, but readability must always be checked on the actual medium.



When a QR Code needs to be scanned from a distance, for example on a poster, shop window or billboard, its size must be increased (DENSO WAVE, n.d.-f).

As an approximate rule of thumb, a reading distance of around 10 times the side length of the QR Code can be considered:
$Reading\ distance \approx 10 \times QR\ Code\ side\ length$

For example, a QR Code with a side length of 10 cm can be designed to be read from approximately 1 meter, while a 1-meter QR Code can be intended for a distance of approximately 10 meters.

However, this relationship is only a design estimate: the actual distance also depends on the density of the matrix, the size of the individual modules, print quality, the camera used, lighting and the viewing angle (DENSO WAVE, n.d.-f).
In fact, the official DENSO WAVE documentation does not establish a universal ratio between the overall size of a QR Code and the maximum reading distance (DENSO WAVE, n.d.-f).



For a standard QR Code, the quiet zone must be at least 4 modules wide on each side (DENSO WAVE, n.d.-e).

For example, if each module measures 0.5 mm, the quiet zone must be at least $2mm$ wide.
Indeed:
$4 \times 0,5\ mm\ =\ 2\ mm$





Logo placement
A logo, icon or graphic element can be inserted inside a *QR* Code to integrate it more closely with the visual identity of a product or project (ISO, 2024).

However, in a standard *QR* Code, the image is placed over some of the code's modules, making part of the information in the matrix unusable (ISO, 2024).
For this reason, it is important to avoid covering functional elements needed for reading, such as finder patterns, timing patterns, alignment patterns and the areas containing format and version information (ISO, 2024).

The logo is often placed in the central area of the *QR* Code because this position tends to interfere less with the main structural elements, but the center is not automatically a completely clear area: the correct position also depends on the version and specific structure of the code (ISO, 2024).



The possibility of covering part of the matrix also depends on the error correction level. A higher level makes the *QR* Code more tolerant of the loss of some modules and can therefore make it easier to insert graphic elements (DENSO WAVE, n.d.-g).
However, there is no universally safe logo size: increasing the covered area also increases the risk that the code can no longer be decoded (ISO, 2024).

For this reason, when customizing a QR Code, it is advisable to (ISO, 2024):

- Keep the code's functional elements intact.
- Leave the quiet zone unchanged.
- Limit the area covered by the logo or graphics.

- Use an appropriate error correction level.
- Always check the final result with different devices and reading conditions.

Highly customized QR Codes can also be created by modifying colors, module shapes and graphic elements. However, customization must keep the structure needed for decoding recognizable: the visual appearance can change, but it must not compromise the code's operation (ISO, 2024).



Printing surface

The surface of the material on which a *QR* Code is printed can affect its readability. A very rough, uneven or porous surface can distort the edges of the modules, absorb ink differently or produce imperfections that make the matrix less distinct (ISO, 2024).

On difficult surfaces, it is therefore advisable to use larger modules and consequently increase the overall size of the *QR* Code (DENSO WAVE, n.d.-f).
On smooth surfaces with good print quality, on the other hand, smaller modules can be reproduced while maintaining good definition (DENSO WAVE, n.d.-f).

However, roughness is not the only factor.
Other characteristics of the medium can also affect scanning, such as glossiness, reflectivity, achievable contrast, the type of ink or printing and any deformation of the surface (ISO, 2024).
A very glossy surface, for example, can produce reflections that make the code harder to read (ISO, 2024).

Materials such as paper, plastic, metal or fabric can therefore be used to print a *QR* Code, but their suitability depends on the specific surface finish and printing technique used, not simply on the material itself (ISO, 2024).

For this reason, when a *QR* Code needs to be applied to a particular medium, it is important to check its readability directly on the final product and under real conditions of use (ISO, 2024).



Uses

The *QR* Code can be used in many fields and perform different functions (DENSO WAVE, n.d.-a).
For example, it can appear on business cards, packaging, posters, advertising materials, documents, tickets, labels and products.

One of its main advantages is the possibility of creating a quick link between a physical medium and digital content (DENSO WAVE, n.d.-a).
By scanning a *QR* Code, users can directly access a web page, video, online form, document, contact information or other services without having to type an address manually.

In communication and marketing, *QR* Codes can therefore be used to extend the information available on printed media (DENSO WAVE, n.d.-a).
For example, packaging can link to instructions, recipes or video tutorials, while a poster can link to a page with further information, a booking or an online form.

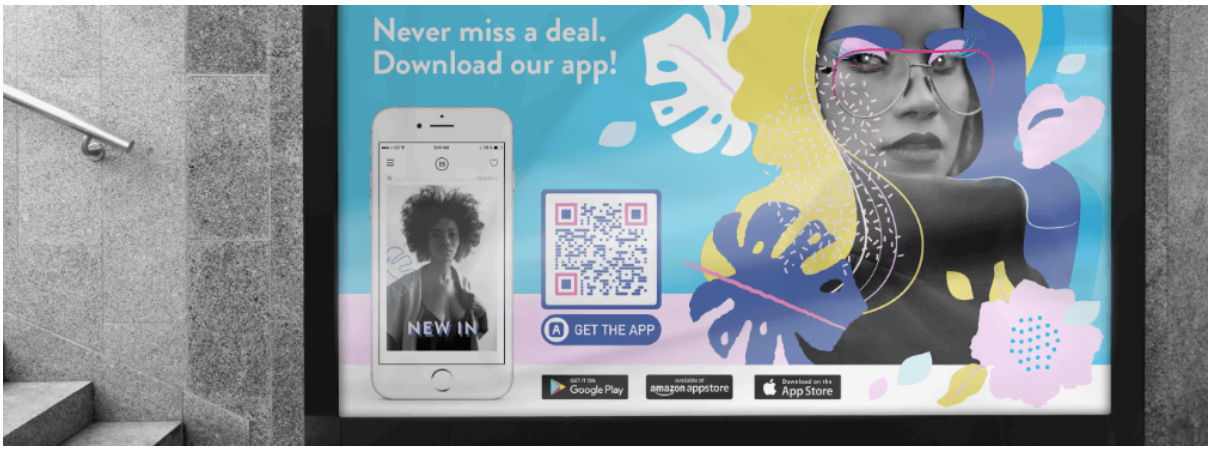
QR Codes are also used in technical and industrial contexts (DENSO WAVE, n.d.-a).
They can be applied to products, components or documents to identify them and link them to information stored in a digital system. For example, an operator can scan a code to consult

data about a component, check a processing stage or update information associated with a production process (DENSO WAVE, n.d.-a).

The *QR* Code can therefore perform a dual function (DENSO WAVE, n.d.-a):

- Communication tool, connecting physical media and digital content.
- Tool for identification and access to data within technical and organizational processes.

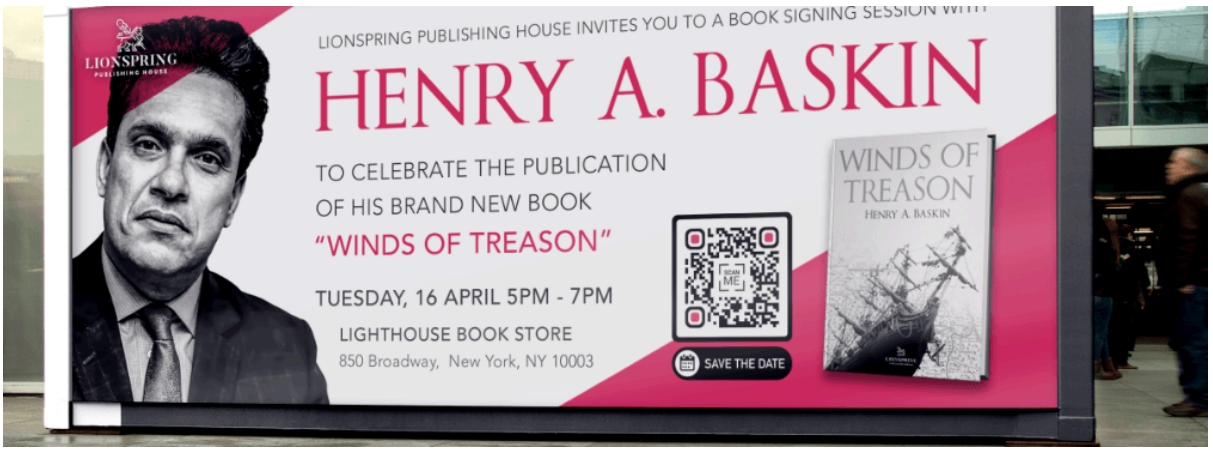





Apparel
Sale
Day
30% OFF on the NEW
COLLECTION
scan QR Code to get
30% off your purchase!


SCAN THE CODE
TO FOLLOW US FOR
DEALS & OFFERS
CIAO PIZZA


GRAND HOTEL
GIVE FEEDBACK
Scan the code to help us improve our services


LIONSPRING PUBLISHING HOUSE INVITES YOU TO A BOOK SIGNING SESSION WITH
HENRY A. BASKIN
TO CELEBRATE THE PUBLICATION
OF HIS BRAND NEW BOOK
"WINDS OF TREASON"
TUESDAY, 16 APRIL 5PM - 7PM
LIGHTHOUSE BOOK STORE
850 Broadway, New York, NY 10003
SAVE THE DATE
WINDS OF TREASON
HENRY A. BASKIN


QR CODE
Business Card
Name
Title
Phone
E-mail
Web Site


CASHLESS PAYMENT
ACCEPTED HERE
Scan to pay

Supplementary materials

Exercises

How is a QR Code constructed?

Observe a normal QR Code and analyze its structure.

- Explain what modules are and what function they perform.
- Explain the function of the three finder patterns in the corners.
- Explain why a QR Code must be surrounded by a quiet zone.
- Describe the function of alignment patterns.
- Explain what timing patterns are used for.
- State what information is contained in the format information.
- Explain what version information represents and from which version it appears.
- Identify which areas contain the actual encoded data.
- Explain why it is not possible to arbitrarily modify any graphic part of the QR Code.
- Draw a schematic QR Code and label at least four of the functional areas studied.

Version, capacity and error correction

Three QR Codes must contain, respectively:

- A telephone number.
- The address of a Web page.
- A very long text.

Answer the following questions.

- Explain what the version of a QR Code indicates.
- Compare Version 1 with Version 40 in terms of matrix dimensions.
- Explain why increasing the amount of data may require a higher version.
- Explain why a larger matrix can make the QR Code denser.
- Describe the four error correction levels L, M, Q and H.
- Which level allows the largest amount of damaged data to be recovered?
- Explain why increasing the error correction level reduces the space available for data at the same version.
- A QR Code needs to be printed on a label that could become scratched during use. Explain why a higher correction level might be appropriate.
- Explain why it is nevertheless incorrect to conclude that level H is always the best choice.
- State the three main factors that determine the actual capacity of a QR Code: encoding mode, version and error correction level.

Static or dynamic?

A company wants to use QR Codes in these situations:

- Case A. The QR Code contains the password for the office Wi-Fi network.
- Case B. An advertising poster must point to Page A today, but to Page B in a month without reprinting the poster.
- Case C. A business card must contain a name, telephone number, email address and website.

- Case D. An advertising campaign must make it possible to know how many times the QR Code is used.

For each case:
- Identify what type of content could be encoded.
- Determine whether a static or dynamic QR Code would be more appropriate.
- Justify your choice.
- Explain why a static QR Code cannot change its content after it has been generated.
- Then explain how a dynamic QR Code works conceptually through the sequence: QR Code → redirect URL → final destination.
- Explain which component is modified when the destination of a dynamic QR Code changes.
- Explain why scan statistics are not an intrinsic property of the QR Code.
- Describe how a dynamic QR Code could be created using your own website, without necessarily depending on a commercial service.
- Finally, explain why, technically, a QR Code described as “dynamic” is still a normal QR Code.

QR Code for a business card
You need to design a QR Code to place on a business card that provides access to your personal portfolio

Create the QR Code in practice.
- Choose the URL to encode.
- Decide whether to use a static or dynamic QR Code and justify your choice.
- Generate the QR Code using a generator.
- Customize the colors if desired, keeping the modules sufficiently dark and the background light.
- Keep the quiet zone intact.
- Insert the QR Code into the business card design.
- Choose an appropriate size, considering a usage distance of approximately 35–40 cm. As a cautious reference, the handout suggests approximately 2–3 cm per side for flyers and business cards.
- Print a copy at actual size.
- Check readability with at least three different smartphones.
- Try scanning under different lighting conditions.
- Gradually reduce the size of the QR Code and identify when reading starts to become unreliable.
- Submit the final QR Code together with a short report justifying its size, colors, content and the choice of static or dynamic.

QR Code for a poster
You need to create a poster for an event. The QR Code must lead to the booking page and be scannable from approximately 2 meters away.
- Create a page or identify an appropriate destination URL.
- Decide whether to use a static or dynamic QR Code. Consider that the destination page might change after the poster is printed.
- Generate the QR Code.

- Using the relationship indicated in the handout as an initial design estimate, according to which the reading distance can be approximately 10 times the side length of the QR Code, calculate a possible starting size.
- Insert the QR Code into the poster without compromising the quiet zone.
- Check that the surrounding graphic elements do not make the code difficult to distinguish from the background.
- Print or display the poster at its intended size.
- Try scanning from 50 cm, 1 m, 1.5 m and 2 m.
- Repeat the test with different lighting and viewing angles.
- If scanning is unreliable, modify the size, contrast or density of the QR Code.
- For each distance, record whether scanning is immediate, slow or impossible.
- Conclude by explaining why the 10:1 ratio is only a design estimate and not a universal rule.

Designing a customized QR Code

A company wants to place a QR Code on a product's packaging that links to a video tutorial. The code must be consistent with the brand's visual identity and contain the company logo. Create an initial version and then optimize it.

- Generate a QR Code containing the video tutorial's URL.
- Choose an appropriate error correction level, considering that a logo will also be inserted.
- Customize the color of the modules while maintaining high contrast with the background.
- If desired, modify the shape of the modules without making them difficult to distinguish.
- Place the logo in an area that interferes as little as possible with the code's structure.
- Avoid covering finder patterns, timing patterns, alignment patterns, format information and version information.
- Leave the quiet zone unchanged.
- Produce three variants with a small, medium and large logo, respectively.
- Check which of the three versions remains most reliable when scanning.
- Print the QR Code on the final medium or on a material as similar as possible.
- Check the influence of any surface characteristics, such as roughness, glossiness or reflections.
- Test each version with multiple devices, distances and lighting conditions.
- Choose the final version by finding a balance between visual identity and reading reliability.
- Submit the final QR Code and document the tests performed, explaining which customizations you kept and which you removed because they compromised scanning.

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Further reading

- Roger C. Palmer, The Bar Code Book: A Comprehensive Guide to Reading, Printing, Specifying, Evaluating, and Using Bar Code and Other Machine-Readable Symbols, 5th ed., Trafford Publishing, 2007 — Probably the strongest technical complement to the handout. It examines both one-dimensional and two-dimensional barcode technologies, including symbol structure, scanning, printing, quality evaluation, standards, and image-based reading. It is particularly useful for understanding why elements such as module dimensions, print quality, contrast, scanning technology, and symbol specifications affect reliability.
- Joe Waters, QR Codes For Dummies, Portable Edition, Wiley, 2012 — The most directly focused book on QR Codes in the selection. It introduces QR Code creation and scanning, practical deployment, links to mobile content, code-management systems, tracking, and strategies for using QR Codes in communication. It is particularly relevant to the handout's sections on static and dynamic QR Codes, business cards, posters, advertising, and real-world applications.
- Daniel Rowles, Mobile Marketing: How Mobile Technology Is Revolutionizing Marketing, Communications and Advertising, 2nd ed., Kogan Page, 2017 — A very useful complement for understanding QR Codes as a bridge between physical communication and digital services. The book contains an entire chapter devoted to QR Codes, including practical applications, adoption, visual customization, and real-world implementation. It also places QR Codes alongside mobile websites, NFC, location technologies, mobile payments, and analytics.
- Marianne R. Klimchuk and Sandra A. Krasovec, Packaging Design: Successful Product Branding From Concept to Shelf, 2nd ed., Wiley, 2013 — Particularly relevant to the sections on QR Code design, printing surfaces, visual identity, color, logos, and packaging applications. The book examines typography, color, imagery, materials, production, branding, and pre-production issues, making it useful for understanding how a QR Code becomes one element within a larger designed artifact rather than an isolated technical symbol.

- Jordan Frith, Barcode, Bloomsbury Academic, 2023 — A more cultural and historical complement. The book examines barcodes as technologies connecting the physical and digital worlds and includes a chapter specifically devoted to the history and development of the QR Code. It is useful for placing QR Codes within the broader evolution of automatic identification technologies and understanding why they became so widespread outside their original industrial context.

Editorial notes

In producing these materials, I have used generative artificial intelligence tools to support the writing process, particularly to improve the form of the text, reorganize content, refine wording, and speed up certain editorial tasks.

As I work independently on the production of these materials, I try to automate any activities that can reasonably be automated, so that I can devote more time to research, design, and content development.

However, artificial intelligence does not determine the content of this work: the choice of topics, structure, ideas, interpretations, examples, and teaching approach are developed by me. AI is therefore used primarily as a tool to support production and formal revision, while authorship and responsibility for the design and content remain mine.

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