Calypso Networks Association Handbook V1.0

Connecting the digital ticketing community

Calypso Networks Association

Executive Summary

The public transport and new mobility sector is at the heart of sustainable development in urban areas. Among all the components of a transport system, ticketing plays a special role. Not only does it partly finance operations, but also it contributes to the appeal of public transport.

Ticketing is a crucial gateway to travel and ensures the right to transport for all. It enables authorities to facilitate and implement their mobility policies. Therefore, ticketing systems must be **simple** to be accessible to all, **open** and **flexible** to keep pace with change, and **sovereign** so that they are not dependent on third-party interests.

Ticketing systems based on the open and innovative technological standard: **Calypso®** achieve this.

Calypso® is first and foremost THE open technological standard used worldwide by public transport networks to deliver contactless ticketing. Resisting cyber-attacks for more than 20 years, it enables security, agility and innovation. The open standard is not tied to any manufacturer or vendor, making it both economical, durable and adaptable to the permanent evolution of technologies, integrated mobility and Mobility as a Service (MaaS).

Calypso is simple and flexible, working for all types of public transport and mobility users, in card form or other form factors, such as in smartphones.

Calypso is a technical solution, widely adopted and deployed by millions of daily users in France, Belgium, Portugal, Italy, Maghreb countries, Quebec, Mexico, Israel and beyond. Efficient, secure and ergonomic thanks to contactless near field communication (NFC), it is much faster and easier to use than other solutions. Vitally, Calypso is supported by a large ecosystem of card and ticketing companies.

Since its inception, Calypso technology has been based on dual sourcing at all levels, making it uniquely resilient at the electronic components level. Calypso proves that issues of component shortages, leading to production delays and disruptions, can be mitigated through secure and diverse supply chains.

Calypso implementation can rely on open-source software modules called Eclipse Keyple. These modules are developed, maintained and enriched by an ecosystem of developers and industrialists, who are committed to economically delivering sustainability, openness and innovation.

Like open data policies, open-source codes, open algorithms, and free and open-source software policies, Calypso Keyple ensures functional, technical, and financial sovereignty for transportation stakeholders. Open source across the industry guarantees the reduction and control of costs. This is fundamental, as cost so often is a barrier to proprietary ticketing systems, which are synonymous with excessive or even impossible evolutions.

Finally, due to its agility, Calypso is perfectly positioned to support the simplification and convergence of digitalised mobility services through MaaS and multiservice, city cards, citizen cards. Calypso products and solutions make MaaS accessible to all. It enables the deployment of contactless multiservice cards (physical or virtual) unifying access to public and private equipment and services, such as parking, swimming pools, gyms, municipal halls, libraries, museums, school canteens or university restaurants, in full alignment with personal data protection.

Who should read this document?

This document should be read by individuals and consultants who:

- Already use Calypso and need to learn more about the standard.
- Are new to Calypso and seek further background and context on the standard.
- Are considering adopting Calypso to deliver an agile ticketing solution.
- Advise clients on sustainable ticketing within mobility.
- Are authorities, regulators and decision makers in the mobility sector needing to better understand the ecosystem and key actors.

The Calypso handbook provides:

- Calypso facts and figures: where it has been implemented and latest figures.
- The role of Calypso technology in the ticketing ecosystem.
- The offering of Calypso and the benefits it brings to different parties in the ticketing value chain.
- Introduction to Calypso Networks Association (CNA) and its governance role to support the evolution and sustainability of Calypso technology.
- The cost of ownership, and how Calypso technology helps transport operators and authorities control finances through a ticketing systems lifecycle.
- Overview of how to implement Calypso technology.
- How to join and participate in the ticketing community to ensure the future of the Calypso technology: Have your say.

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Introduction from the Chairman of CNA

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Introduction from the Chairman of CNA

hello As the governing body of Calypso technology, Calypso Networks Association (CNA) was founded with one simple aim: to support the use of the open Calypso technology standard and to enable transport and mobility operators to control and advance their contactless ticketing systems.

To support our mission, we are pleased to share the CNA Handbook: a comprehensive resource outlining all aspects of the Calypso standard, its role within the ticketing ecosystem, and the role of CNA as a global not-for-profit technical association.

The handbook is designed to educate and provide clarity for new and established members of the Calypso community. We believe strongly in transparency, which is why the information within this document directly answers common questions.

Whether you are reading this as a longstanding member of the community, or considering working with us in the near future, I hope you find this document an informative resource to support your contactless ticketing requirements.

As a reminder, CNA provides a unique opportunity to exchange ideas, experiences, and requirements within a supportive and collaborative environment. By working together, there is an opportunity to secure control over the smart ticketing ecosystem and create a sustainable framework for the future. We warmly welcome new members to join our community.

If you would like to discuss any aspect of Calypso in further detail, please do not hesitate to get in touch using the contact details on page 71.

With warm wishes,

Gianluca Cuzzolin
Chairman of Calypso Networks Association

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Read Transport Ticketing Trends to get the latest industry insights

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Calypso in numbers

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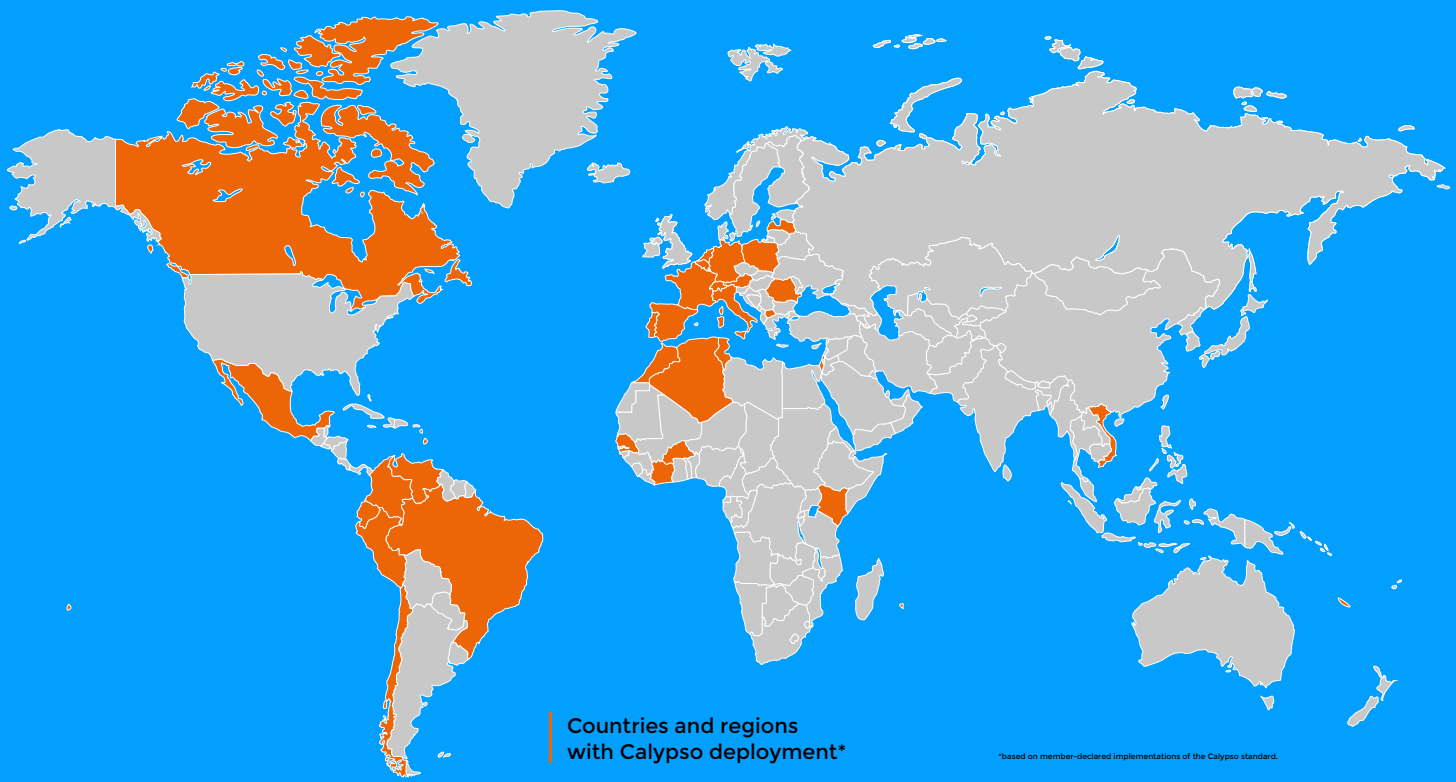
CNA regulates the use of Calypso technology, and delivers expert services, to promote open standards and enable their use across local, regional, national and global ticketing requirements

Calypso in numbers



Countries and regions with Calypso deployment*

*based on member-declared implementations of the Calypso standard.

Number of members

112

Active Technical Committees

6

Countries with Calypso deployment

28

Travel cards shipped in the last three years

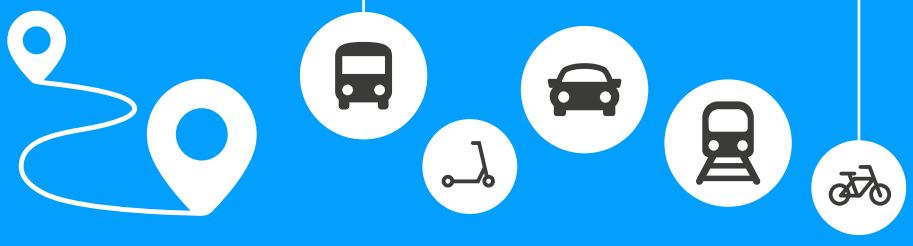
60.7m+

Certified products

48

Activated mobile solutions

1m



Estimated journeys delivered by Calypso each day

31m+

As of the beginning of 2022, the Calypso standard is deployed in 28 countries worldwide. With more than 40 manufacturers engaged with Calypso, 48 products certified and 3 independent sources of chips, transport operators and authorities have confidence that they will not be locked-in by a single vendor.

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Calypso in the ticketing ecosystem

The place of Calypso in the ticketing system

Calypso is a proven, open, and secure ticketing standard that promotes innovation. It is designed by transport operators and authorities for transport operators and authorities, to ensure long-term usability and sustainability.

Calypso is present at every level of the ticketing system. It can be found in:

- The media, either as a smartcard, a mobile or a wearable.
- The protocol used to secure the exchanges between the media and the terminal, providing a strong mutual authentication that is crucial for many usage scenarios.
- The terminal, with a clear set of requirements, recommendations, and even an Open-Source Software Development Kit (SDK).
- Securing the transactions that are exchanged between terminals and central systems, providing a high level of traceability and transparency.
- In multiple modules of the central system, such as online reloading/issuance, clearing, secure access module (SAM) management, account-based ticketing (ABT).

It enables multiple usage scenarios, both for transport and associated services, via a wide range of products and solutions.

The Calypso Specifications started by describing how a Calypso media should interact with the devices of the transit network and have been continuously expanded to bring the same level of standardisation and openness to the terminal and central system level.

Today Calypso's specifications, recommendations, and best practices can be found at any level of a ticketing system, from the media to the central system, bringing an unparallel level of trust, control, and transparency. They cover multiple usage scenarios both for transport and associated services from the classical offline transaction to newer ABT models.

Did you know

Calypso was originally designed as a closed-loop system, addressing the functionality required and technical challenges faced by transport authorities and operators wanting to deliver contactless tickets unique to their specific transport network. As technology has evolved, so has Calypso, and today it can be used in range of configurations, including supporting open-loop ticketing needs.

The Calypso open standard benefits the entire ticketing ecosystem

When a ticketing system is based on Calypso it brings unique benefits to different stakeholders.

For a public authority, for a transport authority:

The mission of a public authority is to organise public transport in its area. It defines all aspects of mobility policy, including infrastructure, types of transport, as well as commercial, social and fare policies. Its objective is to provide sustainable mobility that is accessible to all and attractive, in order to influence the mode of transport used and contribute to decongesting cities. As ticketing is vital to orient mobility policy public authorities must have full sovereignty over this tool; it must be certain that it will not be limited in its actions, decisions or responsibility due to third party interests beyond its control. For example, pressures or restrictions from financial institutions, Google, Apple, Facebook and Amazon (GAFA) or manufacturers and other commercially driven parties.

Positioning a Calypso open standard solution at the heart of a ticketing system provides a transport authority with the best guarantee of ultimate control over its ticketing offering.

KEY POINTS

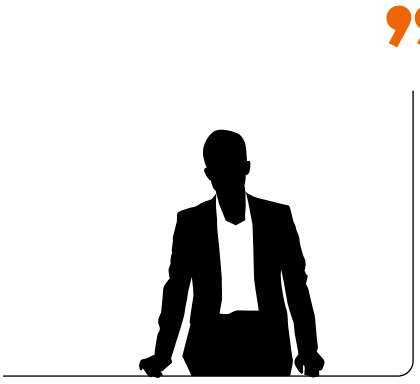
- **Calypso represents a sustainable solution, proven for more than 20 years.**
- **It continues to be at the forefront of innovation, offering the best service to citizens at the best cost.**
- **It can be multi-sourced at all levels, therefore sustainable and resilient to market changes.**
- **The open-source dimension contributes to even further cost reductions.**

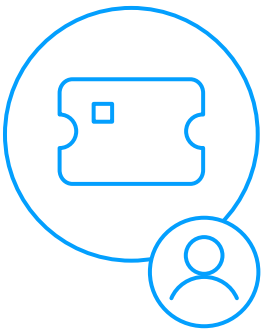
For a transport operator:

The role of the transport operator is to deliver the public transport mission, according to the requirements defined by the transport authority. The contract between the two parties either places the ticketing system under its responsibility and it is mandated to build and operate the system, or it must take over the operation of a ticketing system that has been set up directly by the authority.

The operator must choose a sustainable, reliable solution that will meet public commitments and expectations. Its goal is to understand the intricacies of the system, ensure competitive costs through the system's lifecycle and that the technical investment is effective long-term, offering the ability to evolve in line with customer needs, expectations, and technical advances.

For the transport operator, Calypso means a reliable, proven solution, guaranteed to offer the best ergonomic experience to the customer, avoid operation issues or security challenges and ultimately ensure it fulfils its requirements towards the authority.





For a ticketing consultant:

As a trusted partner for the purchaser of the ticketing system, the objective of the ticketing consultant is to give the best possible advice to their client. They know that they must specify the system, not only in response to the expectations and needs explicitly expressed, but that the specification must also be open and evolving, as it is hard for any client to express from the outset the extent of future evolutions. It is up to the consultant to make the best compromise to prevent defining a system that reaches its limits too quickly or making it to big, leading to unnecessary, excessive costs.

For the consultant specifying a ticketing system, Calypso can answer all their needs: those expressed and those unknown. In the context of cost control brought by a multi-source open standard, and with a clear orientation towards open source, Calypso remains at the forefront of innovation.

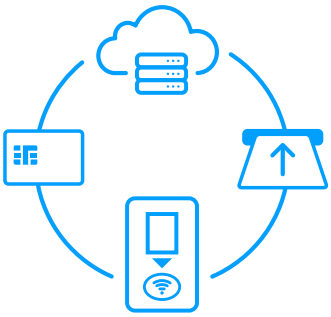
Consultants can provide clients with guarantees of interoperability, resilience, reliability, and independence that no other solution is able to give.

For a MaaS provider:

All transport authorities and providers must increase their focus to offer a cohesive, seamless ticketing experience, accommodating the flexibility of MaaS and the multimodal offering it supports. Mobile ticketing (m-ticketing) will become a big driver of MaaS adoption, enabling multimodal ticketing from a device many people already carry with them everywhere. However, with cards remaining a key tool in the transit planner's portfolio for the long term, ticketing smartcard solutions must also offer the same level of integration and convenience for passengers. By enabling this, transit networks can achieve MaaS for all.

Using Calypso is an opportunity for the MaaS provider to reach a much wider customer base. With its 'MaaS for all' offer, Calypso combines public transport ticketing and MaaS on the same platform, whether it is a transport card or a virtual solution in a smartphone, or even in a bank card.

All mobility offers are therefore fully complementary, and all fare chains are easy to implement.



For a ticketing integrator:

As the party responsible for assembling the system based on different components, some of which are bespoke designs (e.g., application software for servers and equipment), others which are acquired from subcontractors or third parties (e.g., terminals), the integrator must ensure that the system operates in accordance with the functional, performance, interoperability, reliability, availability, and security expectations of the customer.

The integrator cannot take any risks on the technological standard at the heart of the ticketing system: there needs to be absolute certainty that the standard will not be limited, will be resilient to changing market factors/ advances, and, crucially, have an ability to evolve. And of course, the standard must also offer the best quality/price ratio so as not to limit the profit margin.

For the integrator, Calypso offers an agile solution, delivering functional guarantees, reliability and security, alongside the capacity to interoperate. In addition to this, the open-source ability of Calypso to integrate in a system at the terminal level is expected by customers today. It also provides guarantees of solution durability, as there are no unique dependencies needed to manage Calypso during its lifecycle.

For a card manufacturer:

For a card manufacturer: Their aim is to increase their added value in the lifecycle of the products being supplied to customers, in this case: cards. Beyond the integration of a chip and an antenna in the plastic core of a card, what further role can card manufacturers play?

Calypso increases the card manufacturer's added value in the contactless ticketing value chain.

The standard, unlike other technologies, enables the development and certification of Calypso software. This gives the ability to optimise products, to differentiate the offering competitively by its performance, and to freely choose component suppliers to get the best economic return.

For a chip manufacturer:

With Calypso, an electronic component manufacturer does not bear the responsibility for this standard.

Most other ticketing technologies are owned by a chip manufacturer, who is solely responsible for its maintenance and evolution. This position is essentially a monopoly. With Calypso, they can choose to develop the software because it is open and/ or focus exclusively on producing the best possible chip components.

Calypso is an open standard /

Calypso is an open standard, as it fully meets the definition given by the International Telecommunications Union:

"Open Standards" are standards made available to the general public and are developed (or approved) and maintained via a collaborative and consensus driven process. "Open Standards" facilitate interoperability and data exchange among different products or services and are intended for widespread adoption.

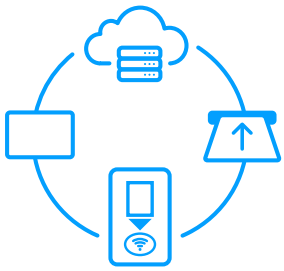
Other elements of "Open Standards" include, but are not limited to:

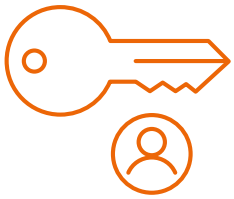
- **Collaborative process** – voluntary and market driven development (or approval) following a transparent consensus driven process that is reasonably open to all interested parties.
- **Reasonably balanced** – ensures that the process is not dominated by any one interest group.
- **Due process** – includes consideration of and response to comments by interested parties.
- **Intellectual property rights (IPRs)** – IPRs are essential to implement the standard to be licensed to all applicants on a worldwide, non-discriminatory basis, either: (1) for free and under other reasonable terms and conditions; or (2) on reasonable terms and conditions (which may include monetary compensation). Negotiations are left to the parties concerned.
- **Quality and level of detail** – sufficient to permit the development of a variety of competing implementations of interoperable products or services. Standardised interfaces are not hidden or controlled other than by the entity promulgating the standard.
- **Publicly available** – easily accessible for implementation and use, and at a reasonable price.
- **On-going support** – maintained and supported over a sustained period of time.

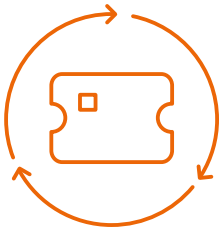
Calypso strictly meets all these characteristics and obligations:

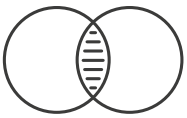
- The standard is managed by CNA, in a collaborative process under the governance of the CNA Board, elected by all its users who have chosen to join the open association. This process brings together users and suppliers of the standard, combining the expression of needs and technological possibilities.
- The standard is accessible through a license available to all contactless smart card and component manufacturers, and is therefore non-discriminatory, with reasonable conditions and rates (and considered as such by all the representatives of the profession) strictly identical for all.
- The Calypso license allows the development of a rich product and software offering compliant with the specifications. It is accessible to buyers in competitive environments, guaranteeing the best price for a given level of characteristics and performances.

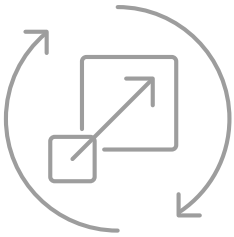
Calypso is more than an open standard









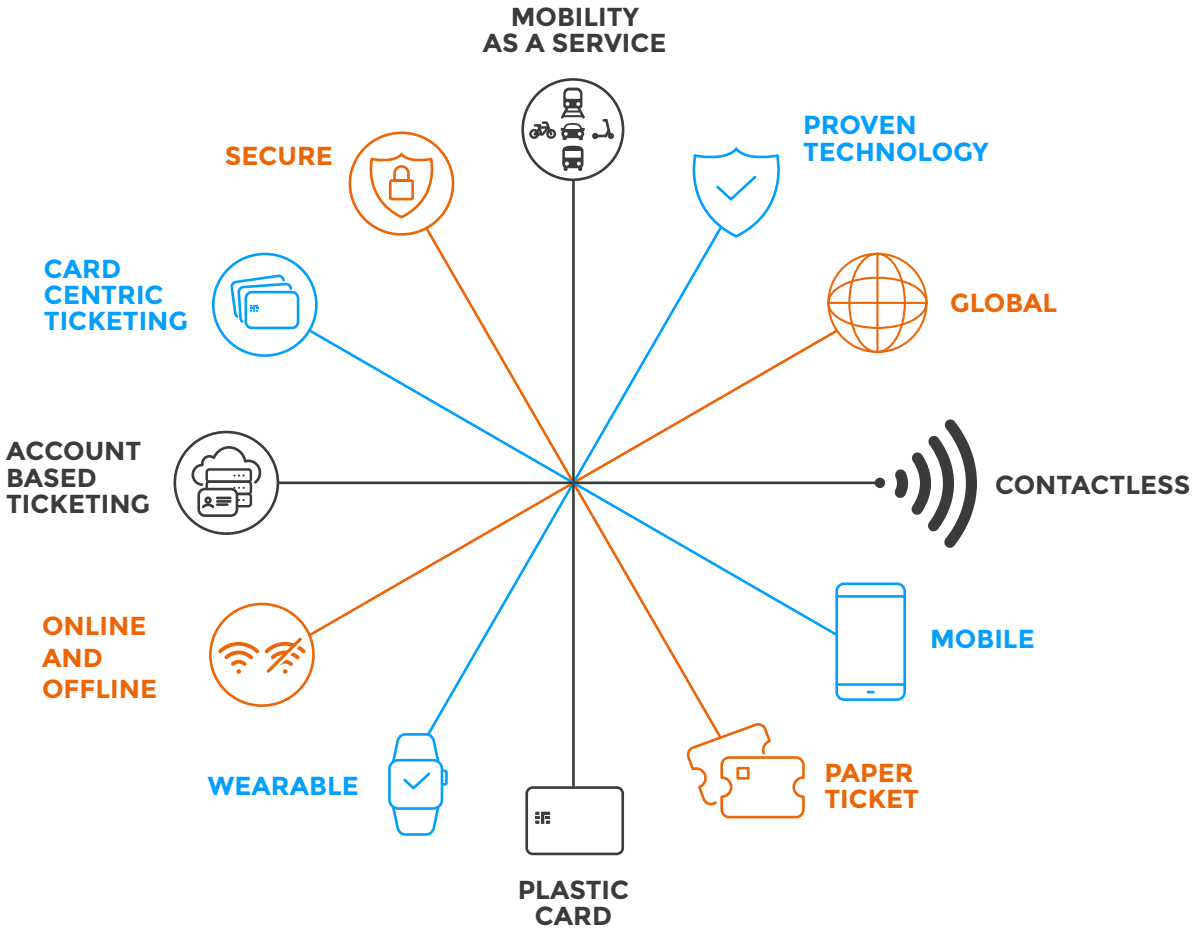


But Calypso goes beyond these basic principles of open standards by offering a greater guarantee of independence:

- The collaborative management process of the standard is ensured by its users alone, including transport authorities and operators, and more broadly, operators of services using Calypso cards, who ensure the governance of CNA and make decisions.
- The financing of the management, the maintenance and the evolution of the standard is ensured by the license revenues. This gives CNA full financial autonomy and guarantees its complete independence.
- Calypso goes beyond open standard principles and offers the possibility of implementation in a ticketing system with open-source modules, which are the ultimate goal of openness and technical independence.

04

How Calypso supports the ticketing ecosystem



An open standard offers a precise, well-defined notion that responds to clear and easily verifiable principles and characteristics: collaborative management, access via non-discriminatory and reasonable conditions, multisource, and interoperability.

In practical terms, this means that while a proprietary solution can only be purchased from a single supplier (even if sometimes a network of resellers masks this exclusivity and the single source), the buyer has a 'real' competitive offer and can compare several solutions from several suppliers to choose the one with the best quality/price ratio.

At a functional and performance level, the open standard therefore translates into savings on the cost of ownership of a ticketing system. Why? Because the possibility of competition at each stage of its lifecycle avoids the high costs involved in a direct purchase.

Calypso's resilience

In addition to its economic efficiency, the open standard also provides resilience. Multisourcing is the best possible guarantee to avoid supply disruptions, and to avoid being subject to the risks of market-driven or shareholder decisions over which the operator of a ticketing system has no influence. The history of industry is marked by these managerial decisions that put an end to a product line, or modify its characteristics, or choose to favour one customer over another.

Calypso addresses these uncertainties. It offers resilience, because all its components can be sourced from several suppliers.

This is especially important at two levels where multi-sourcing is a unique feature of Calypso, compared to all other existing ticketing technologies:

1. **At the card level,** where there is diversity of software provided by many smart card manufacturers: there is therefore no dependence on a single software as is the case with other solutions.
2. **In terms of electronic components,** Calypso has a diversified offer, provided by STMicroelectronic, Infineon or NXP, whereas other technologies are based on a single component supplier. During periods of component shortages, it is easy to understand the interest of being able to guarantee the maximum supply of contactless cards with Calypso by relying on the different chips available.

Calypso open source

Calypso governance, by decision of its Board in 2017, enables the implementation of Calypso in a ticketing system based on open-source software solutions.

While the Calypso standard is open and multi-source at all levels, it was recognised that it would still be possible for a user to integrate it in a proprietary way. The benefits of Calypso would be reduced.

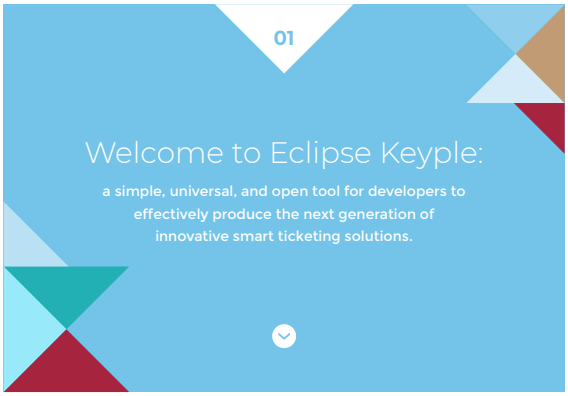
The proprietary integration of Calypso in a ticketing system could lead the system buyer to stay with a single supplier for the entire system lifecycle, generally 20 years. As ticketing systems undergo many evolutions over such a period, the result is a succession of purchases by agreement from a single supplier, synonymous with extremely high prices and very high system total cost of ownership.

To avoid this, and to extend the notion of openness and multisourcing to other levels of a ticketing system, CNA launched Eclipse Keyple, a series of open-source software modules described later in this document. These software modules allow Calypso to be integrated into a ticketing terminal with greater ease as knowledge of all security mechanism is not necessary. This therefore creates accessibility to an infinite variety of software developers. Eclipse Keyple completely decouples a terminal's software from its hardware, whereas such a link is the main cause of terminal becoming proprietary.

As a result:

- In a given terminal, it is possible for any user to make the software evolve, such as manufacturer, software company or developer. It does not have to be the one who developed the original software.
- You can replace a hardware while keeping the software; you just need to integrate it in the new hardware by using the ad hoc plugin.

To learn more about Calypso open source, see the Eclipse Keyple ebook.



Calypso certification

Calypso's openness translates into diverse software options for cards or smartphones.

However, a buyer must be able to buy from any supplier without fearing incompatibility or interoperability problems between their products. Otherwise, this openness is not real, as the buyer would be obliged to stay with the same supplier to avoid technical problems and incompatibility between cards or between cards and terminals.

This is why CNA has implemented a certification policy, which is an essential complement to the open policy.

• Calypso functional certification

The purpose of Calypso functional certification is to offer proof to the purchaser of a product, marketed under the Calypso brand, that it strictly conforms to Calypso specifications, and that it will perform in a manner strictly identical to another certified product.

The functional certification applies to:

- *Card software*
- *Javacard applet/platform (the applet itself is generic and provided by CNA, but its implementation on a platform is subject to certification)*
- *HCE mobile ticketing software*
- *Terminal software (Reader Layer and Calypso Layer - see Calypso for terminals).*

In order to guarantee its independence, the responsibility of issuing the Calypso functional certificate has been entrusted to the accredited certifying body Paycert. Paycert decides whether to grant the certificate on the basis of tests carried out by an approved laboratory chosen by the applicant.

Calypso functional certification is mandatory for manufacturers who sell card products or chips including Calypso software, or applets on Javacard platform. It is the basis of the Calypso license which allows an entity to produce and market a Calypso product.

• **Calypso Security certification**

Beyond the guarantee of interoperability, the buyer of Calypso products wants to be sure of the conformity of the products to the required security level.

In general, this security guarantee is provided by the requirement imposed on the licensed manufacturers to use electronic components with a minimum EAL4+ level according to the Common Criteria classification.

However, in certain cases where this requirement is not possible, CNA has set up a dedicated security certification to guarantee compliance with a necessary and sufficient level of security.

This is the case for:

- **Calypso HCE mobile solutions,** which are purely software based and cannot rely on the security of an electronic component. Therefore, there is a security certification on the resistance of the phone SDK to attacks, following requirements established by CNA. Multiple laboratories can carry out the tests, and the Internet of Trust company acts as a certification body on behalf of CNA.
- **For Calypso Basic,** the entry-level card/ticket, for which an EAL4+ classification of the component used cannot be imposed due to the minimum price sought for this product. CNA has therefore established for Basic an EAL2+ Software + Hardware protection profile, which is required from manufacturers wishing to market this product. A Paycert certification is available as proof.

Finally, CNA is aware that for a Calypso card buyer the concern is not only functional and security compliance, but also compatibility at the radio frequency exchange level. Therefore, CNA has been heavily involved in the European standard CEN TS16794, now international standard ISO 24192, which defines the requirements at this level. A certification is available, and the certifying body is Paycert.

To learn more about the different Calypso certifications:

- CNA-Paycert website
- Calypso Certification ebook
- Calypso website

Calypso license

The Calypso license is based on the certification policy. It is a brand license.

Holders of a Calypso license obtain the right to:

- Access Calypso specifications
- Use the Calypso name and brand to market its products, if and only if, they have received Calypso functional certification (and security certification when applicable).

The Calypso license is only applicable to manufacturers who offer cards or wearables of any kind (smartphones, bank cards, USB keys, watches, for example) that integrate Calypso software, and to manufacturers who provide Calypso security modules.

The Calypso license meets the requirements of the open standard, which are the same as those of ISO, to be accepted in an international standard: it is non-discriminatory and of reasonable conditions.

- For a buyer, the Calypso license is the guarantee of compatibility between the products bought.
- For a supplier, the Calypso license is the guarantee to avoid unfair competition from non-compatible fake Calypso products.

Guaranteeing multisource openness and technical compatibility at the same time is a real challenge. Most existing technological solutions have solved this contradiction by foregoing openness and multisource. With a single product, there is obviously no compatibility problem: it is always compatible with itself. But this is at the expense of the solution's price and resilience.

CNA has made a bold choice to open up the industry, to multisource at all levels, and even to open source, which creates an unlimited field of suppliers for the integration of Calypso. This choice multiplies the offer available to buyers in a truly competitive environment. But this is not at the expense of technical compatibility, thanks to a rigorous certification policy and a non-discriminatory and reasonable associated license.

To learn more about the Calypso license conditions, see the 'Guidance for suppliers' section.

Why Calypso? An overview

Why Calypso Standards?

Choosing Calypso for your ticketing system offers...

HIGH PERFORMANCE:

speed of transaction is unparalleled.

SECURITY:

core to Calypso' philosophy and principles, with session mutual authentication.

PROVEN TECHNOLOGY:

in the field for more than 20 years.

OPENNESS:

multi-vendor, no vendor lock-in, with resilience to external market dynamics.

CUTTING-EDGE INNOVATION:

evolving with market needs and technology advances.

TRUSTED SOLUTIONS:

guarantee offered by certification.

Performance

A high level of passenger throughput is crucial for public transport no matter the transport mean or the access mode (entering a bus, passing a gate to access a station, etc). This is even more important in the case of contactless technology where the cardholder may present the card to the reader in a myriad of different ways.

While Calypso provides the mechanisms to prevent loss, or corruption of data, in the case of interrupted transactions it is always best to keep the transaction between card and reader as short as possible to avoid any chance of error.

Through the years Calypso has followed the evolution of the technologies used for the contactless transaction and has defined 200ms as the maximum time for a complete validation transaction. Using the validation as a reference case means that other operations like *loading* and *issuing* are also positively impacted, resulting in cost savings and higher customer satisfaction.

Security

Trust and transparency are key elements to any interoperable system. Calypso products offer a high level of security, using both symmetric and asymmetric cryptography at the card level with the help of Security Modules, to ensure a clear authentication of all parties involved in a transaction.

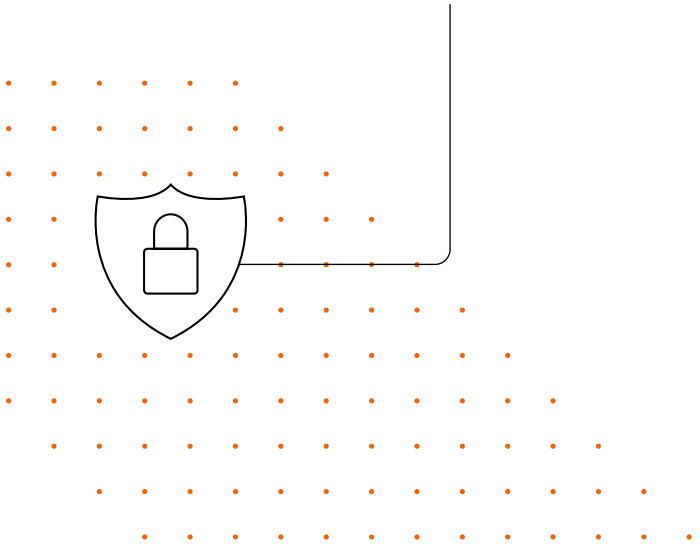
Furthermore, Calypso offers the possibility of signing every transaction that was generated with a card, providing clear traceability of all operations performed.

Philosophy and principles

Calypso was created with the offline transaction model in mind. This means that from its inception, it was crucial to ensure the safety and integrity of the data stored in the card. This meant not only devising mechanisms that will ensure that any change will not disrupt the existing data in the card, but also that only authorised terminals can perform any change in the media.

Calypso has three distinct hierarchal security levels that mirror the main lifecycle phases of a card: **Issuance, Loading** and **Validation**. These levels are ensured by distinct symmetric keys that are present both in the card (in a diversified form) and in the security module that must be accessible to the terminal.

With the growth of account-based ticketing (ABT) solutions and the desire to increase the interoperability of Calypso products, asymmetric cryptography is also available in some products for a strong authentication without the need of a security module.



Session and ratification

The Secure Session serves multiple roles. It ensures that any changes made to the contents of the card are either all done or that no change is performed, it performs the mutual authentication between the terminal and the card, and it performs all necessary cryptographic operations that ensure that the keys present in the terminal have the necessary rights to make the changes being requested.

While the session covers nearly 98% of the anti-tear cases, there can be an interruption right at the last command being sent to the card that leaves the terminal unsure whether the data has been written to the card or not. To solve this issue, the ratification mechanism ensures that this type of event can be recovered from at the next transaction (regardless of whether the card is being presented to the same terminal or not).

Full coverage and consistency of solutions

The Calypso products and solutions answer to a wide range of user needs providing a never-before-seen level of consistency between them. All products follow the Calypso philosophy and principles providing a high level of security and sharing a common command set to reduce the overhead cost at the ticketing system to support different types of products.

This brings more flexibility and freedom of choice on the part of the networks to choose what kind of product is more appropriate, in terms of both functionalities and cost, to each type of user.

Full coverage and consistency of solutions

PRODUCTS	CERTIFIED COMPONENT (EAL4+)	MOBILE	MULTI APPLICATION	#FILE STRUCTURES	INTERFACE	#CONTRACTS	SUPPORTED ALGORITHMS
Calypso® PRIME	✓		✓	Var.	Dual interface	Var.	DESX, TDES, AES
Calypso® APPLET	✓	✓	✓	Var.	-	Var.	DESX, TDES, AES
Calypso® HCE		✓	✓	Var.	-	Var.	TDES
Calypso® LIGHT	✓			2	Contactless	2	TDES
Calypso® basic				1	Contactless	1	TDES

05

Calypso solutions

As the needs, expectations, and behaviours of travellers are so diverse, it is impossible to meet them all with a single ticketing solution. To reflect this, the Calypso standard supports a wide product portfolio of technical standards to accommodate all traveller needs, regular or occasional, in any configuration, media, or system.

- Calypso specifies a fast and secure contactless ticketing transaction.
- It is based on NFC technology, supporting fast throughput at transport locations.
- Used across media, such as smartphones, wearables, plastic card, or paper tickets.
- Suitable both for media-based or account-based-ticketing (ABT) schemes.
- Continually evolves to support future mobility needs and adapt technologies.

Calypso specifications

The Calypso specifications cover card personalisation, purchase, reload, validation, and control of tickets and transport contracts. Manufacturers use the specifications as a baseline on which to develop secure ticketing and access control products that can integrate into established systems; across different modes of transports (bus, train, parking); different transport networks (across regions and cities); and international borders.

All parties using the standards benefit from:

- Avoiding vendor 'lock-in,' as multiple manufacturers provide Calypso products which ensures system sustainability.
- Optimising ticket performance, as Calypso evolves with the latest technology advancements.
- Enabling mobility services to be combined.
- Offering seamless travel and end-to-end ticketing services.
- Delivering true scalability, as the Calypso community evolves and adapts the ticketing technology throughout a systems entire lifecycle.
- Enabling interoperability from the base of the system by following international standards.

All Calypso specifications are available at **www.calypsonet.org.** To download the specifications, you need to register or sign an NDA for security purposes.

If you have any questions visit calypsonet.org

Calypso for cards

The Calypso standard supports three main product lines: Calypso Prime, Calypso Light and Calypso Basic. All products are part of the same family, with the same security mechanisms and the same unique software in the reader, to achieve the required level of protection, ensure compatibility, and ease the integration.

Calypso® PRIME

Designed for transportation and multi-application, ready for multi-service and mobile.

BENEFITS

- **Ticketing across a wide range of platforms and environments, including multi-application and mobile.**
- **Supports an account-based ticketing scheme.**
- **Provides cross network and cross-border interoperability.**
- **Stores a number of contracts / different ticketing options.**

Calypso® PRIME PKI

The latest evolution of Calypso Prime brings together the worlds of closed-loop and open-loop providing the classical symmetric cryptography that has been used in Calypso systems and adds asymmetric cryptography that allows the card to be used in open-loop mode.

BENEFITS

- **Supports all of the functionalities of previous Calypso Prime versions.**
- **Allows the card to be securely authenticated without the need of a SAM.**
- **Enables a combined use in existing closed-loop systems combined with open-loop/ABT/MaaS.**

Calypso® LIGHT

Focused on transport, events, access control, perfect for occasional users

BENEFITS

- Provides same security level as Calypso Prime.
- Supports an account-based ticketing scheme.
- Has lower maintenance costs than magnetic stripe cards.
- Supports two contracts from the same operator.

Calypso® basic

Contactless paper tickets done right, at the lowest cost, for a full contactless ticketing

BENEFITS

- Provides similar security level as Calypso Prime and Light.
- Has low installation and integration costs.
- Supports one contract.
- Calypso basic will be available for on-field deployment from 2022.

How to implement

Multiple manufacturers provide Calypso cards. All card products require functional certification to confirm that they fully conform to the Calypso specifications and therefore connect with a reader in the same manner regardless of supplier. All chips from Calypso cards must also achieve an EL4+ security evaluation or dedicated security guidelines.

Read our ebook, Calypso Certification for Ticketing Today, Tomorrow and the Future to learn:

- Why certification is needed, and the value it brings to the transport ticketing and mobility communities.
- What the elements of Calypso certification and licensing are and how they link together.
- Who provides the independent Calypso certification and licensing programmes.
- Where operators can source Calypso certified products and how to request this.
- How manufacturers can achieve Calypso certification.

Licensing

A licensing agreement is required if a manufacturer wants to create and sell Calypso products. This is a contractual commitment from the manufacturer to comply with Calypso Specification and security rules. It offers reassurances to all entities within the solution chain that the manufacturer is fully and legally dedicated to maintaining the integrity of Calypso. By completing this process, a manufacturer receives access to:

- Calypso technical materials and documents to produce Calypso solutions.
- CNA services, such as unique serial numbers.
- Use of the Calypso brand to sell products, which is a registered trademark.

Licensee agreements are available to any manufacturer interested in producing Calypso portable objects. They are vital to:

- Ensure fair competition between all manufacturers and create a competitive sales environment.
- Confirm the commitment of the manufacturer to support the Calypso community.
- Generate revenue to support the evolution of the specifications and security to meet market requirements.
- Avoid the development of counterfeit products. Guarantee performance of Calypso solutions globally.

Only manufacturers of Calypso portable objects and security modules (SAM) need a license. Other entities can freely use the standard and access the Calypso specifications. For example, users (transport operators and authorities), integrators, manufacturers of readers and terminals.

Calypso for mobile

Calypso for mobile enables smart, innovative, and secure mobile ticketing for iOS and Android devices. This empowers travellers to order, buy and validate tickets using a connected consumer device, such as a smartphone or smartwatch.

Benefits:

Utilising the speed and performance of NFC technology, it ensures operators and authorities can provide their customers with the best possible passenger experience.

- **A focus on security with continual security updates to address new and evolving threats.**
- **System sustainability and flexibility to meet future mobile ticketing needs and requirements, while maintaining backward compatibility.**
- **Ability to open-source tenders for future evolutions.**
- **Consumer convenience, providing new, simple ways to purchase tickets.**
- **Combine real-time transport information and data capture with ticketing capabilities.**
- **Reduce ticketing distribution costs and removal of paper and plastic tickets.**

How to implement

The implementation models allow for a scalable and flexible approach tailored to unique passenger and operator needs, including flexible fare structures and account-based ticketing.

Transport operators and authorities have two implementation options. Both support card centric and account-based ticketing systems, and enable Mobility as a Service (MaaS):

1. Calypso® APPLET
   is available for iOS devices.

2. Calypso® HCE
   Calypso Host Card Emulation (HCE) is designed for Android devices.

Both solutions provide the same functional capabilities as our most advanced transport ticketing solution, Calypso Prime, incorporating card-centric and server (account-based) architectures and supporting MaasS multimodal ticketing.

Calypso® APPLET

Calypso Applet - *Secure element*

A software and hardware-based approach that stores data in a secure environment.

- **Advanced security via an applet hosted within an embedded Secure Element (SE) or SIM card in a connected consumer device.**
- **Fully emulates a Calypso Prime card on a mobile device and offers the same level of functionality and security as a physical card.**
- **Based on a SE certified to a minimum of EAL4+.**
- **Compatible with all operating systems and Java Card platforms.**
- **Easily and securely downloaded, installed and managed using GlobalPlatform mechanisms.**
- **Requires no changes to existing contactless infrastructure.**
- **NFC functions even when a mobile device is switched off or has an empty battery.**
- **Provided free to CNA members.**

Calypso Applet comes with functional certification, ensuring the m-ticketing solution provided by CNA works as a Prime card in each technical context, i.e., with mobile SE and the Java Card platform.

Calypso® HCE

Calypso HCE - *Host card emulation*

A software-based approach that stores limited secure credentials on any Android OS device.

- **Based on two core documents: the Calypso HCE Specification and the Calypso HCE Guidelines.**
- **Fully emulates a Calypso Prime card on a mobile device, and offers the same level of functionality.**
- **Uses tokenisation mechanisms similar to those used in HCE banking applications to change the mobile application serial number at least every three days, depending on the network choice, significantly enhancing security.**
- **Enhanced trust achieved with Calypso HCE security certification for the protection of data within the mobile phone and the self-declared compliance procedure in the implementation guidelines, about security measures at the system level.**
- **Requires some adaptations to the existing ticketing infrastructure to ensure Calypso-enhanced levels of security.**
- **Full specifications and implementation guidelines provided free to CNA members.**

Security

The Calypso HCE Security Certification (CHSC) scheme for HCE solution indicates adherence to state-of-the-art anti-hacking protection levels to protect data within the mobile device.

The certification enhances protection of sensitive data stored on the mobile device and is based on robust mobile security programmes set up by the banking sector, including the Software-Based Mobile Payment Evaluation Process (SBMP) from global payments specification body, EMVCo, which supports contactless payments made using connected consumer devices and digital wallets.

Calypso for terminals

Calypso for terminals supports the security and interoperability of contactless ticketing systems. Any terminal using Calypso for the secure exchange of data with a smart card (or any other portable objects such as a smartphone or wearable NFC) must align to Calypso's open standards.

The Calypso software used for terminals complies with all standards applicable to ticketing transactions (ISO/IEC 14443 and CEN/TS 16794 radio frequency standards, ISO/IEC 7816 1 to 4 card structure and file management, EN 1545 for data description in the transport field).

The Calypso software layer supports the data exchange mechanisms between the terminal and the smart card, and ensures their security (including mutual authentication and data integrity) by linking the customer smart card to a tamper-proof secure component located in the terminal, known as the SAM. The SAM can also be remote on a server.

The terminal's application software layer is interfaced with the Calypso layer and manages the ticketing transaction in real time by analysing the data received, processing it (e.g., checking the validity of a ticket) and modifying it. It then deduces the actions to be taken (e.g., giving an opening order to an entrance gate), and ensures the exchange of information with the central systems.

BENEFITS

- Increased security
- Long-term interoperability
- Flexibility of using an open standard framework

How to implement
The Calypso SAM

To implement Calypso in a ticketing terminal, users may refer to the Calypso specifications on the calypsonet.org website. This information contains the interface specifications for the SAM, which can be accessed subject to the signing of a non-disclosure agreement (NDA), alongside guidance on the complete development of the different software layers.

In order to facilitate development, CNA provides developers with three documents that define the requirements to ensure optimum operational performance, interoperability, modularity and conformance:

- The Reader Layer Requirements, which help to manage all types of cards and SAMs by a smartcard reader, at the lower level of the transaction.
- The Calypso Layer Requirements, which help to specifically manage Calypso cards and SAMs in strict compliance with Calypso specifications.
- The Ticketing Layer Requirements, which outline requirements on the use of the Calypso high-level API.

keyple

Keyple is a simple and universal Software Development Kit (SDK) for technology developers in the transport ticketing community. It is used to help them innovate, create, and deliver advanced contactless ticketing solutions.

It is a library of Java and C++ functions used to develop integrated ticketing terminal applications similar to 'plug-and-play', which communicate with NFC fare media such as smartcards, smartphones or wearables, and operating within several operating systems: Windows, Linux, Android, etc.

It supports developers regardless of their experience or status, whether they are seasoned players or relatively new entrants to the transport ticketing sector.

Keyple provides developers, when they are scoping and designing their ticketing software, with a generic interface that automatically manages transactions, whether it is on a card-centric or server centric (account-based ticketing) architecture.

Alongside supporting the development of Calypso compliant ticketing software and standard terminal readers, solutions developed using Keyple can also be interfaced with proprietary systems by the development of a plug-in. This makes the terminal software free of any proprietary hardware. You don't even have to be a Calypso user to benefit from the 'plug and play' messages that Keyple offers.

To learn more read our ebook:
Blueprint for a Smarter Future:
How Open-Source Development Kits are Advancing Ticketing Systems for Public Transport Operators & Authorities

Calypso for interoperability

CNA advances global standardisation through the development of interoperable systems and standards. All Calypso products and services are based on existing standards and have been designed carefully to ensure seamless integration and interoperability.

Hoplink is based on Calypso ticketing technology to create a robust, effective solution for interoperability between networks. The service allows customers to travel seamlessly locally, nationally, and internationally, by merging all their tickets and travel cards into one single card or app. It is designed to allow interoperability between networks.

With Hoplink, a transport operator can host new ticketing contracts on their Calypso-based cards and mobile solutions from other operators adhering to the same rules. This allows passengers travelling across different transport networks to have a single solution for all their transport needs, which could also include parking or access control. Fundamentally, Hoplink gives greater flexibility to transport and mobility networks, simply and conveniently, while maintaining system control.

Hoplink is managed by an Alliance comprising transport authorities, operators and service providers. Collectively they define and manage the Hoplink service and ensure compliance with pre-defined security principles. This approach removes the need for individual commercial agreements and clearing systems. Transport operators can integrate:

- **The Hoplink application into their travel cards and mobile solutions so customers can use their travel card/app on other travel networks that have also opted into the scheme.**
- **The Hoplink keys into their security modules and adapt the software of sales and validation devices, to accept the Hoplink cards issued by other operators.**
- **Find the Hoplink specifications and guidelines on www.calypsonet.org**

BENEFITS

- **Easy to integrate:** Transport and mobility operators can integrate Hoplink without disrupting the backend systems.
- **Instant access:** Travellers with a Hoplink logo on their card/app benefit automatically from the service.
- **Eco-friendly:** Hoplink is environmentally friendly, as it requires no paperwork or registration and eliminates the need for paper tickets.
- **Improves the customer experience:** Hoplink offers convenience to customers by reducing the need to buy multiple tickets.

Calypso for ABT

Account-Based Ticketing (ABT) provides server-centric solutions where data is stored and managed in a remote data centre. Calypso supports ABT solutions by providing a highly secure authentication of the customer's card as prerequisite to a reliable and trustable ABT service to customers.

Calypso for ABT specifications propose to guarantee validity checks even if there is no network connection by enabling on-media/card decisions.

The guarantee of uniqueness, and strict management of the Calypso Serial Number for each Calypso Portable Object, enables the customer's media to be used as the ABT identifier. This makes the Calypso standard highly suited for ABT systems and allows card-centric and ABT systems to operate easily side-by-side.

How to implement

Calypso offers strong authentication for ABT and evolves some additional mechanisms to improve the ABT experience.

Read our white paper: Account Based Ticketing with Calypso.

BENEFITS

- Improved customer experience by providing pay-as-you-go fares.
- Reduced operational costs, less complexity and reliance on hardware, enabled by moving to a centralised system.
- Greater insights, flexibility and control for public transport operators.
- Easier integration with MaaS systems.

Read: Why Consider Open Ticketing Standards for Account-Based Ticketing

Calypso for Mobility as a Service (MaaS)

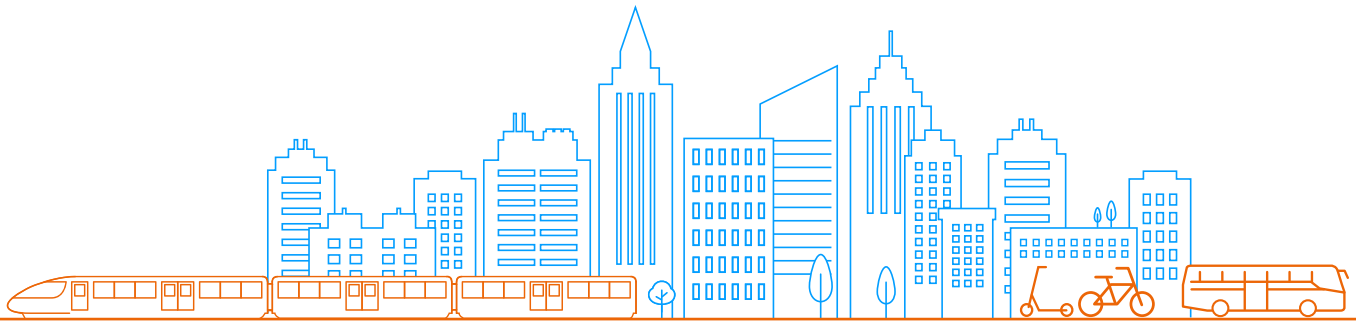
MaaS has enabled the integration of many new mobility services such as car sharing, bicycle-sharing, car parks, taxis, ride hail services, and carpooling with traditional public transport. To get from A to B, travellers have several mobility options, connected to one another, with an open choice of alternatives according to preferences, with multimodal information available at any place and at any time, with easy and unconstrained access and connection from one service to another.

Provided it is both accessible and open, contactless ticketing can accelerate the implementation of MaaS, as it offers concrete solutions to facilitate access to all forms of mobility by integrating sustainable development concerns and by influencing modal balance.

How to implement

All Calypso tools and services can be merged to support MaaS. It achieves this by enabling:

- Easier interfacing / interoperability with other ticketing systems; from sharing customer media to implementing fare products supported by several operators.
- Easier interfacing with a clearing house for a fair distribution of revenues between interoperability scheme stakeholders.
- Control of the system and true independence from suppliers.
- Mastery and ownership of data.



BENEFITS

- Improve the customer experience through convenience.
- Streamlines transport payments.
- Facilitate greater mobility options and customer choice.
- Acts as the gateway to ‘mobility for all’.
- Encourage individuals to move away from their private vehicles by offering door-to-door journey planning.

Calypso and open payment

Calypso guarantees a ticketing solution independence of any third-party interest, whatever its nature. It is the heart of a ticketing system with full and complete control over its operator or transport authority. It is the condition for having control over all its choices in terms of fares, social and commercial policies, without depending on uncontrollable external decisions. It is also a guarantee of resilience; of no price drift.

But it is natural for a transport authority or operator to want to ensure its ticketing offer is able to accept 'occasional users' of its transport network more easily and efficiently. In this respect, it is obviously important to make the customer's journey to the transport network as easy as possible; the acquisition of a specific ticketing medium can be an obstacle.

It is therefore interesting to be able to offer a dematerialised (or virtual) ticket on a medium that the customer already owns. This is what Calypso offers for all smartphones, with its applet and HCE solutions. This is also the purpose of open payment, which allows the acquisition and use of transport rights by using a bank card directly at the network's entrance terminals, most of the time in a 'pay-as-you-go' mode.

The purpose here is not to describe the different existing open payment solutions, their advantages and limitations, but simply to note that the occasional user ticketing options are perfectly complementary to a closed loop open standard ticketing system such as Calypso.

There is no reason to oppose or exclude such solutions. Depending only on an open payment solution would pose a serious risk of control, resilience and independence for a transport network operator that made such a choice. But this risk is perfectly mitigated when the heart of a ticketing system is based on an independent solution that is totally under their control, such as Calypso.

06

Calypso Network Association (CNA and its ecosystem)

Calypso Networks Association (CNA)

CNA is a global not-for-profit industry association for the contactless ticketing community. It brings together more than 100 organisations across the transport, mobility, and services sectors to control and evolve the contactless ticketing ecosystem through open standards.

CNA regulates the use of Calypso technology, and delivers expert services, to promote open standards and enable their use across local, regional, national, and global ticketing requirements. Every aspect of CNA's work is defined and driven by its global network of members.

CNA goals

CNA's commitment / role

To guarantee the sustainability of Calypso to the whole ticketing ecosystem.

Promote and regulate the Calypso open standard.

Be a leader of innovation and encourage dynamic development.

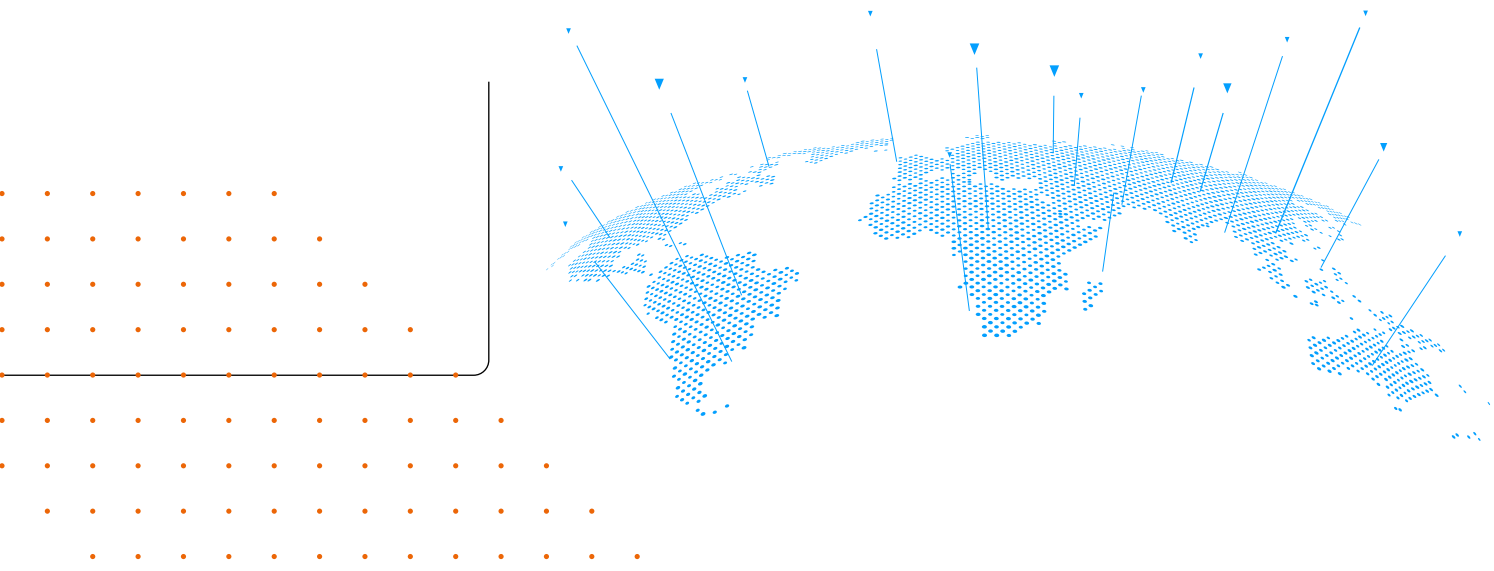
CNA's missions

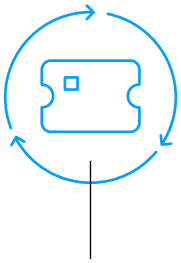
Maintain and develop the Calypso standard.

Facilitate and support Calypso deployment.

Spread the values of Calypso worldwide.

Create a networking platform and facilitate exchanges between users, as well as between users and providers.





Guarantee the sustainability of Calypso to the whole ticketing ecosystem

CNA's fundamental role is to guarantee the durability of the Calypso standard and to guarantee the durability of the ticketing systems that use this standard. Our key priority is the sustainability of the ticketing investments made by all operators and transport authorities. It is also the durability of the investments made by the parties who propose systems or equipment using Calypso, to whom CNA must guarantee that the standard is maintained and evolves in line with market needs and technical capabilities. This is why CNA closely engages industry leaders and technical experts who are members of the association.

These last two dimensions are essential because a standard that does not evolve and adapt to the latest technologies available regresses, and eventually disappears. At the same time, a technology that is not sufficiently used also disappears even if it is the most technically efficient.

These are the principles that guide CNA in defining the missions provided by the association.

These fundamental issues for CNA can be broken down into several operational issues that guide CNA's daily activities:

Ensuring the sustainability of a standard like Calypso relies on three main pillars:

Daily management and technical maintenance of all standard components.

Continuous development and innovation to keep Calypso at the forefront of the most advanced and modern technologies.

Increase the installed base of Calypso ticketing systems worldwide.

01
Regulate the Calypso open standard

02
Promote the Calypso standard

03
Encourage and enable innovation

01
Regulate the Calypso open standard

The Calypso standard is a guarantee for users of an efficient, secure, ergonomic, interoperable, and open ticketing system. CNA must constantly ensure that these fundamental characteristics are not called into question or altered under any circumstance.

Therefore, CNA ensures strict regulation of the standard, of which certification and licensing are the main tools.

Certification enables multisourcing (by guaranteeing compatibility of products regardless of the supplier), enables interoperability, and ensures security (for certain Calypso products). Certification is essential to ensure the confidence of Calypso solution buyers.

The license is issued only for certified products, which fully comply with the specifications and requirements, in particular the security aspects, of the standard. The license is also a guarantee of openness and multisourcing, as it is accessible to all parties at a reasonable cost. The license prevents counterfeit and incompatible products from being marketed under the Calypso brand, and therefore protects the licensed manufacturers.

02
Promote the Calypso standard

Increasing Calypso's market share in transport networks, but also in other application domains, requires an approach to promote the values of this open standard, both to users and suppliers.

A working group, WG3, is dedicated to this activity and coordinates all promotion work, including management of events, participation to conferences and exhibitions, alongside dedicated meetings with stakeholders of the ticketing ecosystem.

CNA also relies on a network of advocates in areas where there is a clear interest for Calypso, in order to facilitate exchanges with local ticketing actors and assist them in the implementation of this standard.

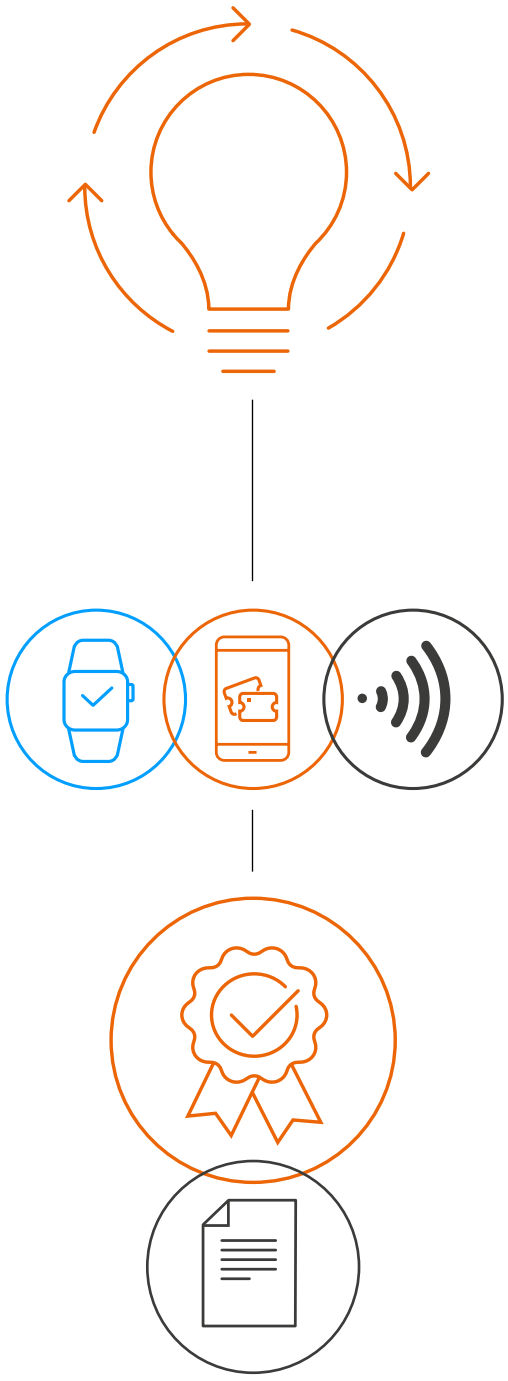
03
Encourage and enable innovation

Ensuring that Calypso remains at the forefront of innovation requires continual technology monitoring and visioning to match emerging technical possibilities with the needs expressed by users, transport operators and authorities, as well as other fields of use, such as event management and access control.

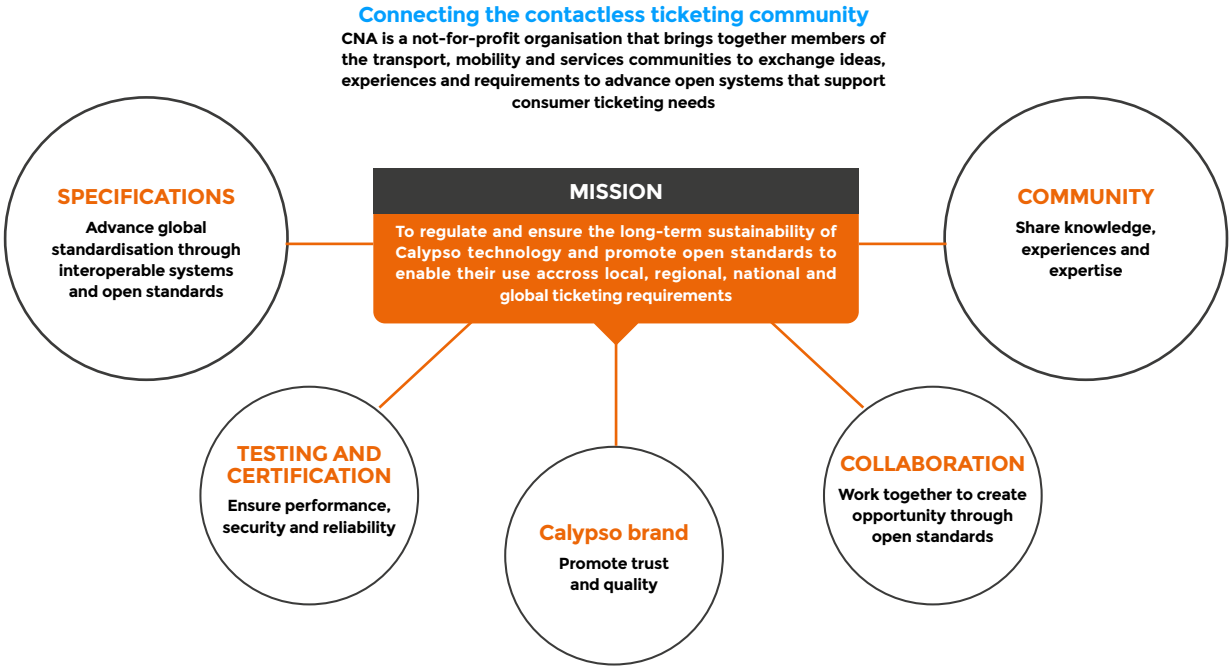
This is a critical strength of CNA, as it brings together those who define current marketplace needs alongside those who can propose new solutions: the manufacturers.

To enable this collaborative work between needs and solutions, CNA has set up task forces to bring together users and other transport technology providers on dedicated subjects to recommend new specifications, which are themselves the basis for new Calypso products or solutions that can be deployed in ticketing systems.

It is in this context that the new families of Light and Basic cards and all Calypso dematerialised / virtual solutions on smartphones or Java cards, such as bank cards, solutions for MaaS and for ABT, were born. The work of these task forces is coordinated by CNA's technical experts, who manage and monitor the work, and are responsible for understanding and predicting technology evolutions, write specifications, manage developments, and provide technical support.



CNA's mission



CNA's mission is to support the use of the open Calypso technology standard and to enable transport and mobility operators to control and advance their contactless ticketing systems. This is achieved by:

- Promoting competition and lowering lifecycle management costs by encouraging open standards and avoiding vendor 'lock-in'.
- Sharing knowledge, experiences and expertise through education and networking.
- Supporting innovation by removing fragmentation and creating a technically secure 'baseline' on which stakeholders can build upon.
- Encouraging the use of open-source software, which is accessible and usable by all.
- Advancing global standardisation through the development of interoperable systems and standards.

CNA collaboration

The collaborative development of Calypso is one of the essential added values of CNA. This success is achieved by closely aligning the user needs with supplier technical possibilities. It allows Calypso to continually meet expectations and keep pace with technological innovation.

CNA has a number of technical committees, led by members of the CNA team, to address different subjects in which CNA members, whether users or suppliers of Calypso, can participate.

The currently technical committees are active:

Card

Exploring Calypso's range of products to support the latest ticketing requirements and customer needs, as well as defining plans for functional tests.

Terminal

Publishing requirements for the programming of Calypso terminals and defining plans for functional tests.

Secure Access Module (SAM) and Security

Exploring the overarching objective of the Calypso Open SAM project: defining the management principles of a new SAM policy, ensuring it is consistent with the openness of Calypso cards developed for terminals.

Interoperability

Exploring the specifications of Hoplink, Calypso's interoperable application, and publishing recommendations for programmers.

Mobile

Defining the development of the Calypso Applet in mobile secure environments and Java Cards, alongside managing the functionality behind the Calypso HCE mobile solution.

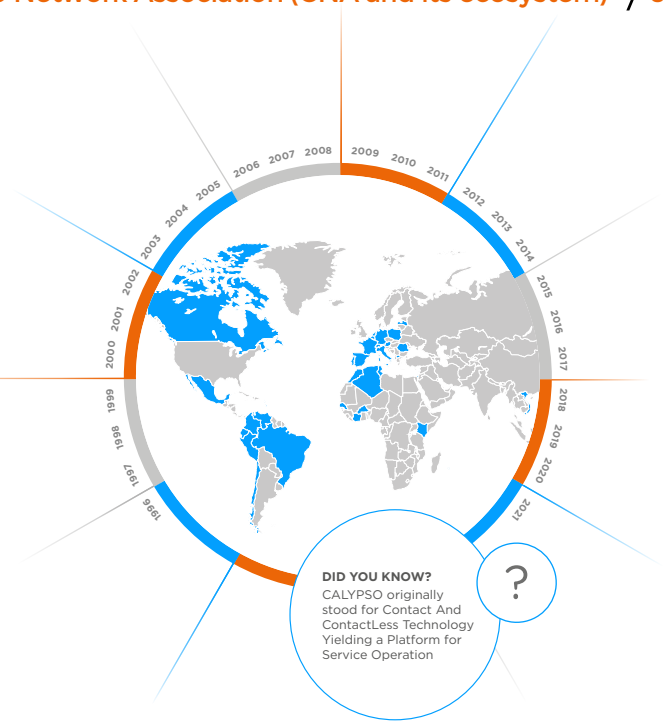
ABT (Account-Based Ticketing)

Exploring how to deliver ABT across a range of solutions including cards, mobile ticketing and open payments, and enhancing Calypso's role in ABT.

Access to these technical committees is subject to a registration request which is available through the WG1 portal or email support@calypsonet.org.

CNA's heritage

CNA is proud to have been a trusted source of support for members of the transport and mobility community for more than twenty years.



Calypso®

25 YEARS OF TRANSPORT TICKETING INNOVATION

1996

Launch of the ICARE project, financed by the European Community, to develop a contactless ticketing system for multimodal and multi-operator public transport environments

This is followed by the Calypso project launching transport ticketing and multiservice payment applications in five initial locations: Paris, Lisbon, Venice, Brussels and Konstanz

1999

Two first in-field deployments of contactless ticketing systems based on Calypso launch in two French cities, Nice and Amiens

2000

Session and Ratification Patents Registration, forming the heart of Calypso's technology

Launch of the TRIANGLE project, precursor to Hoplink, to develop interoperability between European metropolitan areas, piloted on the Brussels-London-Paris triangle

2003

Creation of Calypso Networks Association, an ASBL (not-for-profit) under Belgium law

2006

First reload of Calypso cards on bank ATMs takes place in Lisbon, Portugal

2009

First prototype Calypso transaction from a mobile phone NFC SIM card

2012

Creation of Calypso's interoperable ticketing service, Hoplink

hoplink®

2014

First delivery of a compliance certificate for Calypso Prime cards

2016

CNA reaches 50 members

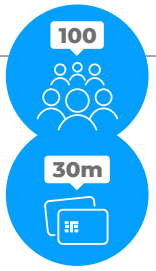
2017

Setup of a permanent, dedicated CNA team, to better answer to the needs of the transport ticketing community

2019

Setup of the Calypso brand license, based on mandatory certification of products compliant to Calypso specifications

CNA reaches 100 members and ships 30 million cards over the year



2020

More than 40 certified Prime, Light cards and a certified Prime applet on Secure Elements or Javacards

2021

Calypso definitively enters the open-source world with the issuance of the Eclipse Keyple API and software 2.0 for terminals

Calypso enhances the security of mobile ticketing on Android devices, officially launching the Calypso HCE Security Certification (CHSC) scheme

Our community is committed to further smart ticketing innovations. Here's to more exciting years ahead!

CNA's commitment to open standards – a true competitive environment

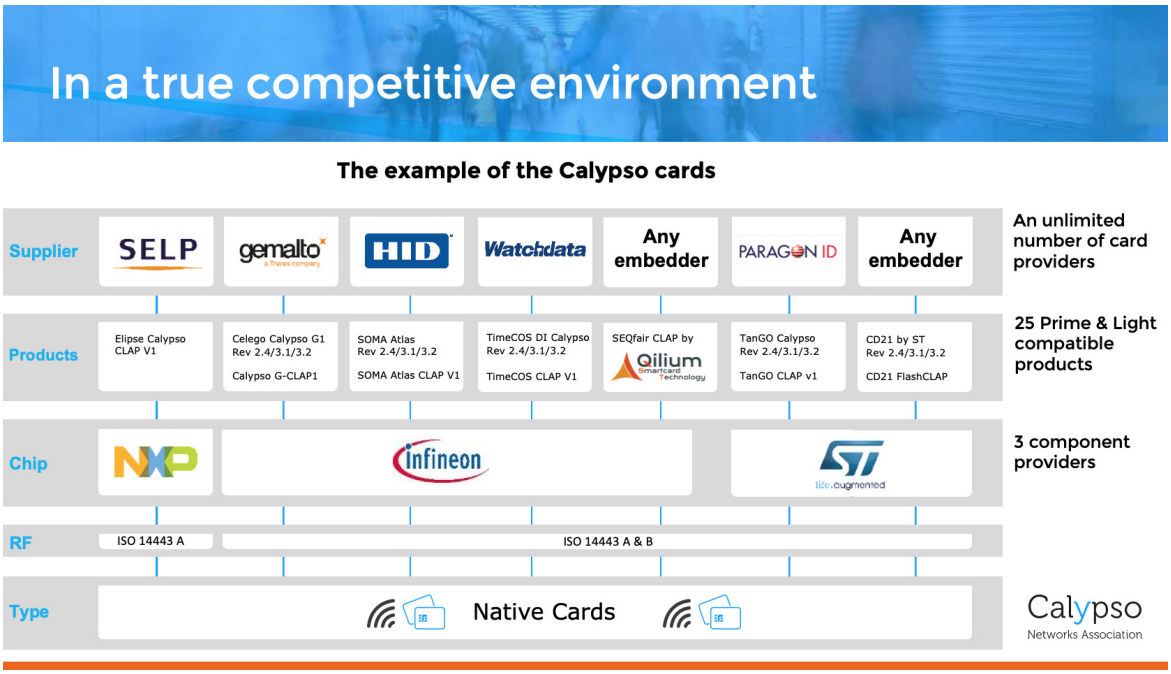
Transport operators need to reduce costs, avoid expensive vendor lock-in, improve the customer experience, and encourage passenger journeys. They must evolve their public transport networks to stay one step ahead of traveller needs.

This requires a simple option that cuts through market fragmentation to deliver a future-proofed ticketing service over which they have full control. This is achievable through open standards.

Open standards give transport authorities and operators control of their ticketing network. It provides the reassurance that they have a sustainable framework that can evolve and support new technical trends and business requirements in a cost-effective way.

More than 50 manufacturers supply Calypso products, solutions, and services, providing multi-sourcing options and enabling competitive bidding over time. There is no vendor lock-in.

By joining CNA, transport authorities and operators are empowered to influence the strategic and technical direction of Calypso technology and open standards.



CNA warmly invites new members to join the community to help shape the future direction of the Calypso standard.

Outline of all different players within the Calypso ecosystem and their link with CNA

The actors of a system using Calypso

The Calypso ecosystem is made up of many companies that perform different roles. The roles indicated below are not restrictive since companies may have more than one role in the Calypso ecosystem.

Consulting companies

Consulting companies are the entities that will, together with the transport operators and authorities, define all the elements needed to migrate to the new ticketing system. They may also help the transport operators and authorities to draft tenders for the necessary elements of the ticketing system while identifying all the processes that must be added and/or changed as well as advise in terms of change management.

Ticketing integrators

Ticketing integrators are the entities responsible for the integration of ticketing terminals with the central system. They may provide solutions as simple as a validator, including all the software that will manage the local ticketing rules and exchange data with the network central system, to a full system, including all types of equipment and all modules of the central system.

Certification level: Calypso Terminal certification for all types of equipment.

Chip manufacturers

Chip manufacturers or chip providers are the entities that are responsible for the design and production of the chips that are at the heart of a Calypso media.

Certification level: Security certification of any chips and/or Calypso products.

Card OS developers

Card OS developers are the entities that develop the Calypso card operating system for specific chip platforms.

Certification level: Calypso functional certification for a given pair of Calypso Operating System and hardware platform (i.e., the chip).

License level: A Calypso card license.

Card embedders

Card embedders are the entities that take the chip, the Calypso card OS, and embed that into a final card product for commercialisation.

Certification level: RF Interface certification for the final card product.

Terminal manufacturers

Terminal manufacturers are the entities responsible for the design and production of the hardware for ticketing terminals, such as Validators, Control Terminals, and Ticketing Vending Machines.

Certification level: RF Interface certification for any reader interface in the terminal. Calypso reader layer certification.

Mobile solution providers

Mobile solution providers are the entities responsible for the design, development, and commercialisation of mobile solutions, both on the mobile device and on the server side, based on Calypso in the following areas: SIM, embedded secure elements (eSE) and HCE.

Certification level:

- SIM and eSE: Calypso functional certification for a given pair of Calypso Applet and Javacard platform.
- HCE: Calypso HCE functional and security certification.

Licence level:

- SIM and eSE: Calypso Applet license.
- HCE: Calypso HCE license.

Read more on Certification

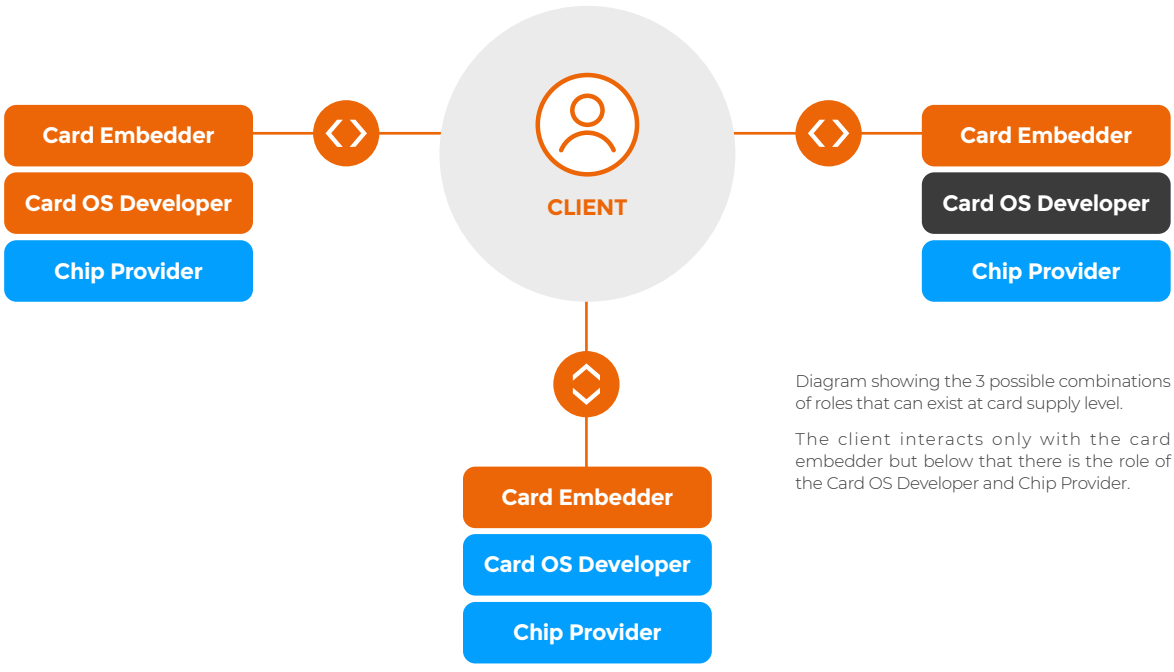


Diagram showing the 3 possible combinations of roles that can exist at card supply level.

The client interacts only with the card embedder but below that there is the role of the Card OS Developer and Chip Provider.

CNA partners

As a technical standard body, CNA recognises the skills and experience required to professionally deliver Calypso. The following trusted partners support the Calypso ecosystem:

Innovatron

Manufacturers require a license agreement to create and sell Calypso products. Calypso is responsible for the licenses signed by the manufacturers, and uses a third party, Innovatron, to provide legal and administrative management.

Paycert

For certification, Calypso appoints Paycert as the independent certification body to manage the product evaluation and ensure the complete neutrality of the programme. Paycert uses accredited laboratories for the testing of Calypso products. Today these include ELITT and ICUBE Testing.

Laboratories

CNA defines the comprehensive functional and security requirements that a product must satisfy to be certified, whereas PayCert is the Certification Body which delivers the certificates on the basis that the results of tests are realised by accredited laboratories. The accreditation of these laboratories is under the responsibility of PayCert. The laboratories define and realise the tools to complete all the defined tests. The manufacturers have the choice between the accredited laboratories and a contract directly with them.

Eclipse

Keyple was donated by CNA and is hosted by the Eclipse Foundation, a global developer community of individuals and organisations with a mature, scalable environment for open source software collaboration and innovation.

Smart Ticketing Alliance (STA)

CNA is a founding member of the STA, a non-profit association that promotes and facilitates cooperation between national and regional smart ticketing schemes to establish seamless ticketing solutions cross Europe and elsewhere. Other founding members include ITSO, MINT, International Association of Public Transport (UITP) and VDV eTicket Service.

GlobalPlatform

GlobalPlatform is the de facto standard for secure digital services and devices for secure element technology. Calypso Applet for Mobile is hosted in an embed secure element or SIM card location in a connected consumer device. This applet is installed and managed using GlobalPlatform mechanisms. It is compatible with all operating systems.

UITP

The UITP (Union Internationale des Transports Publics) is the International Association of Public Transport. Established in 1885, with more than 135 years of history, it is the only worldwide network to bring together all public transport stakeholders and all sustainable transport modes.

CNA is a member of UITP and contributes to its work by providing expertise in the fields of ticketing and contactless card technologies, as well as its values of defending open and sovereign solutions. CNA participated in the production of the UITP's Ticketing and MaaS documents.

CNA is a member of the UITP ITS Commission.

(ADCET)

ADCET is a French non-profit association that gathers political authorities, local authorities, and manufacturers, for promotion and development of digital citizen uses, around the theme of multiservice cards, city cards, citizen cards.

ADCET has established the French AFNOR AMC standard. This defines a multiservice card scheme, based in particular on Calypso cards, through a series of identifiers per service, in compliance with the rules set by the GDPR. ADCET has initiated a process with the support of CNA, to extend the AMC standard to the European scale by making it a CEN standard.

CNA and ADCET have established a cross membership between the two associations.

For more information: www.adcet.org

NFC Forum

NFC Forum is the standards body for advancing near field communication (NFC) technology. NFC Forum has a signed memorandum of understanding to collaborate on educating the market on the value of using NFC technology and to deliver secure, sustainable, and innovative smart ticketing solutions.

OSPT Alliance

OSPT Alliance is a member-driven, global community dedicated to enabling the future of mobility services across a variety of markets including transport.

Both Calypso and OSPT Alliance recognise that open standard ticketing is the future gateway to consumer mobility. Working together, the two bodies jointly educate and promote the role that closed-loop, open standards play in ensuring accessible, affordable, secure, and reliable mobility. This is achieved by ensuring sustainability, lowering costs, and promoting innovation.

To learn more, visit TicketingOpenStandards.org.

07

Calypso economic impact

(translation of benefits of closed-loop, open standard in number)

What impact does the use of Calypso have on the economic balance of a ticketing system? This is obviously the essential question that a system buyer asks when considering implementing or integrating Calypso standards.

The question of the economic efficiency of a solution based on an open standard versus a proprietary solution is therefore raised.

To answer this question, two main considerations must be taken into account:

1. **The logic behind the development of its prices by a manufacturer.**
2. **The Total Cost of Ownership (TCO) of a system.**

Product Pricing

When detailing the price of a product to the market, a manufacturer must take into account all the direct and indirect costs incurred by this product. Among these costs there is always the remuneration of research and innovation costs, and development costs, which led to the design of the product:

- If it is a proprietary product, marketed by a single manufacturer, the costs are made by that one entity as they have had to manage all the research and development of this product.
- In the case of Calypso, research and development costs are partly shared, since CNA is initially responsible and passes them on through the Calypso license fees paid by manufacturers to CNA. While some of the development costs remain the sole responsibility of the specification users, a significant portion is covered thanks to the work carried out by CNA.

Misunderstanding of the Calypso product pricing can result in entities viewing the cost of the license negatively, yet this cost is much lower than the cost of individually investing in research and development and contributes to the long-term sustainability and innovation of the standard.

The pooling of research and development costs by CNA has an undeniably favourable impact on the selling price of a Calypso product compared to the price of a proprietary product from a single manufacturer.

The Total Cost of Ownership: case for an open, closed loop standard vs. a proprietary solution

The Total Cost of Ownership (TCO) represents the total cost of an asset, such as an IT system, over its entire lifecycle. It takes into account not only the direct costs of materials, equipment, network infrastructure, software, specific developments, licenses, etc., but also all indirect costs, or hidden costs, such as upgrades, maintenance, administration, user and administrator training, technical support, and recurring costs (consumables, electricity, rent, for example).

During its lifetime, a ticketing system needs to evolve: new technologies, security updates, new fare policy, and also potentially new suppliers in the case of the initial supplier failing. Evolution costs contribute significantly to the ticketing system TCO and can sometimes prevent upgrade projects from going ahead.

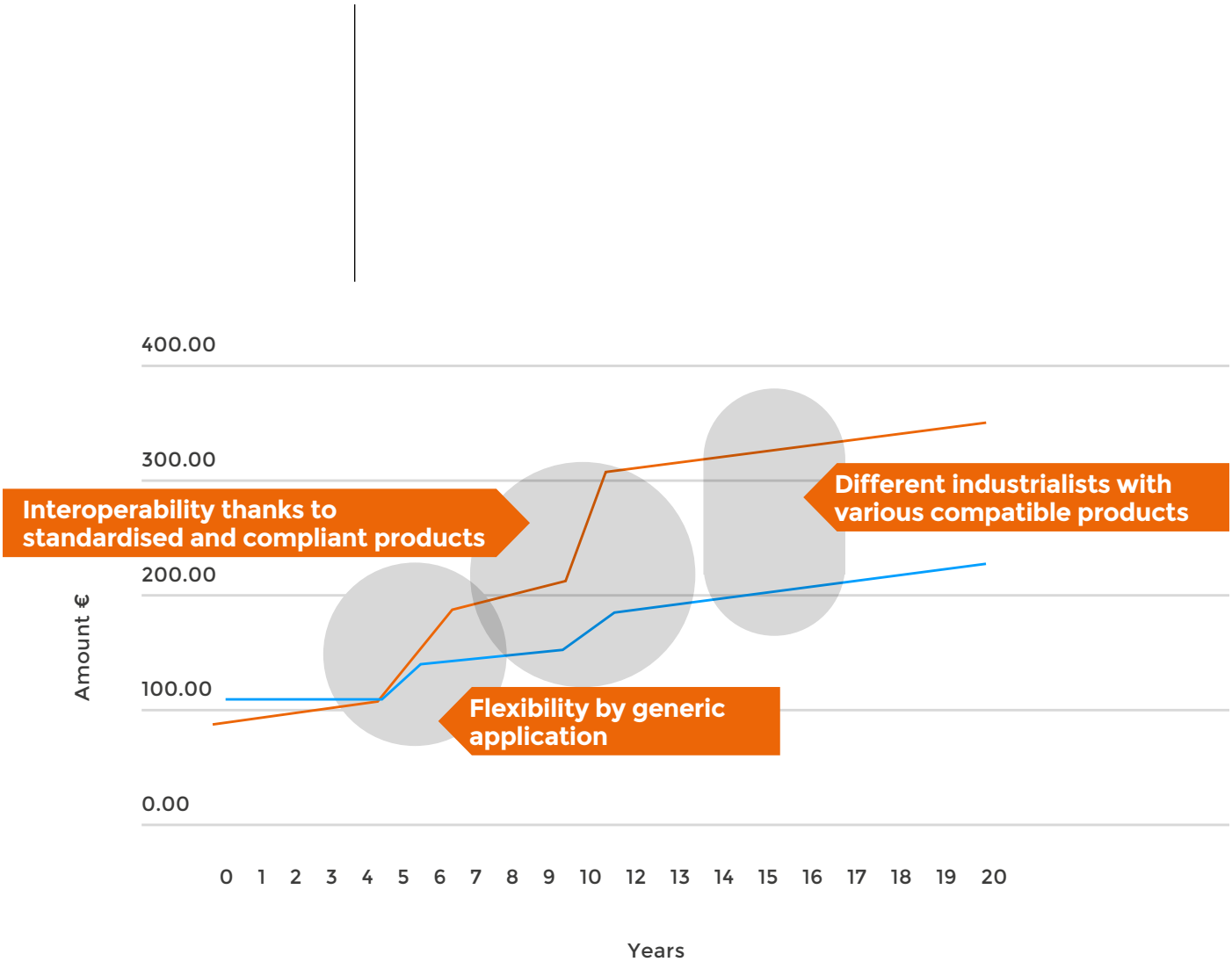
The cost of ownership of a ticketing system is therefore very different in the case of an open, closed-loop system and in the case of a proprietary system.

If only the part of the ticketing system that is purely linked to Calypso, in particular the cards, is considered first, the real competition on the complete chain (chip, software, embedding, personalisation) guarantees the best control; it enables switching from one supplier to another during the whole life of the system, and therefore benefits from the best price, not only at the beginning, but also at each renewal of the card stock.

If the ticketing system as a whole is considered, the impact of Calypso as an open standard is less important directly. Competition is fully in play in the original procurement of the system, and allows the buyer to choose the cheapest offer, or the one with the best price/performance ratio. This is often misleading, because the very low price, is the result of severe competition between ticketing integrators and corresponds to a proprietary system, which is translated throughout the life of the system by direct purchases for all upgrades. And in the context of direct purchases, there is no longer any regulation of prices, which are set unilaterally by the manufacturer: either the buyer accepts them or gives up on the project.

Therefore, CNA has developed the open-source approach to integrate Calypso into a ticketing system. Beyond this integration, the choice of Eclipse Keyple (which can be applied to other technologies beyond Calypso by developing ad hoc modules) allows decoupling software and hardware from the equipment, and therefore allows competition for evolutions during the whole life of the system.

Requiring the use of Eclipse Keyple or open-source software is the best guarantee for a buyer for the best TCO of their system. This is illustrated in the diagram below.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Years
Interoperability thanks to standardised and compliant products
Different industrialists with various compatible products
Flexibility by generic application
Investment (Calypso)
Investment (propriety solution)

08

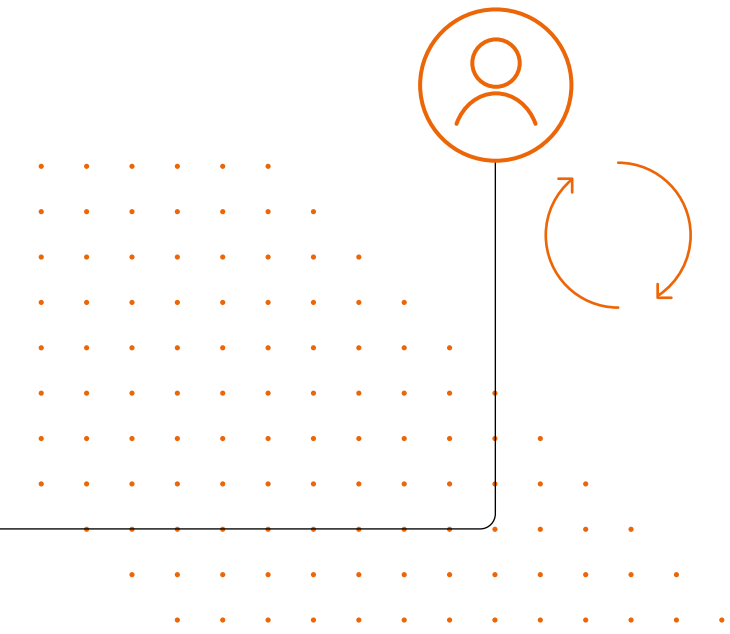
Development of a Calypso System: Roles & Responsibilities

Roles & Responsibilities in a Calypso System

A good ticketing system is the result of the marriage between different visions.

1. Users and owners of the system that know the business and its requirements
2. Consultants who can translate the existing reality and requirements into the future ticketing system
3. Suppliers that will help make the ticketing system a reality

There can be an unbalance in terms of knowledge between, for example, the client, the users, and owners of the system and the suppliers. This is why a third entity is needed. The role of the consultants is usually that of a translator who takes the needs of the clients and translates that into a language that the supplier can understand.



For Users

A deep change, like a transition to a new ticketing system, isn't simply a technological change. It changes processes, it directly affects people and the way they traditionally work, which means that there is a great need for change management.

The owner of the system must have a clear view of what they want the system to do, what kind of tariff models need to be included, and what kind of outputs/ functionalities they want from it. A good practice is to select several key users inside the company that can work with the consultants in defining the processes and system requirements.

Knowledge of both the old system and the new one is key for the longevity of any system and the safety of the investments. Consultants are there to provide advice and help with any required documentation, but final decisions must be taken by those that will have to use, manage, and live with the system.

While it is up to the system owner to decide how much power they will delegate to the supplier, they must always be aware of the risk of relinquishing ownership of the system to a third party. Ticketing systems are ever evolving, and they need to be flexible and agile to changes – operational and technological.

CNA provides a comprehensive training program to ensure that users have the necessary technical knowledge to make informed decisions.

For Consultants

Consultants help in the definition of the system and act as a safeguard that ensures that the system delivered matches the one that was conceptualized. In the process of defining of the system, consultants should not only write specification but also identify key users and help define the change management process that is always required by the implementation of a ticketing system.

Consultants act in all phases of a project lifecycle, from the initial definition of the ticketing system to its maintenance and evolution, bringing with them a deep knowledge of the technology used in ticketing systems as well as the best practices in the area. Their help is crucial to ensure that interoperability mechanisms like the card data model, the security architecture or even the system keys are in possession and control of the network.

Calypso provides security, traceability, and interoperability by design. Taking advantage of more than two decades of presence in the field. CNA has published several white papers that seek to help both networks and consultants in the definition of best practices for ticketing systems. CNA is available to cooperate with consultants and share the experience of their member networks with new networks that are seeking to master their systems.

For Card/Solution Suppliers

Depending on the specific role that a supplier wants to take in the Calypso ecosystem there are different requirements both in terms of certification and licensing. A supplier can cover multiple roles for a single product, being free to choose its level of involvement with Calypso.

For Integrators

A ticketing system is a living thing. It needs to grow to adapt to the multiple changes required to ensure the continued sustainability and survival of public transport. These change requests can come at very different levels of the system: a reorganisation of the tariff system, the inclusion of an ABT like product, adding new media types, supporting mobile solutions, etc.

Integrators may be tempted to either provide custom made solutions to each customer or to try to impose the same full solution to all customers. Both approaches lead into opposite extremes. Developing a custom solution for each customer scales badly, not allowing for reduced costs on maintenance and evolution of solutions. On the other hand, networks have different realities so attempting to fully migrate a solution from one location to another is not feasible.

There is a middle ground to be found and this is where Calypso and CNA come in, bringing a high level of standardisation upon which an integrator can build their solution. With the inclusion of Eclipse Keyple all integrators that support Calypso can reduce the initial investment, as well as maintenance and evolution costs.

A hybrid approach also allows for suppliers to provide added value for customers by applying corrections and improvements that are developed for one customer to all customers using those modules. This type of approach is a much needed one in a market where sustainability is crucial.

09

CNA services

CNA offers a range of strategic services to encourage industry best practice, including dedicated training programmes, technical support, and guidance from technical experts. All services are designed to empower the transport and mobility community and promote the use of open standards.

CNA's services are available to the entire ticketing community, including members and non-members of the association. Members of CNA benefit from preferential rates on services.

Strategic support:

CNA is supported by a world-class team of experts with extensive knowledge and experience across the transport and mobility sector. The CNA team can provide strategic support and expert guidance on industry best practice, aligned to local, regional, national or global ticketing requirements. CNA's expert team is also available to support and educate organisations which wish to learn more about the benefits of adopting Calypso as an open standard ticketing framework.

"

RATP Smart Systems was a pioneer in implementing Keyple in a major project involving some 1500 terminals rolled out in the Paris Region.

Time was critical and although Keyple was chosen to ease the integration of Calypso in contactless terminals, support was required, all the more as this was the first major implementation of Keyple which incurred teething issues for obvious reasons.

The support we received from CNA was invaluable. Not only was their level of expertise second to none but the amount of support they provided and their responsiveness was truly outstanding.

"

Grégory Boissinot,
RATP Smart Systems

RATP

"

Casa Transport, the leading authority for transport within Casablanca and the wider region, needed to establish an efficient intermodal public transport network through the tramway, the BHNS and the bus networks.

Ticketing interoperability was fundamental for this public transport offer. In order to ensure the openness and interoperability of our selected systems and equipment, Casa Transport contacted Calypso Networks Association for support.

CNA evaluated the technology to ensure it was truly interoperable and could provide a sustainable framework that can evolve in accordance with CNA's open standards guidelines. This project was delivered successfully and to the full satisfaction of Casa Transport.

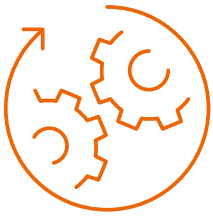
"

Nabil Belabed,
Casa Transport

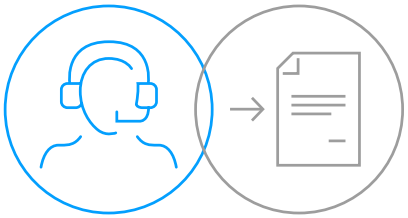
CASA TRANSPORTS SA

Training:

CNA delivers a comprehensive, year-round training programme to promote industry best practice and support the future development of the industry. Training provides an opportunity to learn new skills, share experiences, and gain a deeper level of education on how to get the most out of Calypso technology. All training is tailored to industry requirements, including dedicated sessions for transport and mobility authorities and operators, as well as technology manufacturers and transport consultants. CNA can also support with bespoke training programmes upon request.



Download the training brochure for details.



Technical support and documentation:

Calypso Networks Association (CNA) offers comprehensive technical support and documentation to ensure all users can get the most out of Calypso technology. All Calypso technology respects existing standards to enable seamless integration and support global interoperability.

All technical documents, including the Specification for the Calypso OS for portable objects, are available on the technical support website, calypsonet.org. Simply register to gain access.

Test Kit is available to better understand Calypso, to test its functionality and to master integration in different environments. The kit includes Calypso Prime and Light cards from different suppliers, and SAM access modules in different configurations. It is particularly suitable for IT developers who use the open source API SDK Eclipse Keyple.

This is available to all parties. Get in touch.

The CNA team manages all Calypso documentation, specifications, guidelines, recommendations, security notes, etc. This documentation is available on the Calypso website (link when available).

Access to this documentation is free after registration, and to CNA members after signing an NDA, depending on its classification and according to the security criteria.

The CNA team also provides technical support to all actors of the Calypso ecosystem, both to users, such as transport operators, and to suppliers of equipment and solutions that integrate with Calypso.

There are numerous services that support a range on needs from a variety of suppliers. This includes, but is not limited to:

- Support to Calypso integration in terminals, in particular for those using Eclipse Keyple open-source modules, including the supply of a test kit with a set of Prime and Light cards and security modules.
- Support for the personalization of contactless cards prior to their certification.
- Expertise on technical problems encountered by networks, such as card/reader incompatibilities.
- Support for the use and implementation of the generic applet for smartphones and cards on Javacard platform.

These services are available upon request from the CNA team at contact@calypsonet.org

Monitoring the security and quality of service of ticketing systems – known as the Club

CNA has established a body dedicated to analysing the security and quality of services related to ticketing information systems that are based on Calypso. The Club is open only to ticketing system managers (mainly transport authorities and operators).

The issues addressed relate to the entire Ticketing Information System, not only those related to the Calypso protocol for data exchange between card and reader. For example, topics being addressed by the Club include attempted fraud in remote reloading or in the sequencing of payment/reloading sequences, problems of incompatibility between cards/phones and validators, problems of duplicate transactions, to name a few.

The work of the Club is delivered by experts comprised of staff made available by CNA, with technical skills on Calypso and on the operation of a ticketing information system, as well as IS security experts with the required qualifications. The three main objectives of the Club are:

1. **Collection of all operating anomalies, security problems and frauds reported by member networks + monitoring.**
2. **Analysis of anomalies and frauds, and proposal of remedies in the short term (reaction measures) and in the longer term (prevention measures and sustainable solutions).**
3. **Organisation of exchanges with the manufacturers concerned and all the transport authorities and operators.**

10

Become part of the community

Becoming a member

Any member of the transport ticketing community is welcome to apply for membership of CNA. All CNA members benefit from greater ownership over the smart ticketing ecosystem via:

Networking and collaboration:

CNA brings together the brightest minds within the transport and mobility community to share experiences and facilitate industry collaboration

Strategic support and expertise:

Receive preferential rates on strategic support aligned to local, regional, national or global ticketing requirements

Access to CNA's working groups:

Join and participate in CNA's working groups to promote open standards and influence the future direction of Calypso technology

Training opportunities:

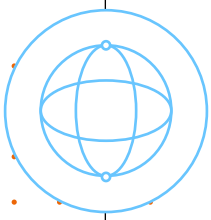
Gain new skills via preferential rates on CNA's year-round training programme, tailored to member requirements

Invitations to CNA's global events programme:

Partake in CNA's global programme of events, networking opportunities, and annual awards ceremony

Exclusive access to Calypso technology documents:

Access the Calypso library, including documentation, specifications, and guidelines



Technical support:

Receive comprehensive technical support and preferential rates on Calypso technology

CNA offers three different types of membership:

EFFECTIVE MEMBERSHIP

for local or transit authorities, ticketing system operators and for other organisations deploying Calypso technology in contactless ticketing solutions e.g. bank or mobile phone operators.

ADHERING MEMBERSHIP

for providers of Calypso based solutions e.g. IC manufacturers, card embedders, terminal providers, fare collection integrator and software providers. This type of membership is also for consultancies supporting users to implement Calypso based technology.

GOLD MEMBERSHIP

This is open to all regardless of their role. Current Effective and Adhering members can pay to access Gold membership to unlock the extra benefits and support.

Getting involved [and voting]

Calypso members work hard to:

- Improve and develop Calypso's reference specification.
- Favour interoperability between transport networks.
- Promote Calypso technology worldwide and participate in international standardisation.

CNA's working groups have led to important developments including:

- The specification of the Calypso Light card and its functional test plan.
- The specification and guidelines of the Calypso HCE application.
- The user manual for version 1.3 of the CNA applet, which aims to promote Calypso on NFC phones.
- Revision 3.3 of the Calypso Portable Object Specification with PKI cryptography, avoiding SAM in the terminal.
- Revision 3.2 of the Calypso Portable Object Specification, with AES encryption algorithm and new features for privacy and data protection.
- Issuance of the ABT guidelines for Calypso systems.

How can Calypso support your long-term technical and operational needs?

Join now, be part of the discussion and influence the future of your transport standard.

Membership fees

Membership of CNA is secured through an annual fee, which is paid in due once membership is approved and at the start of each calendar year from there onwards.

CNA is a not-for-profit organisation and delivering value to members will always remain a priority. To promote and encourage access to the association, the statutes of CNA contain a clear policy on membership fees, with a limit on future increases.

For a detailed breakdown of the various member benefits and fees, please visit the CNA website: **www.calypsonet.org/become-a-member**

Application process

To become a member of CNA, applicants must complete an online application form at **www.calypsonet.org/become-a-member** Once submitted, each application is reviewed carefully by the CNA Board of Directors. Applicants should receive a response within 10 working days.

Current members

Current members of CNA span both the public and private sector, transport operators and authorities, suppliers, consultants, integrators, and software developers. To find out more about our membership, including a list of current members, please visit www.calypsonet.org/current-members

CNA is led by a world-class team of experts with extensive knowledge and experience across the transport and mobility sector who are always available to offer support.

For general enquiries related to CNA, please complete the online form: **www.calypsonet.org/contact-us.**

A member of the CNA team will be in touch as soon as possible.

Calypso
Networks Association