Expressions of Interest

REQUEST FOR EXPRESSIONS OF INTEREST FOR THE DELIVERY OF AN INITIAL OPERATING SEGMENT.

High-Speed Rail Solutions

September 28, 2015

CALIFORNIA
High-Speed Rail Authority

indra

September 28, 2015

Rebecca Harnagel

California High-Speed Rail Authority
770 L Street, Suite 620 MS 2
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Subject: Request for Expressions of Interest for the Delivery of an Initial Operating Segment.

Dear Ms. Harnagel,

On behalf of the 39,000 Indra professionals worldwide, we are pleased to submit our response to RFEI HSR#15-02, Request for Expressions of Interest for the Delivery of an Initial Operating Segment.

Originally founded in 1921, Indra is a global provider of complex IT services and systems, with 2014 revenues exceeding $3 billion, over a third of which came from international markets. With our North-American Headquarters in Miami, Indra USA Inc. is a wholly owned subsidiary of Indra Sistemas S.A., a premier European information technology company specializing in providing cutting edge technical services to the transportation and defense industries.

Indra responds to this Expression of Interest individually, bringing with us our wide experience in operating rail control centers and in managing the second largest High Speed Rail Network in the world with our unique self-developed software DaVinci.

We understand and appreciate the level of professionalism and dedication that the California High-Speed Rail Authority has undertaken in procuring the future first high-speed rail system in the nation. In order to provide the best service, Indra would be glad to hold a one-to-one meeting with the Authority, where we can widely discuss and answer questions about the EOIs.

As requested, please find below Indra's contact person information.

Juan Carlos Villar Castaño
Commercial Director
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We thank you for the opportunity to submit our response and all of us on the Indra team look forward to working with you in service to the people of California.

Sincerely yours,

[redacted]

Manuel Areosa
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Subject: Request for one-to-one meeting with the Authority

Dear Ms. Harnagel,

Indra formally requests to hold a one-to-one meeting with the California High-Speed Rail Authority in order to discuss and provide all specific information and experience related to the EOI statements.

Indra is also interested in introducing to Authority the capabilities and skills of its self-developed state-of-the-art software for rail control centers DaVinci.

We will be glad to host the Authority members in a visit to the High-Speed rail control centers where Indra manages more than 1,800 miles in Spain.

Please find below Indra's contact person information for scheduling a meeting at your convenience.

Juan Carlos Villar Castaño
Commercial Director
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1 INTRODUCTION

In response to this request for Expressions of Interest, we would recommend a different approach to the one proposed in the documentation. From our experience in similar projects (commissioning of railways networks) what seems a reasonable approach, and with higher guarantee of success, is to have separated contracts between pure civil works and installation of the specifically railway subsystems.

For the railway subsystems as Signaling, Traction Power, Communications or the Operation Control & Maintenance subsystems can be managed in different projects for the whole line, which it will help to reduce the internal interfaces of each subsystem if the final decision is to add new stretches to the line. These projects can be in separate contracts, but what we recommend is to have at least a different contract for the Operational Control Center, because an advanced Control Center should have the integration capability not only to integrate the different subsystems under this program, but also integrating the subsystems for future stretches or managing the information of commercial subsystems.

In order to coordinate the different projects and to manage the interfaces between them, it is convenient to have an independent Project Management contract in charge of managing the planning of the whole program, managing the interfaces between the subsystems, coordinating the Test & Commissioning phase.

2 FIRM EXPERIENCE

Indra has **redefined successfully the method for operating rail control centers**, allowing operators to focus on real-time tasks like rescheduling and monitoring traffic by automating the most repetitive tasks and integrating the different systems needed for operation.

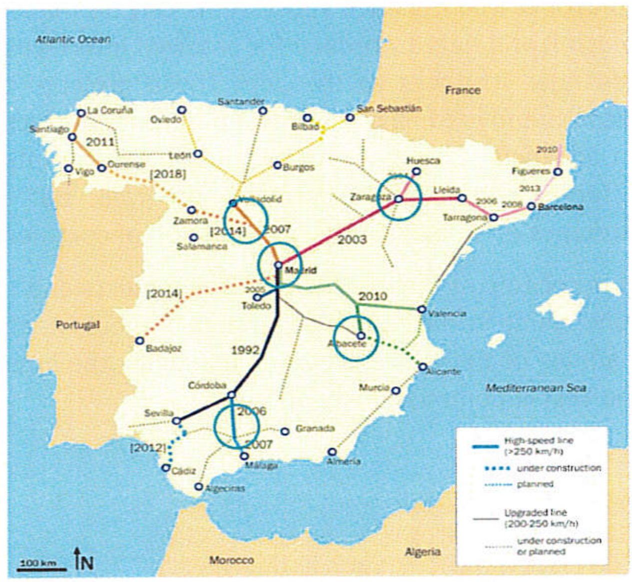
We have a **wide-ranging experience** that includes solutions for different infrastructure types, such as high speed lines, conventional lines and subway lines, and we have the tools needed to manage all of these lines from the control centers. We have also experience in the design and build of control centers taking into account the ergonomic and the functional aspects required to operate and control on a 24/7 basis.

NUMBER 1 — AVERAGE OPERATIONAL SPEED (138 MILES/H)

NUMBER 2 — NETWORK LENGTH (AFTER CHINA)

NUMBER 2 — PUNCTUALITY (AFTER JAPAN)

NUMBER 1 — DENSITY (KM PER HABITANT)



1.1 SPAIN - ADIF

In the year 2000, ADIF, the Spanish national railway infrastructure administrator, embarked on an ambitious growth plan for more than 2,250 km of high-speed tracks to be in service by 2012 and 10,000 km by 2020.

To fill this requirement, ADIF contracted Indra to design and supply a completely new traffic management system which would give them independence from the underlying technology, **integrating all the systems**. It was to cover all elements of managing the system, from the strategic planning through execution and control of the plan, designing it top-down, from the operational needs concepts to the signaling interface. This was the birth of the **DaVinci system**.

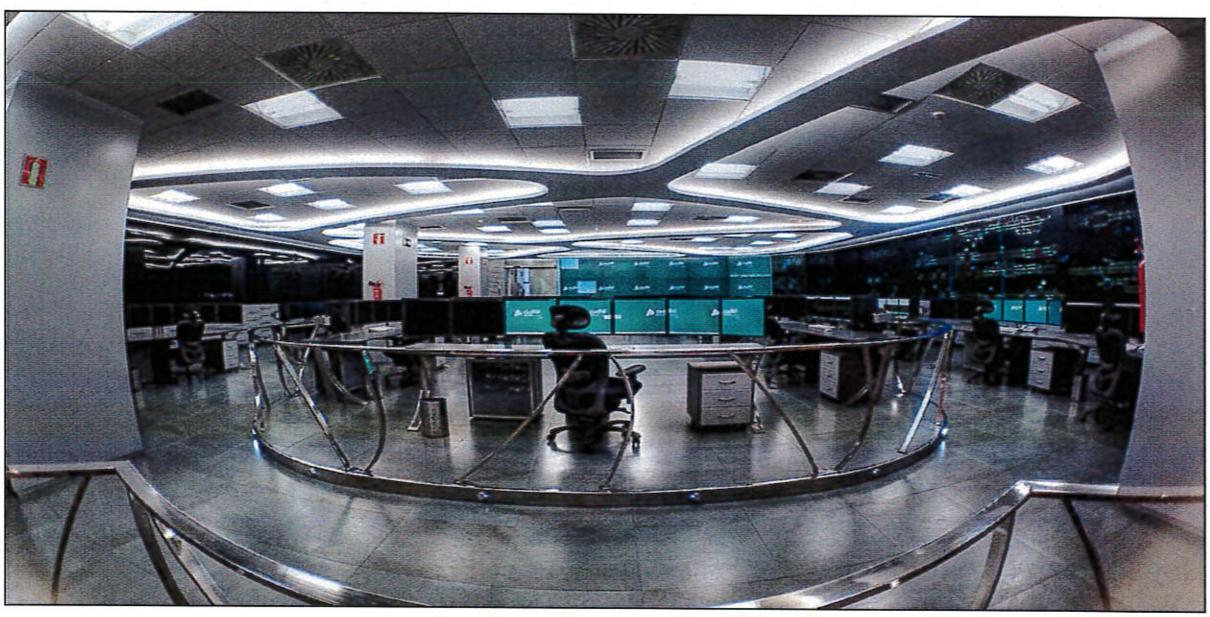
ADIF currently plans and manages more than 5,000 trains per day, from four different operating companies, running a total of some 500,000 km/day over a network of 13,325 km; more than 14% of this traffic is managed over the 1,509 km of High-Speed line.

The DaVinci system is now installed in five control centers around Spain which control the complete current high-speed network. It will be installed in all new high-speed developments growing as new lines are built to form a redundant network of a national control centers working with eight line control centers controlling the entire system.

The three driving factors of the DaVinci functional designs are:

- Enabling the automation of the operations
- Moving from signaling managers to traffic flow managers within the control center
- Implementing the concept of "Control through re-planning"

The system provides **the integration of all remote control systems** (energy, ERTMS, detectors, interlocking), planning and fleet management, real-time monitoring, forecasting, conflict detection and resolution, automatic routing, geographical information system, voice dispatching, traffic regulation, statistics, passenger information systems, billing, simulation, reconstruction of events, etc.



The DaVinci system was developed closely with ADIF in order to meet their exact needs for all aspects of railway management from the strategic plan generation, all the way through, to the operational plan execution, predicting, detecting and resolving incidents automatically.

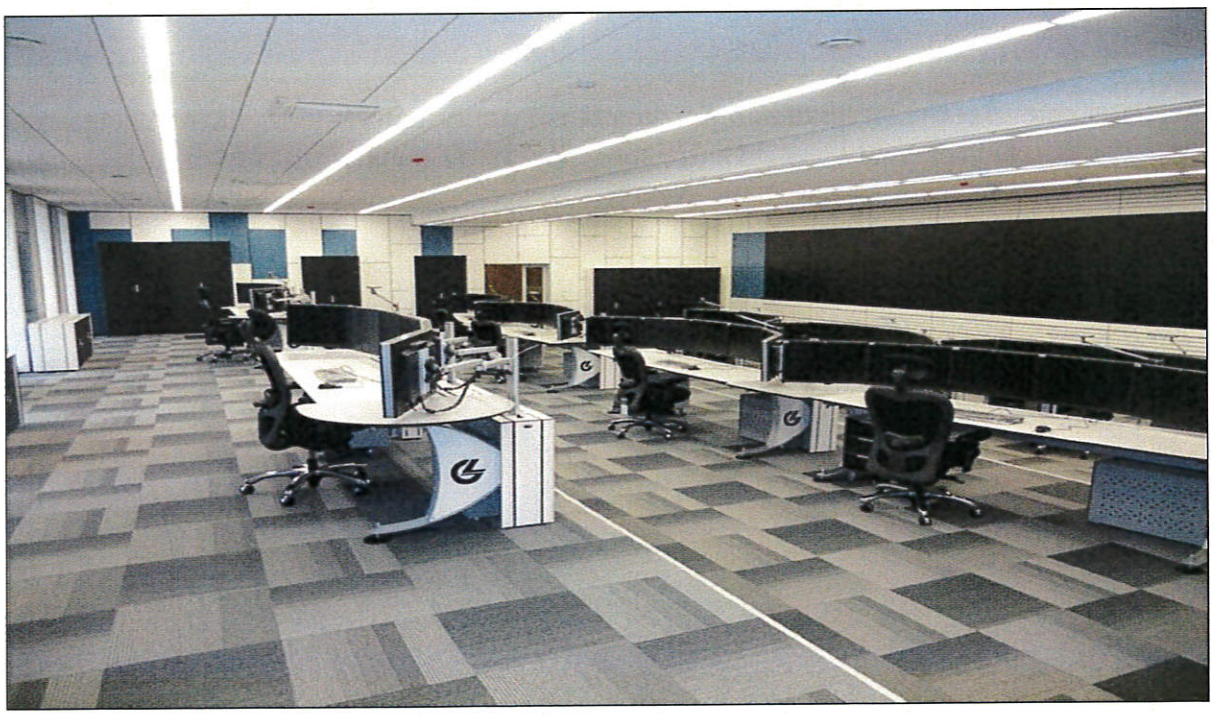
The system was designed as a completely modular, open architecture based on the Railway Services Bus integrating existing legacy systems; Indra software modules; modules from third parties; as well as being prepared for integration of future systems to be contracted independently of the supplier.

The system deployed has already been interfaced to systems from many third party manufacturers both infrastructure components (interlockings, ATPs, safety detectors, etc.) and software control modules for these and other systems (CTC, Energy SCADA, Safety Detectors, etc.).

1.2 LITHUANIA - LIETUVOS GELEZINKELIAI (LG)

In 2010 Indra was awarded the contract to implement the railway traffic management DaVinci's platform and the construction of a new traffic control center for the management of **the whole railway network in Lithuania**. The Lithuanian administrator and operator Lietuvos Gelezinkeliai (LG), issued a tender for the project to optimize company processes and improve the quality of service to the users.

The project involves the modernization of all management and rail traffic control systems of Lithuania's 1,800 kilometers network.



Among the advantages the DaVinci system provides to Lithuania's Railway total integration between all elements of control, integrated management of all railway lines and the ability to automate the operation. In this sense the flexibility, performance and technological advances of the DaVinci platform is the key **to simultaneously manage the diversity of current systems,** next-generation interlocks of major brands such as SIEMENS, BOMBARDIER, AZD Praga and existing electromechanical Russian technology facilities which is more than 50 years old, connecting through a single CTC all interlocking with DaVinci Traffic Control systems.

The traffic control center **integrates the information from these and other systems**, such as power control system (SCADA), telecommunications network or new axle counters.

The control center and traffic management is supported by local stations centers. They need to have the capacity to carry out the following functions:

- Remote control of all interlockings
- 120 Russian technology interlocks (about 1980) integrated through PLC
- 30 interlocks by AZD, Bombardier and Siemens companies
- Automatic routing capacity
- Allow manual intervention
- Generate schedules and operating forecasts
- Modernize and integrate power SCADA
- Improve telecommunications

The project includes the modernization of all management systems and traffic control, engineering, installation, commissioning, training, maintenance and warranty.

1.3 SAUDI ARABIA - SAUDI RAILWAY ORGANIZATION

The Haramain High Speed Railway (HHSR) project is divided into two phases, the first phase is the design and construction of both railway infrastructure and stations, the second phase is the construction of the superstructure of the track, the commissioning of the line, the supply of rolling stock and subsequent maintenance and operation of the line for a period of 12 years.

The line reduces travel times, reaching a commercial speed up to 186 mph. Demand studies conducted for the "Haramain" line estimate figures up to 160,000 passengers per day, with peak times of 13,000 passengers per hour.

Under Indra's scope are:

- **Operations Control Centers**. Where the OCC and the Backup CC are in an active-active configuration for all the traffic related systems.
- **Railway Management Systems.** DaVinci's Planning Tool, DaVinci's Traffic Management System, Voice Dispatcher System and DaVinci integration platform.
- **Remote Control Systems**. Power Supply Control System, Detectors Remote Control System, Centralized Stations Management System (to control the fix installations)
- **CMMS.** Centralized Maintenance Management System to manage all the infrastructure, IT facilities and rolling stock maintenance to ensure the SLA and manage the maintenance of a complex infrastructure.
- **Management Systems.** Corporate Systems for the Operation and Maintenance Company (Enterprise Resource Planning, Customer Relationship Management, Contact Center, BI, Document Management System and Geographical Information System).

3 PROJECT APPROACH

3.1 PROJECT VISION

3.1.1 Expression of interest

Indra as an advanced control centers supplier, provides solutions where the geographical area controlled rests almost exclusively on configuration data of their systems. From this point, Indra considers as feasible and suitable the IOS South as the IOS North for the initial commissioning of this project.

Our vision and proposal for this project is to provide a **global control center** with the capacity of scalability that allows to increase the geographical area controlled with minimum effort and cost, so that fits without conditioning the commissioning order for the segments of the alignment, directly subordinated only to the needs and constraints of civil works.

Inside our main field of interest is the supply of operation control centers (OCC) with:

- Advanced features for operation (both manual and automatic)
- Ability to integrate (both technically and operationally) all operation areas of a railway network
- Great adaptability to multiple technologies from different control systems of the different controlled areas (both now and in future extensions)

3.1.2 Problem Vision and Proposed Solution

From a global point of view, the selection of the initial operating segment, as well as the subsequent extensions, can be crucial an orderly commissioning, effective and well-adjusted in cost and time.

Given our expertise and extensive experience, the control center commissioning decision is not as critical as for the other parts of the project, particularly for civil works.

We believe the implementation solution should go through carefully identifying parts of the system that can be independent at different segments of execution, and those that should follow, necessarily, uniformity and standardization, in order to ensure the success of the mission.

Firstly they could be considered as independent, for their execution and contracts the parts concerning the basic civil work, (platform, stations, tracks, etc.).

Secondly power supply systems, signaling systems and detectors implementations should be treated with other consideration although for different reasons that we will explain.

As well in power supply equipment as in detectors equipment, is advisable some level of standardization (uniformity in the various solutions of different geographical areas) in order to achieve a uniform and standardized operation in the control center (OCC) more natural and effective way.

Since the existence of different systems to cover the same subject of exploitation, differentiated by the geographical area of control, always complicates the implementation of its control systems in the control center as well as the possible integration between these systems and with other operating systems.

In this regard, as we understand it, the **signaling equipment is however even more critical**. For the signaling equipment we believe that should be ensured the same signaling system throughout the complete projected alignment. This will facilitate all critical aspects of the operation:

- Standardization of rolling stock equipment
- Implementation of monitoring and signaling control systems in the OCC
- Standardization of the operation in the OCC.
- Reduced maintenance costs of systems, because the existence of a single supplier and architecture for each subject of exploitation.

Indra has extensive experience in successfully implementing control centers in which homogeneous systems from different suppliers and technologies are integrated. Based on its integration platform, Indra greatly facilitates such integration and interfacing, and achieves a high level of standardization in OCC operations. Thanks to this experience, Indra recommendation is just the opposite, a single signaling system as we already explained above.

3.1.3 Our Proposal

Based on the premise expressed previously, that our control center solution is somewhat irrelevant of the geographic order of commissioning the line, our proposal would establish three levels of operation:

- A main operation control center (OCC)
- A backup control center (BCC)
- A local control center for each station

The underlying idea is to replicate the operation capabilities of the centralized control center in different location, so that, if there is a serious problem which prevents operation from the OCC, may be possible **to transfer full control of the line** to the BCC, quickly and effectively, allowing minimal disruption in the service delivery of the line.

In addition, the provision of local centers to locally operate a geographical area of the line ensures the operation in situations where they cannot be operated from the centralized centers and, of course, with some degraded capabilities of operation. Local centers do not have available the advanced systems for operation control.

Therefore, the local centers must be considered as last resort control centers only for specific situations, since the normal operation and the majority of abnormal situations must be resolved from the centralized control center (from main control center or from the backup control center if the main control center is not available), where the full operational capacity of all systems is available. Therefore, local centers will not be permanently cared for, which means significant savings in operating costs. For this reason, local control centers do not require dedicated permanent staff, achieving significant savings in operating costs.

This configuration of **two centralized control centers, one acting as master and the other as backup,** provides high availability of the service, which added to the individual high availability configuration of each installed system at each site, involves extremely high levels of service required for exploitation as sensitive as high-speed lines, which involve, for example, punctuality commitments associated.

Indra's recommended configuration is to provide the backup control center the same functionality provided from the main control center, so that both can operate as fully operational control center, without necessarily seeing the backup control center exclusively as a temporary operation center.

The implementation of this architecture implies the need to duplicate all control center systems in order to have a full operational capability in the backup. Furthermore, to provide the shortest operation switching and avoid the service quality loss, it is necessary that the information kept permanently synchronized between both control centers.

The supply of two centralized control centers, one acting as master and the other as backup, with different geographic location (often distant), is that we have been deployed in major projects, as well as the usual requirement of all Rail Infrastructure Managers for high-speed lines operation. For these reasons, our control center solution incorporates right now and in a natural way, the existence of a backup control center and manages of synchronization data between both of them.

Regarding the implementation and operation capabilities, our control center solution, forged and modulated with our experience, in which is possible to highlight the following features by its relevance in this decision phase:

- Facilitates and promotes **the integration of all operation systems** in the control center, taking advantage of the information exchange and providing advanced high level tools.
- **Scalable architecture** of all components, allowing for natural growth, primarily by new data incorporation, from the geographical control area, which is a great advantage for gradual commissioning of the line.
- Provides designed specifically tools for facilitate the incorporation and integration **of systems from different suppliers and technologies**.
- Through the mentioned integration and standardization **saves efforts on maintenance**.
- It facilitates and simplifies user training, by working with integrated systems that follow a standardized operation.

The functional and operating characteristics of our solution are detailed in a later chapter.

3.1.4 Points of view on the project approach

Analyzing the proposed strategy of commissioning, it seems a bit dangerous the dissociation between the implementation of control systems (the central place of operation) contract and the Train Operator establishment contract for the line operating. It is necessary to note that the operator will be responsible for maintaining and getting the highest performance from the railway network; it seems clear that the Operator's involvement during the control systems definition and implementation phase should be high as well as for advanced exploitation tools definition and implementation. The Operator should guide the definition of all the systems that will be part of their daily tools, or even to provide the systems definition.

However, we advise against the concentration of all systems in a single operations control room since the timeline, the needs and the potential users of each system are clearly different.

From our point of view, the minimum systems dispersion would be:

- Main control room: All control subsystems (signaling, power supply, detectors, communications, advanced traffic management systems, etc.)
- Maintenance room: Maintenance subsystems and positions, as well as playback and data analysis tools.
- Planning Room: Services planning subsystems and management systems for rolling stock and crew.
- Training room: Simulation subsystems and training equipment.

This subsystems' globalization should be taken into account from the beginning, from the conception and commissioning of the initial operating segment (IOS), because a subsequent forced integration of different systems will bring integration efforts that inevitably, will produce problems during the commissioning of the IOS and during the growth of the operating stretches until the entire line operation.

3.2 OPERATION AND FUNCTIONALITY

The aim of the Operation Control Center (OCC) is to provide advanced systems to carry out, in a centralized manner, the monitoring and control of the systems in charge of the railway operation. To achieve this, the OCC requires access to data obtained from all the equipment distributed along the high speed line.

To cover the specific needs of the railway operation, the control center must provide the following systems:

- **Planning systems**: Systems in charge to fix a long term planning for commercial services that moves along the railway line and make the necessary short-term changes inside the established planning (transport plan).
- **Remote systems**: Systems that allow managing remotely the equipment in charge of control the railway infrastructure (signaling equipment, power supply equipment, detectors...).
- **Traffic management systems**: Systems in order to facilitate the fulfillment of the established planning.
    - Trains monitoring and provision of current traffic information, delays and forecast regarding the established schedule.
    - Analysis of the overall traffic situation, providing tools to adjust their established planning and troubleshooting.
    - Automation of traffic control operations to facilitate the daily tasks of the dispatchers and to optimize the movement of trains.
- **Playback and data analysis systems:** Systems in charge to analyze, in an isolated environment of railways operation, the situations occurred during the train's movement. These systems can retrieve the same traffic information available for the dispatcher during a specific interval of time and reproduce their field state evolution.
- **Simulation systems**: systems to emulate, in an isolated environment of railways operation the field behavior and their interaction with identical systems to those existing in the OCC.

- **Maintenance systems:** Set of tools oriented to monitor the availability of OCC systems in order to minimize interruptions in their service and tools for resolve it as quickly as possible. As part of these systems, strategic technology solutions as EAM (Enterprise Asset Management) tools can be included in aim to reduce dwell time, to increase the uptime of the equipment, and to increase the useful life of equipment by additional providing an overall reduction of maintenance costs.

OCC must be flexibly designed in order to be easily and highly scalable on all its functions so that is prepared to control geographic expansions of project scope, like phase 2 expansion to Los Angeles-San Diego or further.

In addition to traffic control functionalities, OCC must provide integration capabilities between OCC systems in order to facilitate the end user tasks and to easily increase the functionalities available in the OCC. OCC also must provide integration capabilities with OCC external systems, fostering the OCC evolution.

Another key aspect in control centers supplying is to ensure railway operation in degraded conditions, so that redundancy of the necessary infrastructure and communications should be considered in the design of the OCC.

3.2.1 Operation vision

Modern high-speed lines **require high levels of availability in their services**. Therefore current OCC must be designed to minimize disruption to the operation of the railway line as well as the resolution of incidents produced in the shortest time possible.

The OCC design should provide redundancy at communications systems to prevent that the service of high-speed line may be affected by situations of unavailability of equipment. This first level is covered with hardware clustering in critical systems.

To **ensure maximum availability** during railways operation, Indra highly recommends to provide another OCC (BCC) in a different location with the same functionality than the first one (OCC). For this, the control centers must be designed to allow centralized operation from both locations. Thus the supply of two control centers synchronized for the control of the high speed line of California provides high availability in all critical functions of the operation. Thus, the operation can be resumed normally from the BCC without being affected by major disasters that may affect the OCC.

3.2.1.3 Main Operation Control Center (OCC)

The purpose of the main control center is to provide the usual location to carry out the complete operation of the high speed line centrally. OCC has remote controls and systems with information about the entire geographical area of the line. OCC design must take into account the need for implementation of a local communications network that ensures high availability for interconnection between OCC systems and equipment distributed along the line.

Generally, the OCC includes, in addition to critical systems for operation, other systems that are part of the life cycle of railway operations that do not require high availability; such planning systems or playback and data analysis system. These systems can be deployed in the same physical location of the OCC or at a different location and will include the necessary interfaces for the exchange of information.

3.2.1.4 Backup Control Center (BCC)

The purpose of the backup control center is to provide a location, instead OCC, to perform the complete operation of the high speed line when the OCC is not available. Useful for:

- Issues affecting the operation of the OCC.
- Disaster affecting the location of the OCC.
- Failure in communications between the OCC and countryside.

In terms of functionality, the BCC must have replicated all remote controls and systems deployed in the main control center in charge of critical operations. That is, those responsible for real-time operation.

Therefore, two control centers, OCC and BCC, must have synchronized and updated information at any moment, operation tasks are undertaken only from the "active" control center.

Among the OCC and the BCC, there is an interface that synchronizes from the active control center to the control center that is not operating as active data information relating to all operations carried out in the OCC like:

- Specific changes to the transportation plan made inside the active control center.
- Manual operations taken by dispatchers.
- Automatic operations carried out OCC systems.
- Configuration of automatic operations performed in the active control center.

The planning functions normally are provided centrally in one location and automatically updated in each control center synchronously. In the same way, interfaces to provide real-time information to playback and data analysis systems or other additional systems are provided to increase the availability of these systems despite not being critical.

3.2.1.5 Local control centers (LCC)

The purpose of local centers is to ensure the operation in a limited geographical area, in cases where it is not possible to operate centrally in a part or the entire railway alignment. Useful only for resolution of temporarily communication failures between field equipment and centralized control centers.

The total area of the railway line is geographically divided into defined areas according the installation of railway infrastructure, each area is controlled by a local control center. The local control center has no information on the collateral geographical areas. Only remote control systems of each technique will be available in local control centers but traffic management systems or integration functions will not. These local control centers are geared solely to cover the operation in degraded mode because it is not possible to provide optimal management of rail traffic since it does not have the advanced features for traffic management.

3.2.2 Advanced control center concept

The main aim of Indra in the **supply of modern control centers is to provide a technological, innovative and flexible platform that integrates and automates all processes and systems that**

comprise the reality of the current railway operations. Unlike traditional control centers where each dispatcher is dedicated to a single technique (either signaling, either energy control or regulation among others) and requires a specific command position.

Indra provides an overall integrated vision of the operation and its possibilities, from real-time integration of a set of applications that transparently exchanges information through a middleware. The integration platform supports specific railway operation systems functionality, offering common architecture, design, integration and configuration functionality, and a homogenization of the user interface with the purpose of to simplify operations. Indra provides single management and authentication tools for all systems integrated in the OCC. This integration provides the ability to access from the same dispatcher position to different remote controls according with the user permissions.

At the same time, according to operational requirements, each dispatcher position is able to be used for required remote controls or different control areas, dynamically, increasing the versatility of the OCC.

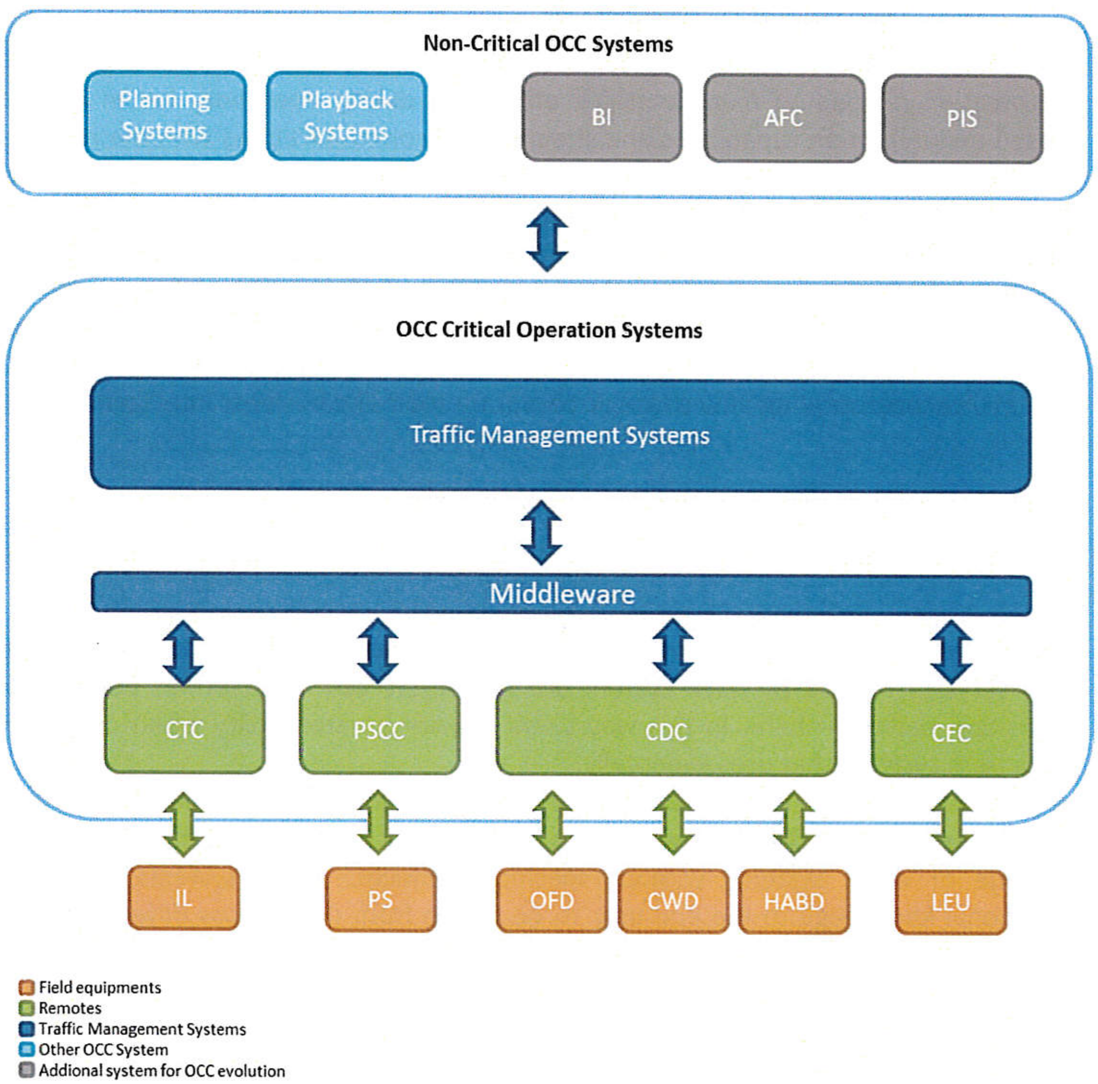


FIGURE 1: MAP OF OCC SYSTEMS

The figure above shows the map of the OCC systems displayed by criticality level. The following outlines from high to low level of criticality in railway operation of each group of the systems:

- **Field equipment**: Systems installed along the line alignment to ensure the control of the field elements with the highest level of security. As they are:
  - Interlockings (IL)
  - Object fall detector (OFD)
  - Cross wind detector (CWD)
  - Hot axle bearing detector (HABD)
  - Lineside electronic unit (LEU)
- **Remotes**: Systems that allow remotely operate a set of equipment. These systems sometimes require some level of security associated with commands exchange with the field equipment. They are:
  - Centralized Traffic Control (CTC)
  - Centralized ERTMS control (CEC)
  - Power supply centralized control (PSCC)
  - Centralized detectors control (CDC)
- **Advanced traffic management systems**: Systems that provide the overall vision and the automation needed to manage traffic effectively during operation, i.e. in real time, based on integration capabilities and standardized communications with the remotes of each technique. These systems facilitate the daily tasks of traffic operation, increasing the service quality and facilitate information distribution.
- **Additional systems to traffic management**: Other railway operation systems that based on the information provided by the integration platform and traffic management systems can be incorporated to the control center automating tasks. **Like passenger information systems (PIS) or Automatic fare collection systems (AFC).** Similarly the OCC can evolve incorporating new strategic corporate tools like business intelligence systems (BI).

3.2.2.3 Advantages of system integration into the OCC

Apply of robust integration features as mentioned before achieve the following advantages in the OCC:

- A better end user experience of the global system, thanks to similar look&feel of tools and services offered by each system are consistent with each other, being smooth transition between them. In this way users acquire greater agility when dealing with data from systems that uses eventually.
- A great added value at the global level is obtained in the OCC. **Information distribution favors the incorporation of new systems in OCC** that can get the information published by one or more systems without specific interfaces. These systems can provide additional knowledge to the end user to be drawn from data across different systems, both as corporate as purely rail systems.

3.2.2.4 Information distribution

Integration between integrated systems that form the OCC is implemented using a messaging system that will act as middleware. The main application of this software module will run on integration servers, and each system must have an adapter module messaging system. Thus, the messaging software purpose is to provide the necessary transportation to communicate heterogeneous systems with each other. It also allows interfaces definition between existing remotes systems in a clear and flexible way. This solution, offers multiple configuration options. To choose whether messages are generated synchronously or asynchronously is allowed according to the publishing-subscription paradigm.

3.2.2.5 OCC integration platform

The integration platform provides the following functionalities for managing the integrated OCC systems:

- Authorization and authentication.
- Users, profiles and permissions.
- Configuration and user preferences.
- Degraded mode for systems.
- Systems initialization.
- Integration messages.
- Administration and monitoring.

These features allow the OCC operation by "multi-system" positions that can be configured dynamically during operation by increasing the versatility of the operation position and the availability of systems that form the OCC.

A Single-Sign-On tool (SSO) is provided in the operation positions from which, each user can access to their authorized systems, thanks to the unified management of users, roles, permissions and access areas available into the platform. Integration platform also provides a web application to set up the user's permission.

Features and functionality of the integration platform mentioned above are carried out within flexible technical specifications:

- Operating system independence
- Architecture based on Message-oriented middleware (MOM)
- Components and open source tools
- Interoperability and standardization ensured by XML.

3.2.2.6 Interoperability Platform

The interoperability platform which act as middleware and repository is capable of processing thousands of events per second with Big Data capabilities and integrated rules, multiprotocol interfaces and multilanguage APIs.

The platform provides a long list of capabilities which makes it a very powerful solution in those contexts where interoperability, real time event processing, security and big data analytics are a must.

Besides interoperability capabilities, the other major features of the platform are based on its oriented approach designed towards Big Data, allowing the platform to support massive data volumes. The platform is especially suitable for solving the problem of 4Vs: scenarios in which a large **Volume** of data from devices and systems of **Varied** nature, generated at a high **Velocity** and this information should be controlled and validated in order to assure its **Veracity**.

The platform has been designed from the beginning in order to be built on parts that support and ensure horizontal scaling, i.e. that compared to the traditional concept of requiring increasingly powerful or with greater capabilities machines (**vertical scalability**) for lowering increases (logarithmic growth) of performance, the platform is designed to allow processing capabilities to improve linearly by adding new machines to the platform. Moreover, these additional machines do not require high technical characteristics, allowing to achieve this growth by installing what is known as "commodity hardware" (ie, basic hardware at low cost) which allows the acquisition of several less powerful machines, but whose sum gives the system a better performance and a much larger ROI than continuously making upgrades on the existing machines.

This **horizontal scalability** has the advantage of being able to **grow in stages** without being accurately dimensioned from the initial infrastructure, reducing costs of acquisition and operation of the platform and only having to invest the required cost at each time.

The platform will allow external entities from private and public sector to exchange data in order to create new innovative applications and functionalities based on transportation management. The API Manager and the Developer Kit provided with the platform will allow partners **creation of new services (Transport System Information Center, Users Information Center)** based on published services through well-known interfaces (such as HTTP REST) to "open" the platform to almost any system, given its standardization (eg Smartphones, browsers, Enterprise systems, etc.). Users not only are able to consume services, but also search for them using keywords and subscribe to the APIs. This concept has been used a lot lately in the social media environment, allowing any user and system to interoperate with the system.

This module also has an **Open Data** component with the capabilities of publishing certain information from the platform publically to the outside.

3.2.2.7 Multi-modal Operation Platform

The multimodal operation platform will provide functionalities to **integrate mobility and public transport systems** and encourage multimodality, allowing more efficient resource management where different transport operators collaborate offering better services adjusted to the citizen's real needs.

The features provided by the Multi-modal Operation Platform will allow the creation of an Enterprise Transportation Management Center where the following global functionalities will be possible:

- **Global real time monitoring**: The platform is able to receive, analyze, and present all real time information provided by the different sources. The openness of the solution will allow in the future adding new data sources or optimizing the current ones.
- **Global Transportation Planning:** the multi-modal platform is able to receive data from others transports operators, not only about transport assets but also about users, preferences, incidents or events. Through the Data Analysis, Simulation and Forecasting modules this data will be transformed to an optimal planning and resources assignment for all transport means with the next advantages:

- **Operate according to the published timetable.**
- **Travel reduction.**
- **Predictable journey times for users.**
- **Maximization of vehicle flow, maximizing also the value of the infrastructure.**
- **Enhance coordination between the different transport means.**

- **Global Transportation Management:** This capability allows analyzing together and in real time the Global Transportation Planning with the real time monitoring. The Platform will be able to detect automatically incidents, deviations and mitigation actions comparing the optimal situation with the current situation. The global transportations management is a continuous process. The platform will store every data and information and with the help of the simulation tools the management process will be continuous improved.
- **Real multi-modal and schedule adaptation:** With the data obtained from different sources: OCC's, alternative data acquisition and future real time sources, the platform is able to create patterns about transport uses which will result in real time coordination applying always cost-benefits policies.

3.2.2.8 Crisis Management Platform

The Crisis Management Platform will support operator in coordinating services, incidence management, emergency operations and crisis scenarios.

The aim of this platform is to improve events, incidences, and emergency management which can be planned or unplanned. For each case, the operator can define a set of actions to be taken in order to mitigate negative impact or restore normal operational status.

The platform improves on this functionality through a high level subsystem that automates detection of incidents, events or cases, also automates the response to the incidents and it guides users in those actions that the system cannot do automatically. The main features of this subsystem are the following:

The Standard Operating Procedures (SOP) is completely configurable in the system, defining mandatory and optional actions, priority, resources, coordination action and everything included in the SOP.

The platform allows **integration of heterogeneous information** sources as an origin of incidents. The risk in the management of an incidence depends on its rapid detection. Every second that passes, increases the risk of escalating the complexity of the accident due to subsequent accidents caused by the first one. Therefore, it is very important to carry out effective management of incident detection, allowing triggering the necessary actions as soon as possible to mitigate the impact.

The Crisis Management Platform implements a seven-phase Incident Management (IM) model:

1. **Discovery:** In the Discovery phase, Incidents shall be detected by the Platform. Detection / discovery of Incidents lead to Events in the Platform. Events indicating Incidents, or developing Incidents, shall be lifted to Alarms.

2. **Verification**: In the Verification phase, the Operator verifies Incidents detected by Platform, or by other sources.
3. **Initial Response**: In the Initial Response phase, the Operator shall manage, control and prevent the Incident from developing further. This phase may include alerting the emergency services if necessary.
4. **Scene Management**: Incident Scene and execute their mission. The Scene Management phase starts when responsibility for the Incident Scene is transferred from the Operator to the person in charge as Incident Scene Manager. The phase ends when the rescue and support mission has been brought to an end.
5. **Recovery**: The Recovery phase is where the Incident Scene is cleared in order to resume to normal operation. The rescue and safety related activities by the emergency services are over and only clean-up and (temporary) repair works remain.
6. **Restoration to normality**: The Restoration to Normality phase is where traffic conditions and systems are reset prior to Normal operation.
7. **Normality**: The Normality phase is the phase for daily operations. The Operator shall in this phase always be prepared to step into the IM management circle. In this phase activities and procedure related to everyday activities and task are placed.

The use of the platform provides the following benefits:

- Maximize security and minimize risks:
- Reduce reaction time to road incidents.
- Guarantee that the response time towards one same incident in different periods of time is homogenous and follows the Operation Manual.
- Facilitate the Operation.
- Register all of the operations carried out, both normal operations described in the SOP, and those carried out to solve an incident described in the Response plan.
- Allow this registered information to be used, not only at a statistical level, but also based in actions carried out during the resolution of a specific incident.
- Quality service management.
- Provide a high service. The high level execution of the objectives is essential to provide all the road users an adequate level of safety and comfort.

3.2.3 OCC Functionality

Systems integrated into the OCC can be grouped according to their purpose into the railway operation (involved operation phase of use) in the following **operational environments**:

- **Planning environment**: Is an isolated environment from operation environment that allows planning new services prior to its execution. As well allows evaluating the capacity of the line and the feasibility of include modifications into the current plan.
- **Operation environment**: This environment includes systems in charge to control and manage the railway operation in real time: traffic management systems, remotes like CTC, CDC, CEC, PSCC and communications dispatchers at least. Also may include additional systems for traffic management.
- **Playback and analysis data environment**. Is an isolated environment from operation environment that provides analysis and off-line playback tools based on historical data

stored during real-time. This environment also provides real-time mechanisms and tailored storage policies to record the necessary information without affecting the performance of critical systems of operation environment.

- **Simulation environment.** Provides an isolated environment from operation environment where systems like OCC systems (new instances of same systems) control a virtual field similar to the real field equipment. Really, this environment is not part of the OCC, but complements it with the purpose of facilitate the OCC evolution and the knowledge of the OCC systems.

Below you will find a detailed description of the functionalities for each system proposed above:

3.2.3.3 Planning systems

The aim of planning system is to manage the programming of the use of the rail network optimally. Planning systems provides the planner the tools and support necessary to perform everyday planning tasks in a simple and intuitive way. Based on the route and type of rolling stock planning systems provides a realistic travel time for each given service. Providing a planned schedule for all services, planning systems contributes to making it easier, the traffic management in real-time.

Indra's planning system allows the configuration of the default values used in schedule planning as margins UIC, rounding of travel/stop times or parameters used in the travel time calculation (acceleration values comfort, braking comfort, strength tunnel, and accuracy in the calculation of minimal running ...).

Main functionalities of planning systems are the following:

- Rolling stock type management: Allows modelling into the system the physical characteristics of each rolling stock type available in the railway operation.
- Running simulation specific for each commercial service based in the rolling stock type used.
- Plan management. Provides a long-term schedule for trains along the rail network and the incorporation of specific modifications in short-term schedules. Allows defining new long-term plans in advance as well as modifications to the current plan by assessing their viability and the line capacity without affecting the operating environment. For each planned service it provides information about train numbers, timetables, rolling stock composition and other data.
- Conflict detection and resolution. In order to help the user during planning tasks Indra provides tools that detect potential conflicts in planning and proposes overall solutions tailored to the produced conflict type for its resolution.
- Rolling stock labeling and staff assignment system. Based on the scheduling information planning systems may include tools for optimizing the personnel and rolling stock necessary to fulfill the scheduled plan and the allocation of specific resources for each service.

3.2.3.4 Centralized traffic control system (CTC)

The aim of the centralized traffic control system is to control centrally the interlocking systems that make up the line. The CTC system provided by Indra has been designed by the highest standards of software design and programing. Conceived as a highly modular and configurable system at all levels of its architecture, allow CTC adaptation to multiple projects without re-implementation of its main modules.

Some of the key features provided by Indra's CTC regarding other suppliers are:

- Modular and easily scalable system.
- Designed for high availability.
- Control of different interlocking (technology and suppliers) from a single CTC system.
- Certified as SIL2 in accordance with CENELEC security normative.
- Modern GUI with dynamic views highly configurable.
- Natively designed to integrate with traffic management systems.

The CTC provided by Indra covers the following features related to traffic control:

- **Field monitoring.** Provides required methods to maintain at all times the current state of the field elements and provide a real-time graphical representation adapted to the specific videographic standard of each client.
- **Sending interlocking commands.** Allows to dispatcher request interlocking commands inside a controlled area: Establishment and dissolution of routes, points movements and blockings, closures and blockades of signals, etc. Indra's CTC also provides to the dispatcher advanced facilities for the construction of macros, ordered sequences of operations, to perform certain complex simple and repetitive operations that the dispatcher can run when deemed necessary.
- **Train inference and tracking.** Detection of sequence occupations and releases of track circuits (and similar elements), in order to, through tracking algorithms, performing inference and train tracking.
- **Train numbering.** Allocation and management of specific identifiers for each material manually by the dispatcher. Indra also provides advanced features to schedule numbering operations for trains to run automatically in base of field conditions and periods of application set by the dispatcher.
- **Alarm management.** Notification of abnormal operating conditions that require special attention from the dispatcher registering them as alarms in the system and establishing a life cycle that allows the management and monitoring of its evolution. Provide information of CTC and interlocking with different levels of severity and whether the alarms are repairable manually or automatically.
- **Sectorization:** Enables to dynamically manage the distribution of all existing interlocks between operating positions available at the OCC.
- **Remote Management:** Provides protocols that allow switching the interlocking control between the OCC, the BCC or the local control center.

3.2.3.5 Traffic management systems

The aim of the traffic management system is to provide the dispatcher the neccessary information and assistance to optimally perform daily tasks arising from train movement, with the main purpose of fulfilling the established trains' schedule. Through the automation of operations, traffic management system is able to improve the train punctuality and reduce the risks from human errors during railway operation. The traffic management system provides a high degree of parameterization that allows adapting traffic management capabilities to the specific traffic type of each railway operation. Automatically traffic management system provides updated information on scheduled planning and allows performing necessary adjustments during the operation.

Functionalities of traffic management may be classified into three groups:

- Train movements monitoring
- Regulation operations
- Automation of operations

Functionalities for monitoring the movement of trains are detailed below:

- **Trains movement management.** Provide updated information during the entire life cycle of the train movements: state, number of identification, travel direction, location (position and track), planned times, actual times and forecasts ...
- **Positioning system integration and automatic tracking.** Provide easy integration whit different positioning systems (CTC, ETCS, and GPS), supporting different suppliers and technologies. And able to provide transparently tracking information to other systems and applications.
- **Automatic time registration.** In base to obtained information automatically record into the system the arrival/departure time through each checkpoint for each train (audited time). So that the dispatcher does not need to take any action to record the times of movement through checkpoints of train travel. Supports changes or manual registration in the absence of information from positioning systems installed.
- **Forecast calculation**. Automatically for all trains, provides accurate estimation for the actual time of passage of trains for the part of the route that has not yet been reached, based on the planned schedule and the actual schedule reached. The forecast estimation is kept update on every train movement, taking into account factors related to traffic conditions and infrastructure restrictions which may require an increase of travel time.
- **Delays and justifications.** Automatically provides information about the difference between planned and actual audit for trains schedule. It allows the dispatcher to easily justify audit operations registered in the system to reflect abnormal situations of traffic. Algorithmically it detects and highlights the situations defined by the customer as required justification.
- **Automatic delay justification**. Allows programming justification tasks for fixed-term points of the route, so that the trains running in the indicated direction if they acquire delays will be automatically reflected the cause for the delay as justification.

Regulation operations provided by the traffic management system are detailed below:

- **Scheduled plan management.** Allows performing punctual modifications into the scheduled planning to contemplate unanticipated movements and urgently carry it out like creation of new services or cancellation of planed services.
- **Train movement behavior management.** Provides the capacity to set a target schedule for trains in movement from the planed schedule according to the forecast information

in order to regulate optimally the network traffic. The purpose of the traffic management system will be meeting the target rather than the planned time schedule.

- **Real composition management**. Allows update in real-time the rolling stock information defined to include data of the specific rolling stock which carries out the planned service. New data are taken into account for the forecast calculation and the other traffic management functions.
- **Detection and Resolution of Conflicts**. Provides an overall of the traffic situation, analyzing the interrelationships between trains' movements and detecting potentially degraded situations. Determines and propose possible solutions to the conflicts, modifying the behavior of the train's movements involved and ensuring that the new behavior doesn't cause more conflicts.

Main automatic operations provided by Indra are detailed below:

- **Automatic route of trains.** Provide a system able to determine the authorization required from each interlocking to fulfil the scheduled train movements. During the movement of trains, automatically sends orders of routes establishment for each train to the centralized train control remote (CTC) taking into account the position of the trains, planned and scheduled times and the priority of the configured rules.
- **Automatic numbering of trains.** For inferred trains by the centralized traffic control remote (CTC), is able to determine which number corresponds to each train movement within the scheduled planning, and send automatically the necessary train's numbering orders to the CTC. Thus it is not necessary for the dispatcher to manually number each train in the CTC system.

3.2.3.6 Playback and analysis data systems

The aim of playback and analysis data systems is to allow recovery and when off-line to analyze the events occurred during the railway operation. For this purpose all relevant data produced during railway operations by remotes and traffic management system are recorded and persisted in DB (Data bases).

The main functions of playback and analysis data system are:

- Recover information recorded during a selected interval through specific mechanisms, and ensure synchronization state elements during the interval playback.
- Easy selection of time window for the playback interval and easy control of playback with Play/Pause/Stop buttons and the possibility of changing playback speed by user.
- Display graphically during playback events and actions occurred in the operation position through similar views to those available in the centralized traffic control (CTC) remote graphic interface.
- Display graphically during playback events and actions occurred in the operation position through similar views to those available in the traffic management system graphic interface.
- Provide user facilities to analyze the information published by OCC systems oriented to easily interpreting the volume and type of data using filters, viewers, and allowing the

definition of specific configuration views. In the same way also provide reporting features.

3.2.3.7 Simulation systems

The aim of the simulation systems is to substitute the real physical world for a simulation of it, called the Integrated Synthetic Environment, and control it via similar applications and interfaces used in real world control.

The simulation system user is able to modify the virtual world from the simulation environment station with the same tools as in the OCC operation environment (replicated systems for planning, CTC and traffic management systems). The virtual world will evolve based on user's commands, who will receive the changes caused by his actions in simulation tools. The virtual world changes in coordination so that all applications receive coherent information. In this way, the simulation environment will recreate situations like those occurred during the real operation.

The main features that offer field simulators are:

- **Simulation of signaling interlocking**. Based on the detailed knowledge of each interlocking basic features that affect the movement of trains and control from the CTC (state of the field elements) are implemented.
- **Simulation of the detailed topology of the railway infrastructure**. Virtually recreates the real railway operation with all its circulation facilities and its collaterals connections; That is, the railway line is modeled and is aware of the absolute and relative position of its elements within the line, keeping all positioning data for track circuit, turnouts, signals ....
- **Simulation Train**: Allows the movement of the rolling stock to make and evolve the field.

Simulation environment provides specific graphical user interface (GUI) to control field simulators and synchronize all simulation systems. The user, from the simulation environment position, can operate to modify the field condition to determine the movement of trains, ultimate goal of railway operations. For each simulation different models of train's behavior and train drivers can be established.

The simulation environment is a complementary environment to the centralized control center that nevertheless provides many **advantages for the control center** itself:

- Training:
  - The operator can practice on the same applications to be used in real operations with complex situations, without affecting real scenarios.
  - Aptitude maintenance in the face of degraded situations.
- Operational procedures design and trial:
  - Availability in the synthetic environment of infrequent situations for testing.
  - Testing possible solutions or already established operational procedures via operation applications.
  - Possibility of generating many incident situations without any real risk.

- Possibility of testing the same situation until the operator fully masters it.
- Possibility of testing different solutions for the initial situation.

- Analysis and verification of new operation plans:
  - Operation plans generated in real planning tools.
  - Performing operation plans in the simulator, making them valid in the environment, with or without automatic routing, also involving CTC operator operations allowing fulfilment of said plan.
  - Manual re-planning tests or inserting new trains.
  - Checking automatic routing configuration plans.

3.2.3.8 Response to questions

1. The delivery strategy is to have separated contracts between civil works, railway subsystems and Operational Control Center. This strategy reduces the lifecycle cost because of the reduction the interfaces between the same type of subsystem for different stretches. It reduces the maintenance cost because of the reduction the suppliers' number, just having one supplier by subsystem
2. As we explained before, having contracts for the whole alignement for each subsystem reduces the interface risk and the integration with new stretches
3. Considering that the role of the Authority needs the arm of an independent Global Control Solution and that economically the implementation Global Control Solution do not represent a big amount in comparison with civil works supply. The implementation must be through a individual and separate contract.
   This governance of this contract must not be connected, even in the financing with others (developer one, ...) and could be financed directly by the Authority or by the private Contractor through an specific concession. Control projects must be separated from other projects, otherwise, integration, interfacing and contamination risks will appear.
   In this case (Technological PPP/Concession) the special nature of the supply (technology and services) introduces specific factors to consider:
   Availibality payments is the most suitable way for the succesfull financing, due to that nature of the services given. This kind of concessions only admits availability payments through KPI applied to each level of service required (Spanich Infrastructure manager contracts).
   The term of the services should be no longer than 20 years, the financing market will not accept the risk of obsolescence of the technology for a longer period.
   For a better project financing of the business plan (financial model) of each concession/PPP contract we consider very useful to perform a special mechanism of information to the financial market with the general state of the art of the project and with the specifics consideration for this project. This will allow the Authority to evaluate and mitigate factors the financial market will arise through these conversations.