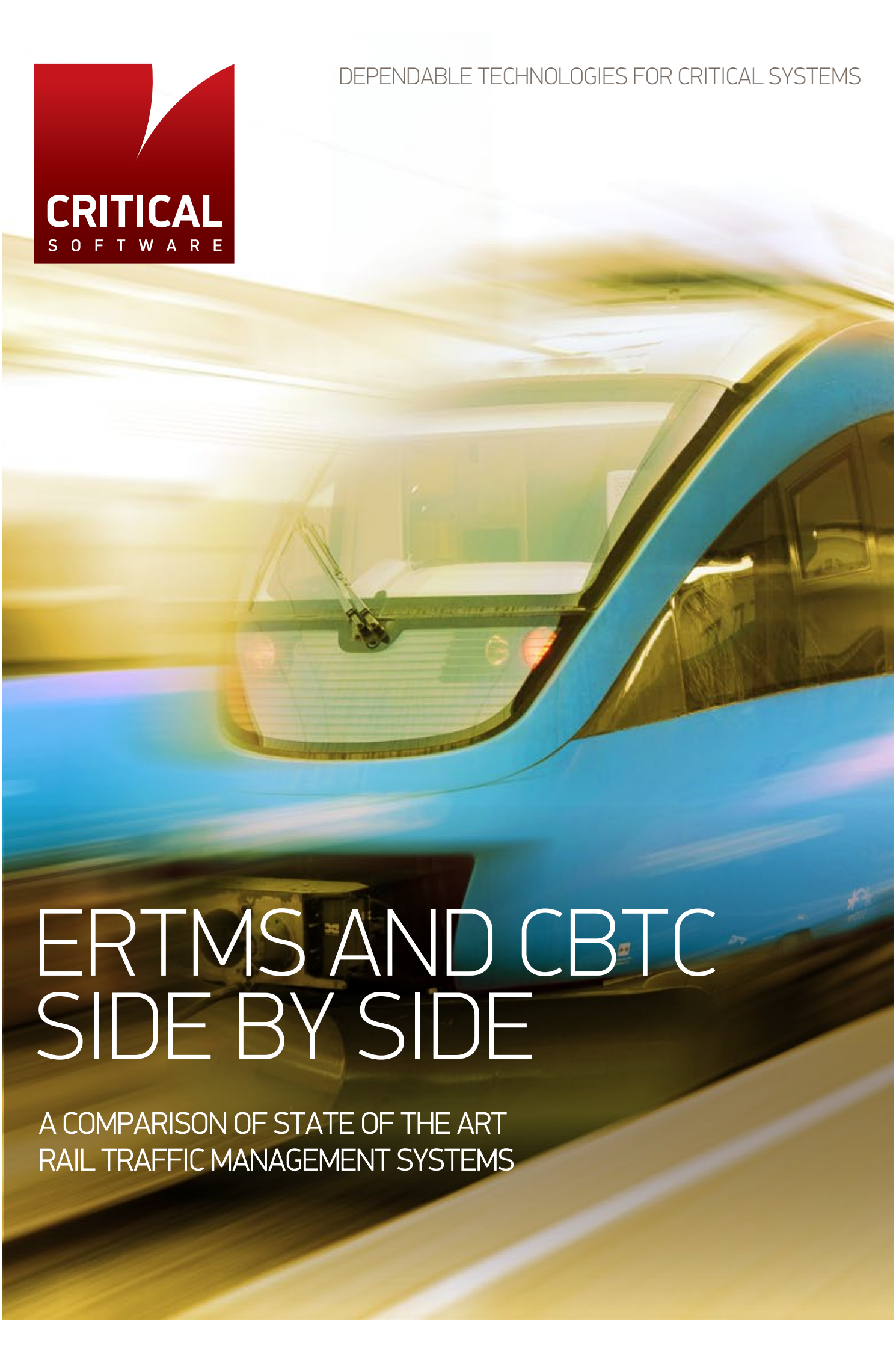
CRITICAL SOFTWARE

DEPENDABLE TECHNOLOGIES FOR CRITICAL SYSTEMS



ERTMS AND CBTC SIDE BY SIDE

A COMPARISON OF STATE OF THE ART RAIL TRAFFIC MANAGEMENT SYSTEMS

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The current needs of railway operators for higher traffic capacity, shorter headways and improved customer services, without affecting safety, have been growing exponentially in the last years. This situation provides manufacturers with the opportunity to explore the advantages of evolved communication systems, like GSM and similar, in the context of safety-critical applications in train control systems.

The ultimate goals of railway operations can be summed-up as:

- Achieve the minimum headways of Mass Transit in the Mainline;
- Achieve the interoperability, already standardized in the Mainline, for Mass Transit.

ALL THIS BY PROVIDING A GREATER NUMBER OF SERVICES WITH A HIGHER LEVEL OF QUALITY TO CUSTOMERS AND ENSURING THE NECESSARY FLEXIBILITY. THEREFORE, ALL OPERATORS CAN HAVE THEIR REQUIREMENTS MET, WITHOUT BEING DEPENDENT ON A SINGLE SUPPLIER.

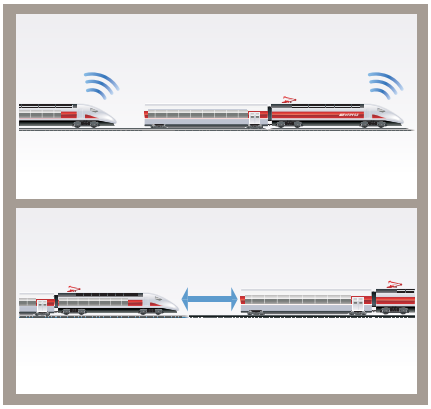

Figure 1: Optimised safety distance between trains - Minimum headways.

ALTHOUGH THE NECESSARY FUNCTIONALITIES TO ACHIEVE THIS GOAL ARE ALREADY DEVELOPED AND IMPLEMENTED IN SEVERAL NETWORKS AROUND THE WORLD, THEY ARE NOT BEING USED ALL TOGETHER IN A SINGLE SYSTEM.

There is a well-defined separation between the systems that are being used in Mass Transit networks and the ones being used for Mainline. However, each of these systems has the necessary maturity to step forward to an integrated solution that comprises the best of both worlds: European Rail Traffic Management System (ERTMS) and Communications-Based Train Control (CBTC) system.

As a relevant case study, these two systems already coexist in some networks, such as the Marmaray project in Istambul, which extends for, approximately, 77 kilometers and is equipped with CBTC for passenger services and ERTMS level 1 for freight transportation. Although both systems are being used in the same project, they will be installed in different lines. This leads to rolling stock constraints, which must be equipped with two different onboard systems or they would otherwise be unable to run in some sections of the network.

Converging these two technologies will also tackle the current problem of lacking a system that covers the operational requirements of suburban lines.

CBTC VERSUS ERTMS

Each of these two systems can be divided into four main components. When looking at them in a generic way they are actually fairly similar.

CBTC Communication-Based Train Control			
Onboard Equipment	Control and Command Centre	Communication System Spread Spectrum	Trackside Equipment

Figure 2: CBTC System's components.

ERTMS European Railway Traffic Management System			
ETCS Wayside + Onboard	Traffic Management System	Communication Sytem GSM-R	Signalling System

Figure 3: ERTMS' components.

WHAT ARE THE MAIN DIFFERENCES?

Interoperability - Strongest point of ERTMS. Not yet available for CBTC systems.

Flexibility - ERTMS allows for a smoother migration from conventional systems without disrupting the operational services.

Automatic Train Operation (ATO) - Available in CBTC systems. It is still in development for ERTMS.

Moving block principle - Available in CBTC systems. It allows for shorter headways and, consequently, increasing the capacity. It is still in development for ERTMS (Level 3).

WHAT ARE THE BLOCKING ISSUES THAT ARE PREVENTING THESE TWO SYSTEMS FROM CONVERGING?

Operational requirements - Each costumer/network has specific operational requirements, different infrastructures and may use different communication technologies. The system being developed must be flexible enough to support these differences without compromising the features already achieved by each of the individual systems (ERTMS & CBTC).

In the future everything will converge towards the standardization of the operational requirements for train control systems. However, this goal will be difficult to achieve due to the big number of stakeholders involved.

Some attempts at requirements standardization are already being pursued, like the EURO Interlocking initiative from the International Union of Railways (UIC).

Train integrity - Ensuring the train integrity is one of the challenges facing effective usage of ERTMS Level 3. This is mandatory for the system being able to support moving block operations, while being able to reach the headways already available in CBTC systems.

THE IMPORTANT ROLE OF COMMUNICATION SYSTEMS: WHAT SHOULD BE CONSIDERED WHEN CHOOSING THE RIGHT ONE?

The communication system is the basis for providing a safe and optimized operation and, ultimately, for guaranteeing customer satisfaction by improving services available on-board and adding new ones in the same line.

The goal when choosing the appropriate communication system should be to ensure that it has the ability to manage, in real-time and simultaneously, a large amount of vital and non-vital information, ensuring high levels of safety, reliability and availability.

Since communication technologies are always evolving, it is very important to prepare the networks to support future upgrades. This would allow operators to take advantage of new and improved services and technologies without having a major impact on their current infrastructure and their normal network operation. It is also important that the choice between systems does not restrict the operator to a single supplier of train control systems. The interoperability principle is being pursued very actively nowadays and it is part of any operator specification for new lines, or for the modernisation of existing lines.

Figure 4: Train communication network.

THE WAY FORWARD

There is still a long way to go before the full integration of these two systems becomes possible, but its gradual approach is a reality, as they already coexist in some networks.
The simultaneous usage of these two systems will bridge the current lack of specifications for suburban areas, where the operational requirements turn out to be a mixture of current target scenarios where ERTMS and CBTC systems are applied.
The interoperability between different systems will also lead to a reality where situations such as transhipment and rolling stock constraints (different on-board systems for different facilities) will no longer exist.

CRITICAL SOFTWARE'S CAPABILITIES

CRITICAL Software's engineering capabilities may be compared with the independence principle necessary for railway certification: system development or independent validation and RAMS.

SAFETY-CRITICAL DEVELOPMENT SERVICES

The safety-critical development area comprises expertise in the development of high-integrity embedded software and systems, particularly when real-time and/or safety and dependability issues are concerned. This expertise area holds a body of knowledge in specific standards such as EN 50126, EN 50128, EN 50129, IEC 61508, DO-178B, ECSS, Galileo SW Standard and MISRA, among others.

We have vast experience in developing real-time software in all development life cycle phases, from system requirements to validation. Our software development competencies include:

- Model Driven Development through SCADE and Simulink;
- Real-Time and embedded software development (Ada, C and C++);
- EN 50128 and DO-178B software development;
- RTOS development (RTEMS, LynxOS, Integrity and VxWorks);
- On-board satellite software development;
- MIL-BUS-1553, CAN, CANOpen, J1939 and Link16.

We are used to adapting our engineering capabilities to what is required and to what is used by our customers. Our tool chain includes experience with different commercial and open source tools.

SAFETY-CRITICAL VALIDATION SERVICES

We have a solid track record acting as an Independent Verification & Validation (IVV) and RAMS service provider. We have an engineering area dedicated to supporting our customers in performing validation to their systems, with experience in regulation for different kinds of applications, namely:

- Railway systems: EN 50126, EN 50128 and EN 50129;
- Transports system: ISO/IEC 61508 or ISO 26262;
- Airborne systems: DO-178B, DO-254 and ARP4761;
- On-board systems: ECSS Q-40 and NASA STD-8719.13;
- Support software certification: DO-178B, ISO 61508 and EN 50128.

Our IVV methodologies go far beyond "traditional" Verification & Validation techniques applied by development teams. While development teams aim to ensure that the software performs well against the nominal requirements, our IVV team is focused on non-functional requirements such as robustness & reliability and on conditions that can lead software to break.

Our experience in RAMS (Reliability, Availability, Maintainability and Safety) comprises a set of techniques and analytical tools to assess the safety and dependability of a system. We have know-how in applying different techniques depending on several aspects of the system (criticality, system requirements, etc.).

ABOUT CRITICAL SOFTWARE

Since 1998, CRITICAL Software has developed capabilities to deliver high integrity systems for safety and mission critical oriented solutions. These capabilities were built following demanding international standards and providing services for customers in areas related with Aeronautics, Space, Defence and, most recently, in Railway markets. Having the opportunity to work on applications in different domains, all with high levels of dependability, allowed us to leverage knowledge and experience across different markets, something that is recognised by our customers as a strong competitive advantage. Our capabilities originated from on both safety-critical development and safety-critical validation projects.
In recent years we have worked at system level in system analysis, design, validation and certification support, acting as an independent safety, RAM and validation team.

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