The Central Operation Cockpit – The Heart and the Brains of Autonomous Steel Production

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Demographic change and the demand for higher efficiency are among the most pressing challenges facing steel plants worldwide. As a pioneer in the steel industry, Primetals Technologies Limited has addressed these challenges with the development of the ***Central Operation Cockpit (COC)****. This solution enables AI-powered, intelligent centralized supervision and assisted control of entire plant areas by a single operator—an important step toward fully autonomous steel plants.*

Through intuitive visualization, context-aware guidance, and multimodal operator support, the COC assists operators during complex tasks while ensuring consistent decision-making. Developed through close interdisciplinary collaboration combining deep process knowledge, automation expertise, and advanced digitalization capabilities, the COC acts as a technological flagship for Primetals Technologies and the global steel industry. It demonstrates how innovation and domain-specific artificial intelligence can fundamentally transform steel production.

1. Introduction

The global steel industry is currently at a critical turning point. Demographic shifts have led to a decline in the number of highly specialized operators, while increasing demands for efficiency, product quality, sustainability, and operational reliability drive the transition toward higher levels of automation and, ultimately, autonomous production.

Traditionally, steel plants are operated by several highly trained senior controllers, each responsible for a dedicated process area. Although this approach has proven effective in the past, it is becoming increasingly unsustainable due to its heavy reliance on individual expertise. Critical situations—especially during night shifts or abnormal process conditions—are prone to delayed reactions, inconsistent decision-making, and vulnerability to human error.

To address these challenges, Primetals Technologies developed the **Central Operation Cockpit** (hereinafter referred to as COC): a centralized concept that consolidates supervision and decision support for entire plant areas into a single-operator environment [(1)]. The COC combines domain-specific AI and deep process expertise with intelligent visualization, guided workflows, and event-driven orchestration across video management, automation, and digital assistants. This provides a foundation for progressively higher levels of autonomy, enabling a structured transition from operator-driven to autonomous operation (**Figure 1**), while maintaining or improving safety, stability, and throughput.

Beyond solving immediate operational pain points, the COC is positioned as a strategic platform for continuous evolution. Its modular architecture, rule-based configurability, and operator-centric design enable rapid adaptation to plant-specific requirements, integration of new assistants and analytics, and scalable deployment across different plant types. As such, the COC functions both as an operational cockpit and as an enabling infrastructure for the next generation of autonomous steel production.

This manuscript presents the motivation, development approach, and functional architecture of the COC, positioning it as a major milestone toward next-generation steel plant operation.

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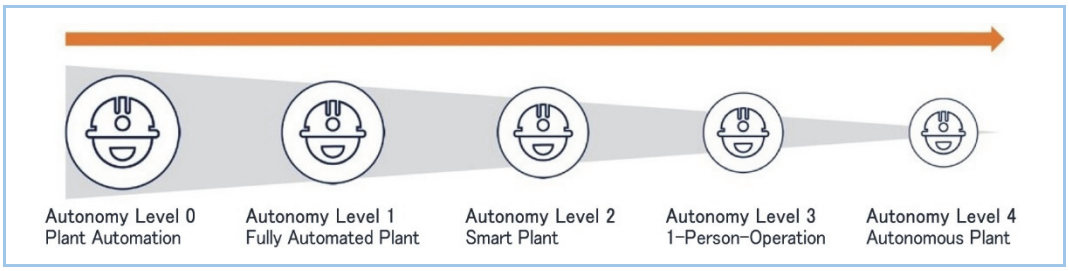


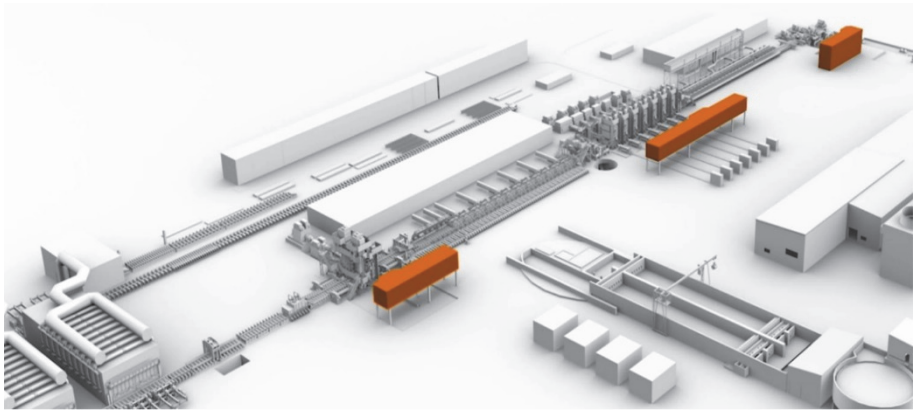
Figure 1 Levels of plant automation

2. Development

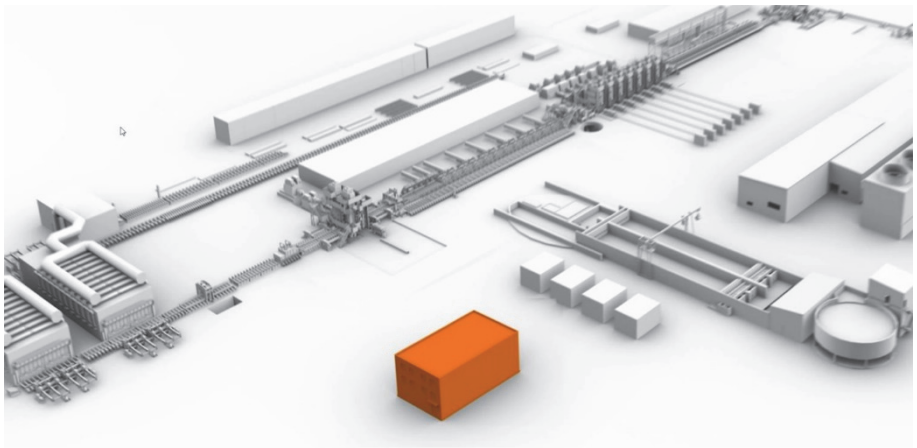
2.1 The transition from traditional control rooms to the COC

Figure 2 illustrates the fundamental shift from traditional control room layouts to the COC concept. Historically, hot-strip mills require *three separate control rooms*, each positioned close to the production line and staffed by dedicated operators.

With the COC, these functions are consolidated into a *single centralized control room*, which no longer needs to be located near the process area. The loss of direct visual contact is compensated for through comprehensive CCTV coverage and advanced digital assistant systems [(2), (3)].



(a) Classic hot strip mill layout with 3 control rooms



(b) Hot strip mill layout with a COC

Figure 2 Hot strip mill layout

2.1.1 Avoiding operator overload

This raises the question: *How can a single operator supervise multiple process areas without being overwhelmed?* This is achieved through intelligent assistance systems. **Digital Assistants** (hereinafter referred to as DAs)—AI-powered analytics tools—monitor camera streams and process data, automatically detecting abnormal situations. For example, as shown in **Figure 3**, the Ski Detection Assistant identifies the formation of a ski and provides precise measurements. The operator is alerted only when intervention is required.

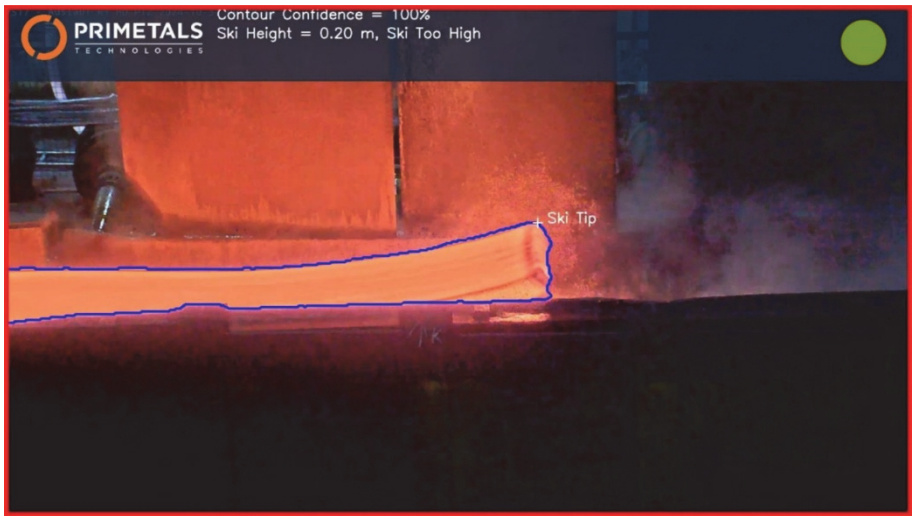


Figure 3 Digital Assistant for ski detection in hot rolling

2.1.2 The role of the COC in the plant of the future

The COC filters incoming information to ensure operators receive only relevant data and recommended actions. This reduces cognitive load, improves focus, and lowers the risk of human error.

That means only selected camera streams and system HMIs (Human-Machine Interfaces) are shown at any given moment. This requires three key components (**Figure 4**):

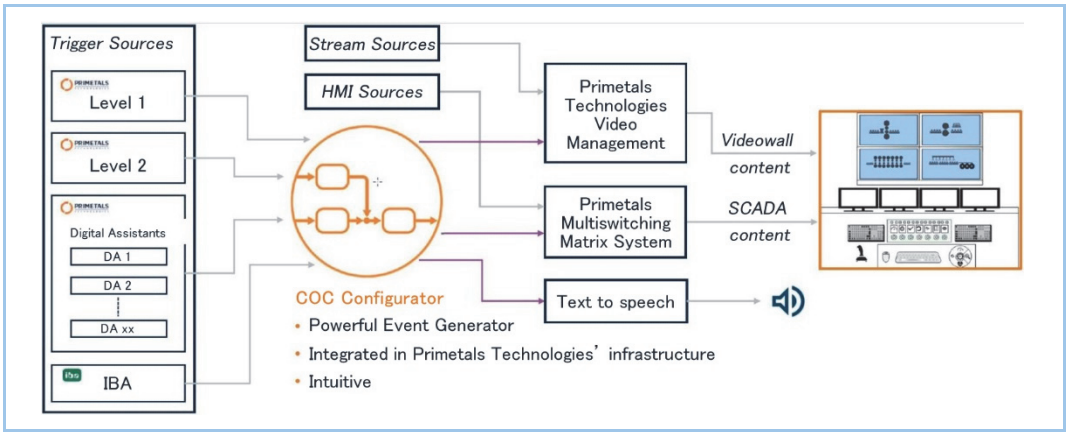


Figure 4 COC system overview

- **COC Configurator** – a central rule engine that determines which content is based on inputs from automation systems and DA analyses.
- **Video Management System** – dynamically switches between camera streams.
- **KVM Switching System**[1] – switches between system HMIs.

The COC Configurator manages all other components. In critical situations, it may also trigger audio alerts for both operators and field personnel.

1 A KVM Switch is a system that allows the control of multiple computers from a single keyboard, video (monitor) and mouse (KVM).

2.2 COC Configurator

The COC Configurator forms the core logic engine of the COC, orchestrating all connected systems through rule-based automation to ensure operators receive the right information at the right time.

2.2.1 Design requirements

As the central intelligence of the COC, the Configurator must unify automation systems, digital assistants, video management, and operator interfaces under a single rule engine, while remaining easy to adapt for users with varying technical backgrounds. To fulfill this role, it must provide:

- Flexible rule creation and editing for defining cockpit reactions to process events
- Direct connections to automation systems and digital assistants for real time-context

- Seamless integration of all COC components (Figure 4)
- Low complexity rule adjustments for users with minimal programming experience
- Support for customer and third-party rule extensions to tailor cockpit behavior

2.2.2 Implementation

The COC Configurator operates as the orchestration layer for all rule-based logic within the COC. Built on a web-based workflow automation environment, it integrates with automation systems, digital assistants, and the full COC ecosystem through dedicated function blocks and interface modules. A graphical rule editor enables intuitive drag-and-drop workflow creation.

This allows experienced operators to create or modify rules without programming knowledge, enabling the COC to evolve continuously as new operating practices, process situations, and plant-specific insights emerge.

2.3 Video Management

Video supervision is essential for enabling a single operator to safely oversee multiple plant sections. Primetals Technologies selected **ΣSynX®** an advanced video management system developed by **Mitsubishi Heavy Industries, Ltd.** (hereinafter referred to as MHI) [(4)], as the backbone of video-based monitoring within the COC.

The integration is the result of close collaboration between Primetals Technologies and MHI, merging MHI's extensive expertise in industrial video analytics with Primetals Technologies' deep process and automation knowledge.

2.3.1 Design requirements

Key requirements for the video management subsystem include:

- Centralized monitoring of multiple plant areas
- Event-driven and assistant-linked visualization, automatically surfacing critical camera streams
- Scalability for future expansions and higher automation levels
- Operator-centric usability, minimizing cognitive load
- Seamless integration with the COC Configurator

2.3.2 Implementation with ΣSynX by MHI

Σ SynX acts as the management layer between cameras and the COC Configurator. A customizable display wall enables operators to assign screens for monitoring, assistant feedback, or analysis tasks.

The system dynamically introduces relevant camera streams during anomalies. For example, when the Ski Assistant detects a ski, ΣSynX automatically highlights the associated camera views—allowing immediate validation and faster operator reaction.

2.4 Ergonomic design

Ergonomics was treated as a core design objective from the outset to ensure that the COC supports safe, efficient, and fatigue-free operation over long shifts.

2.4.1 Design requirements

To meet these goals, the ergonomic concept needed to ensure an intuitive and operator-centered working environment. This included:

- Optimal placement of screens and controls
- A clear visual hierarchy with logically grouped information
- An adaptive layout that prioritizes critical events
- A comfortable and accessible workstation design
- Effective multimodal feedback combining visual and acoustic cues

2.4.2 Implementation

Primetals Technologies adopted a collaborative, operator-focused development approach to shape the cockpit's ergonomic layout. Through iterative mock ups and prototype sessions involving experienced operators and a professional carpenter, the workstation was refined to achieve optimal screen positioning, natural control reach, and a clear, easily navigable display structure. Visual elements—such as layout and color coding—were progressively adjusted to support rapid orientation during critical situations, while notification methods were shaped around real operator response patterns to ensure timely and intuitive guidance. The resulting cockpit design minimizes fatigue, guides operator attention effectively, and supports reliable supervision of multiple plant areas.

3. Conclusion

The COC represents a decisive step in modernizing steel plant operations. By unifying advanced automation, intelligent video management, and domain-specific digital assistants within an operator-centric, ergonomic environment, the COC delivers measurable improvements in situational awareness, response time, and process stability. This centralization simplifies supervision across multiple plant sections, reduces cognitive load, and provides guided, consistent interventions—particularly valuable during off-shifts and abnormal situations.

Early industrial deployments demonstrate that COC-driven operations can reduce manual interventions, standardize decision-making, and improve transparency across the line. Industry recognition—including the *MHI President's Award*, the *MHI IP Award*, and the *German Best of Industry Award*—underscores both the technology's maturity and its broader applicability beyond steel. Equally important, operator feedback confirms that the combination of intuitive visualization, event-driven guidance, and an ergonomic workstation reduces fatigue and supports safe, reliable operation over long shifts.

Strategically, the COC establishes a robust platform for the progressive introduction of autonomy. Its COC Configurator enables rapid adaptation through rule-based orchestration, allowing plants to encode best practices, integrate new assistants, and refine behaviors without deep programming expertise. Looking ahead, the roadmap includes deeper predictive analytics, expanded assistant coverage (e.g., anomaly detection, quality prediction, and scheduling support) and broader rollouts across plant sections and sites. As customers adopt centralized operation models, the COC is poised to become a reference architecture for intelligent, scalable, and safe plant supervision.

In summary, the COC is more than a control room modernization—it is a strategic enabler for autonomous steel production. It bridges today's operational realities with tomorrow's autonomous capabilities, delivering immediate value while laying the groundwork for continuous, data-driven improvement across the lifecycle of steelmaking assets.

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