

Transition Toward “AI-Friendly Manufacturing”

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Abstract

Japan’s manufacturing sector faces an unprecedented convergence of demographic decline and rapid digital transformation. The diminishing labor force who traditionally are compensated by superior on-site expertise, have reached a critical threshold, while the application of artificial intelligence (AI) within key domains such as control system development and skill transmission remains minimal. This paper examines the structural barriers that hinder AI adoption, including fragmented information environments, proprietary control architecture, and the absence of standardized data frameworks.

In response, Mishima Kosan Co., Ltd. is developing a novel industrial foundation that integrates generative AI, cloud computing, and robotics across its three principal business areas: process outsourcing, in-house products, and engineering services. Guided by the principle of “nurturing and leveraging AI” rather than merely using it, the company, hand in hand with FPT Corporation, has initiated the co-development of two core platforms: MK Solution Cloud and AI Mentor. These systems aim to eliminate individual dependency and embed AI into design, verification, and workforce-development workflows. The following paper presents the conceptual framework, technological realization, and roadmap toward a scalable model of AI-friendly manufacturing designed for deployment in both Japanese and global markets.

1. The Reality of Japan’s Manufacturing Industry

Japan’s working-age population (aged 15–64) declined by approximately 13 million (15%) between 1995 and 2023 [1]. According to projections by the World Economic Forum [2], a further decrease of 12 million (20%) is anticipated by 2040. The resulting labor shortage has already produced the following macroeconomic consequences. In 2024, 342 companies filed for bankruptcy due to workforce scarcity, which is a whopping 1.3-fold increase over 2023 and the highest number on record for the second consecutive year [3] (see Fig. 1). Small and medium-sized enterprises (SMEs), particularly in regional manufacturing clusters, now face severe labor shortages that threaten business continuity and the stability of national supply chains.

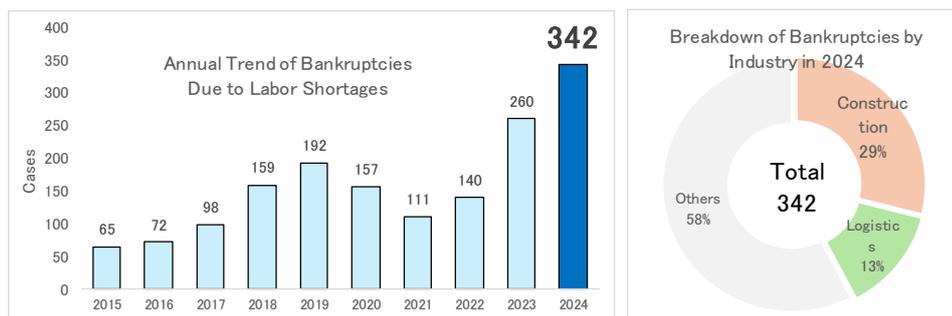


Fig.1. Annual Trends in Labor-Shortage Bankruptcies and 2024 Industry Breakdown.

Despite these challenges, Japan’s adoption of AI technologies remains strikingly low. In FY 2024, only 26.7% of individuals reported using generative-AI tools such as ChatGPT—far behind the United States (68.8%) and China (81.2%) [4]. At the organizational level, just 25.8% of companies had introduced generative AI, of which only 4% had achieved company-wide implementation [5]. Among SMEs, the adoption rate drops to 16%, while over 40% of the remaining companies report having no understanding of AI’s potential benefits [6]. Moreover, adoption scales sharply with corporate size: firms with fewer than 300 employees show 19.7% adoption, whereas those exceeding 5,000 employees reach 55.5% [7] (see Fig.2). This disparity underscores a systemic and structural imbalance in Japan’s digital transformation readiness.

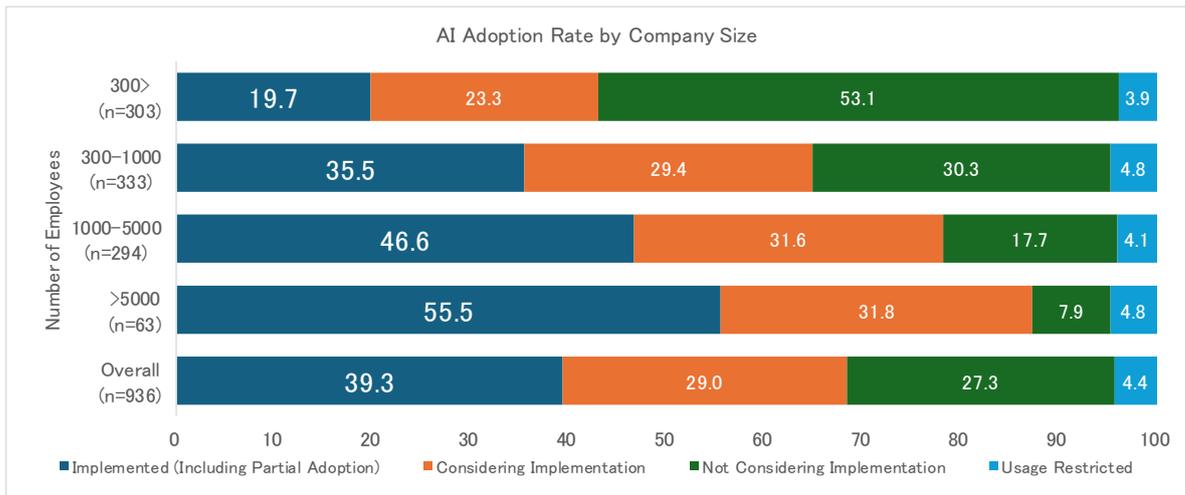


Fig.2. AI Adoption Rate by Company Size.

The industrial control-system domain exemplifies these issues. Its strong dependence on proprietary programmable-logic-controller (PLC) and robot-controller ecosystems—most of which rely on ladder logic—renders integration with modern AI frameworks difficult. In contrast, environments supporting higher-level languages such as Structured Text (ST) facilitate automation and analysis, underscoring the technological gap that continues to impede AI’s effective utilization in Japanese manufacturing.

II. Overview of Mishima Kosan Co., Ltd.

Founded in 1916, Mishima Kosan has built a century-long foundation of technological competence and customer trust within Japan’s industrial landscape. Through its three core business pillars; process outsourcing, in-house products, and engineering, the company has enhanced productivity across the steel, chemical, and automotive sectors. The firm comprises six domestic affiliates, two overseas subsidiaries (China and India), and approximately 2,700 employees. Its technologies command a 75% domestic market share in continuous-casting molds. Its proprietary products which include conductive IC trays for semiconductors and magnetic-field cancellers for MRI systems, also maintain strong global competitiveness. Within its engineering division, Mishima Kosan offers integrated services encompassing design, fabrication, installation, and maintenance of industrial equipment. These capabilities continue to expand in growth industries such as electric vehicles, semiconductors, and flat-panel displays. The company also emphasizes human-capital development through rigorous on-the-job training (OJT), aligned with its management credo: “Lively and joyful, for ourselves and for society.” This philosophy aims to harmonize employee autonomy with an enduring spirit of technical challenge. These initiatives are fundamental in shaping a sustainable competitive advantage across the company’s evolving business domains.

However, the full-scale utilization of AI across the organization remains limited. As of 2024, adoption was confined to a few experimental initiatives, with an internal usage rate of roughly 20%. Key contributing factors include inadequate infrastructure for data collection, the lack of digitized manufacturing knowledge, and minimal short-term performance visibility. Consequently, establishing a unified AI-integration framework across operational and managerial domains has become a strategic imperative.

III. The Disconnection Between Japan’s Manufacturing Sites and Artificial Intelligence

Although the necessity of AI adoption in Japan’s manufacturing sector is widely acknowledged, its implementation at the operational level remains limited. The issue lies not in the technical insufficiency of AI but in the incomplete utilization of its capabilities. Historically, Japanese manufacturing has prioritized on-site optimization driven by individual craftsmanship. Tacit expertise, precision, and responsibility have long served as the backbone of productivity; however, this structure now acts as a barrier to digital transformation.

Three structural factors contribute to this stagnation:

1. Lack of Standardization: Individually optimized procedures are rarely standardized, hindering AI training and inference.
2. Closed System Architectures: Many PLC and robot-control environments remain proprietary, limiting integration with AI.
3. Cultural Resistance to Experimentation: An intolerance for errors and the invisibility of short-term benefits discourage bottom-up innovation.

Consequently, AI applications remain fragmented and case-specific rather than systemic. The two domains, control-system development and workforce training, help illustrate these obstacles precisely.

A. Control-System Development

Control systems, central to manufacturing-line design, continue to rely on ladder-logic programming, which is highly dependent on individual expertise and vendor-specific tools. The closed nature of development environments inhibits AI-assisted design automation and verification.

Similarly, industrial robotics remains constrained by proprietary command sets and teaching pendants, leading to low portability and extended commissioning periods. Although AI-based motion generation and collaborative control have become technically feasible, adoption lags due to high implementation barriers. Virtual commissioning is often regarded as a procedural formality rather than a genuine optimization phase, leaving functional validation to occur late in the process. This often results in costly rework and last-minute on-site tuning during system start-up.

B. Workforce Development

The traditional OJT (on-the-job training) model, once the foundation of Japan's competitive advantage, is reaching its limit amid increasing labor mobility, multi-skilled demands, and the diversification of workforces. The absence of standardized curricula and data-driven feedback mechanisms hampers skill acquisition and complicates knowledge transfer.

To address these limitations, Mishima Kosan conceptualizes AI not merely as an automation tool but as a catalyst to overcome person-dependence. By democratizing access to expertise and enabling platform-based learning, the company seeks to enhance both productivity and knowledge retention. Two initiatives, MK Solution Cloud and AI Mentor, serve greatly as concrete embodiments of this transformation.

IV. "MK Solution Cloud": Transforming Control-System Development

A. Platform Architecture

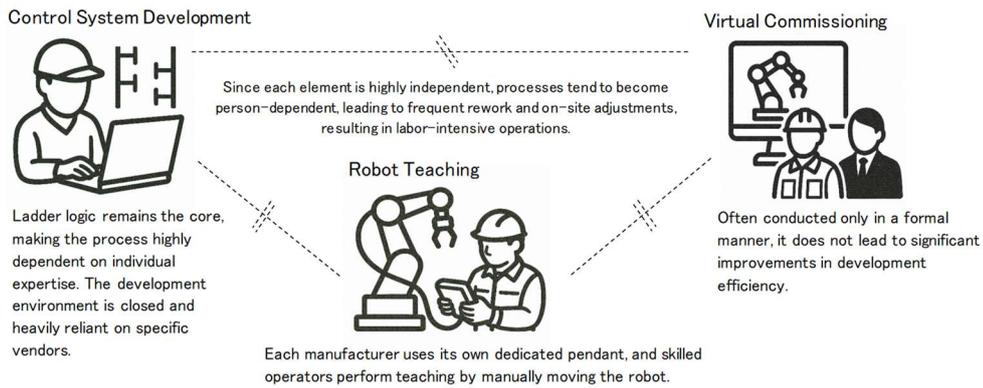
The MK Solution Cloud initiative integrates open-source and commercial tools into a hybrid, cloud-based environment that unifies virtual and physical design workflows (Fig. 3).

Core components include:

1. 3-D Design – Tools such as FreeCAD support flexible equipment modeling and dynamic simulation, enabling digital continuity between conceptual and control design.
2. Virtual Simulation – Platforms such as Genesis allow multi-device monitoring and interactive control within virtual environments, maintaining UI consistency through direct coupling with control systems.
3. Control Construction – Solutions including RoboDK, MotoLogix (Yaskawa), and NOVA (Wandelbots) facilitate robot-motion generation, interference checking, and vendor-independent path verification.
4. Integrated Control – TwinCAT (Beckhoff) provides a Structured-Text-compatible PLC framework, supporting AI-assisted code completion, logical-structure analysis, and design standardization.

This architecture supports distributed, remote, and collaborative development regardless of individual skill levels and serves as the technical foundation for the MK Solution Cloud.

<Current Situation (Especially in Japan's Manufacturing Industry)>



<MK Solution Cloud Concept>

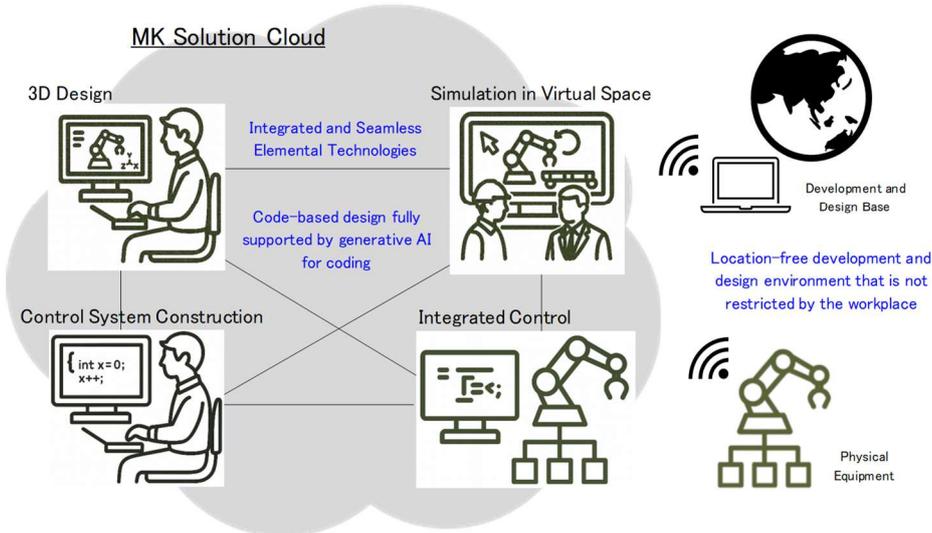


Fig.3. Challenges in Control System Development and the MK Solution Cloud Concept.

B. Objectives

The MK Solution Cloud initiative aims to achieve three principal objectives:

1. Early-Phase Virtual Verification – By coupling 3-D models and simulators at the conceptual stage, inconsistencies between control specifications and real behavior can be detected early, reducing downstream rework.
2. AI-Supported Development Systematization – AI assists in generating control-logic templates, motion commands, and discrepancy analyses, enhancing design intent clarity and educational outcomes.
3. Manufacturer-Agnostic Reusability – Modularized development assets can be shared across platforms, accelerating replication for similar production lines and improving reusability in robot control and I/O configuration.

C. Anticipated Impacts

The MK Solution Cloud is expected to deliver three principal impacts:

1. Reduced Electrical-Design Workload through AI-assisted ladder completion and early specification finalization.
2. Streamlined Robot-Teaching Processes via pre-validated virtual motion scenarios and AI-generated motion suggestions, reducing dependency on skilled operators.
3. Accelerated Verification Cycles via synchronized digital twins that enable regression testing and facilitate rapid iteration.

Collectively, these outcomes shift control-system engineering from artisanal craftsmanship toward reproducible, automated, and collaborative practice which then enables capability leveling, shorter commissioning times, and efficient knowledge transfer.

V. “AI Mentor”: Reconstructing Workforce Development

A. Conceptual Framework

Amid diversifying labor environments, OJT-based training alone no longer sustains competitiveness. Mishima Kosan’s AI Mentor addresses this by introducing an AI-driven educational infrastructure that integrates generative-AI models with enterprise knowledge bases. The goal is to provide individualized learning pathways and immediate, context-specific support while ensuring standardized instructional quality across all sites.

B. System Structure

The AI Mentor framework comprises four interdependent layers (Fig. 4):

1. Data Layer – Digitizes training assets—including manuals, standard procedures, technical drawings, and video archives—into structured, AI-processable data using natural language processing (NLP) and optical character recognition (OCR) technologies.
2. AI Model Layer – Employs a fine-tuned model developed via FPT’s AI Factory to deliver context-aware, expert-level responses while continuously adapting to site-specific terminology.
3. Interface Layer – Provides multi-device access (PCs, tablets, smartphones) with voice and image search capabilities, functioning as an on-site microlearning assistant.
4. Dashboard Layer – Visualizes learning progress, usage metrics, and frequently asked questions, enabling instructors to design personalized development plans and continuously refine educational content.

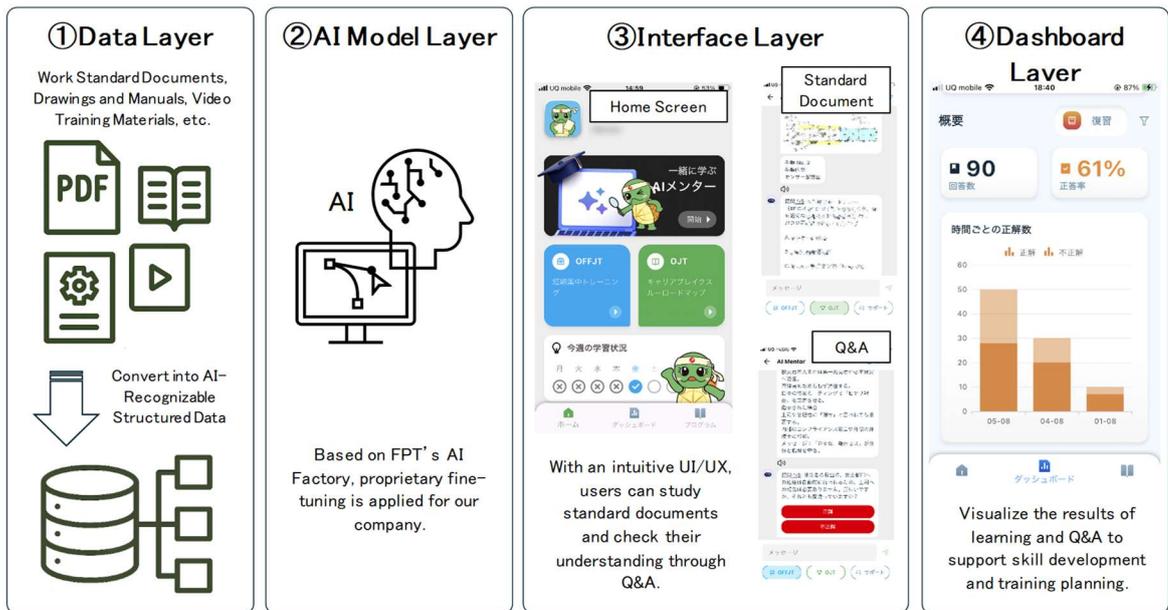


Fig.4. Structure of AI Mentor.

C. Expected Benefits

Deployment of AI Mentor promises transformative outcomes:

1. Condensed Training Cycles: Reduces time-to-competency from months to weeks through standardized, responsive instruction.
2. Workload Reduction for Trainers: Automates repetitive guidance while ensuring uniform teaching quality.
3. Multilingual Accessibility: Supports native-language education for foreign personnel, broadening workforce inclusivity.
4. Knowledge Visualization: Aggregates question logs to identify systemic weaknesses and inform curriculum improvement.

Rather than merely serving as a Q&A interface, AI Mentor functions as a cognitive infrastructure for continuous skill development and organizational learning.

VI. Broader Prospects for AI Applications in Manufacturing

A. Data Infrastructure as the Prerequisite

Effective AI utilization depends more on data architecture than algorithmic sophistication. Key prerequisites include:

1. Digitization and structuring of manuals, drawings, and standard documents.
2. Unified naming conventions and metadata tagging for unstructured media.
3. Terminology and prompt standardization.
4. Version-controlled input-output management.

Though labor-intensive, these foundational steps are indispensable; without them, even state-of-the-art AI cannot perform reliably.

B. Production Planning and Scheduling

Production scheduling in high-mix, low-volume manufacturing remains heavily reliant on human intuition. AI can augment decision-making by processing complex multi-constraint variables—materials, equipment, manpower, and delivery priorities—to generate optimized suggestions. Such systems are not designed to replace human oversight but to enhance decision precision and reduce cognitive load, fostering a collaborative human-AI operational paradigm.

C. Safety, Quality, and Knowledge Integration

Japan's manufacturing safety and quality culture historically depends on both formal documentation and tacit field wisdom. If AI systems can contextualize and deliver such insights in real time, they can serve as intelligent copilots for stable operations. Furthermore, by mining extensive records such as Tool-Box-Meeting notes and troubleshooting logs, AI can extract latent patterns and propose preventive strategies. The fusion of explicit (documented) and tacit (experiential) knowledge thus forms a new epistemic layer—an AI that learns and evolves with the field—enhancing collective intelligence at production sites.

VII. Building the Next-Generation Global Manufacturing Infrastructure with FPT Corporation

To confront the structural challenges confronting Japan's manufacturing base—particularly labor shortages and accelerating technological change—Mishima Kosan entered into a Memorandum of Understanding (MOU) in 2025 with FPT Software, a Vietnam-based global IT enterprise. FPT operates in 30 countries with a workforce of exceeding 80,000 engineers and specializes in large-scale AI and digital-transformation solutions for manufacturing, including its proprietary AI Factory platform.

The significance of this collaboration extends beyond outsourcing. It represents a co-creative partnership established from the conceptual stage, uniting Japan's accumulated on-site expertise with FPT's software-engineering capacity. Together, the partners aim to formalize and elevate tacit manufacturing knowledge through prompt engineering, data structuring, and workflow co-design.

Through this alliance, Mishima Kosan and FPT are jointly developing MK Solution Cloud and AI Mentor—systems that convert person-dependent know-how into reusable, AI-readable knowledge modules. These solutions are designed to integrate seamlessly into industrial workflows such as control-system design, verification, and human-resource training. The shared objective is the establishment of a globally deployable, a Japan-originated, AI platform that democratizes manufacturing expertise.

The collaboration with FPT constitutes the first phase of a broader global co-creation strategy. Future initiatives will extend this model to additional technology partners that share the philosophy of "AI that empowers the workplace," thereby accelerating international dissemination of AI-enabled manufacturing practices.

VIII. Future Roadmap and Recommendations

The preceding sections have demonstrated that Japan’s lag in AI adoption stems less from technical immaturity than from structural constraints—fragmented data environments, excessive reliance on individual craftsmanship, and a cultural hesitancy toward systemic reform. This final section outlines a pragmatic framework for achieving sustainable transformation.

A. Three Phases for Overcoming the Status Quo

For AI to take root in daily operations, technological sophistication alone is insufficient. A phased, human-centered roadmap is essential.

1. Data and Infrastructure Preparation

All tangible and intangible knowledge assets—work standards, manuals, drawings, training materials, and troubleshooting records—must be digitized and structured. A secure, AI-compatible infrastructure with unified connectivity and access control should be established to enable cross-departmental interoperability.

2. Process Innovation through Human–AI Collaboration

AI should be introduced as a collaborative assistant across training, design, and verification domains. Cultivating a correct understanding of AI’s capabilities and limitations is vital to dispel fears of job displacement. Constructive dialogue between engineers and AI systems fosters complementary relationships and smoother adoption.

3. Field-Driven Implementation and Sustainability

Transformation should begin with small-scale proof-of-concept (PoC) projects targeting specific tasks. By accumulating incremental successes, frontline engineers can gain familiarity and confidence, eventually institutionalize a culture of nurturing and leverage AI.

B. “AI That Is Easy to Implement” as a Success Criterion

Practical deployment depends not solely on AI accuracy but on ease of implementation, meaning the degree to which the technology integrates, scales, and improves through feedback. Key design imperatives include:

1. Intuitive UI/UX: Operators must navigate the system effortlessly within existing workflows.
2. Interoperability: Compatibility with legacy tools and flexible cloud architecture ensures continuity of operations.
3. Continuous Feedback Loops: Real-time incorporation of user feedback enables ongoing refinement of accuracy and usability.

An AI system that satisfies these conditions naturally embeds itself into routine activities, leading to enduring operational transformation.

C. Redefining “AI-Friendly Manufacturing” in Japan

The notion of “AI-friendly manufacturing” transcends mere adoption. It denotes an organizational ecosystem where AI is understood, utilized, and continually improved as part of workplace culture. Achieving this state requires synchronized evolution of technical infrastructure and human mindset.

AI implementation should therefore be positioned as a form of organizational innovation, not isolated digitalization. Frontline teams must assume ownership, build self-directed improvement cycles, and take pride in quantifiable outcomes. A co-creative learning culture—where tacit know-how becomes explicit, shared, and refined collaboratively with AI—elevates collective intelligence. By visualizing and celebrating these successes, companies can stimulate motivation for transformation across all levels.

Mishima Kosan continues to advance deployment of MK Solution Cloud and AI Mentor upon this foundation of cultural readiness. Ultimately, an AI-Friendly Japan is not defined by the presence of AI but by the capacity to nurture and leverage it—a philosophy central to the future of manufacturing excellence.

Declaration of Conflict of Interest

The authors declare no conflicts of interest concerning the research, development, or publication of the initiatives described herein.

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