May 2025 Technical Information

Green Energy & Mobility

Research & Development

#Carbon Neutral #Innovation Creation #Co-creation and Open Innovation #Sustainability #Generative AI #IoT/Data Utilization #Digital Solutions #Energy #Railway Systems #Research & Development

1. Energy Management Technology for Small Commercial Facilities

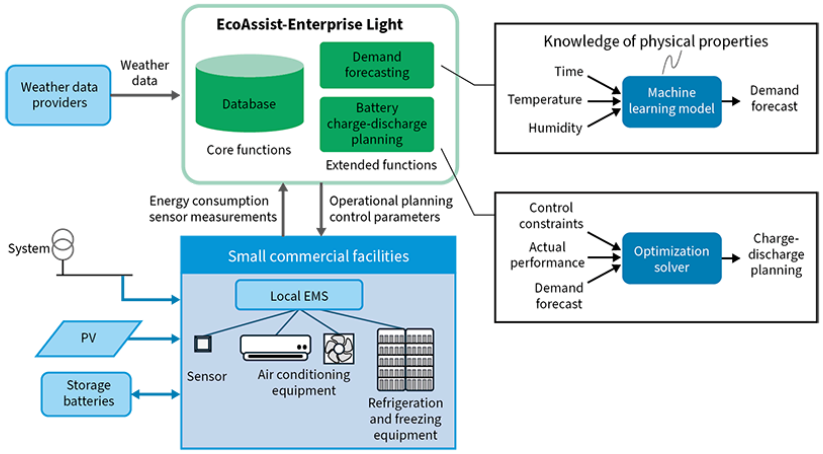
With a growing awareness of environmental issues, there are increasing demands for efforts toward carbon neutrality. Small commercial facilities such as convenience stores are exploring energy-saving and peak-shifting measures through the adoption of photovoltaics (PV), battery storage systems, and optimized control of air conditioning and refrigeration equipment.

Therefore, in order to expand the functionality of its environmental information management database “EcoAssist-Enterprise Light” and better understand and control the usage of air conditioning and refrigeration equipment, Hitachi is promoting the technical development of demand forecasting based on weather data, and of charge-discharge planning that factors in operational constraints.

Demand forecasting incorporates knowledge of air conditioning power consumption characteristics in response to temperature and humidity, thereby improving prediction accuracy compared to conventional machine-learning-based models. Additionally, in battery charge-discharge planning, a short-term operation plan is combined with a predefined target contract power level based on historical data—this approach enables faster planning while considering contract power constraints.

Looking forward, using collaboration with partner companies, Hitachi aims to enhance and diversify the system anticipating wide-scale deployment in stores.

[01] Energy Management System for Small Commercial Facilities



EMS: energy management system

2. Carbon Neutral Navigator for Rapid Proposal and Deployment of Decarbonization Measures

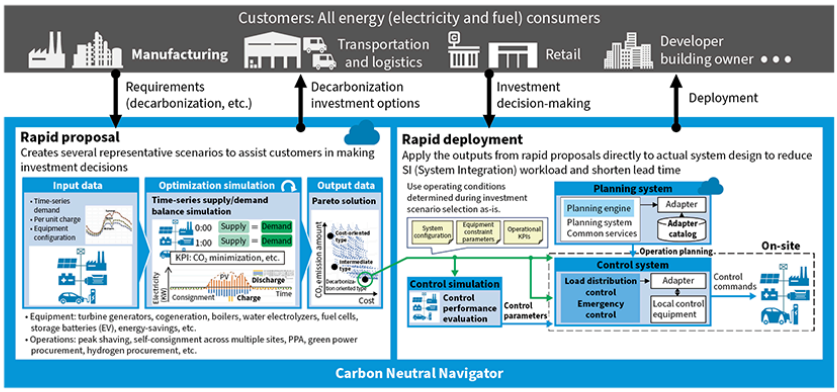
The Carbon Neutral Navigator has two functions: investment decision-making by offering multiple decarbonization investment scenarios (Rapid Proposal), and shortening lead time by applying the proposed equipment operation conditions directly to detailed system design (Rapid Deployment).

The rapid proposal is based around a time-series supply-demand balance optimization simulator that incorporates various operational constraints such as self-consignment and peak shaving. This performs large-scale simulations of numerous investment scenarios on the cloud, taking future uncertainties into account,

calculating the costs [capital expenditure (CAPEX), operating expenditure (OPEX)] as well as CO_2 emissions of each scenario. Based upon this, it then presents several representative scenarios to assist customers in making investment decisions.

Once a customer has made a decision on an investment scenario, rapid deployment inherits the equipment operation conditions from the rapid proposal phase, whereupon it simulates and verifies control functions for actual equipment along with configuring control parameters in the actual system, and builds the control logic. Inheriting and reusing the operation conditions from the rapid proposal phase means reduced design workload, with a shorter lead time for delivery to the customer.

[02] Carbon Neutral Navigator



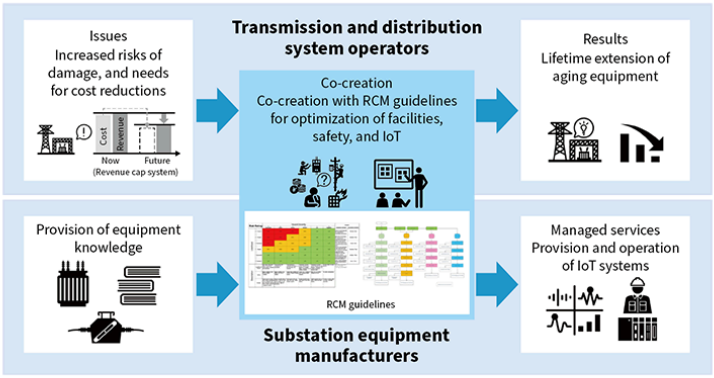
PPA: power purchase agreement
KPI: key performance indicator
SI: system integration
LT: lead time

3. Maintenance Planning Support Technology Based around Reliability-centered Maintenance

In the electric power industry, extending the lifespan of aging infrastructure such as substations while maintaining their reliability has become an urgent challenge. To assess risk factors over operating periods that exceed the original design expectations, a practical approach is needed for applying reliability-centered maintenance (RCM)—a method that optimizes maintenance by fully leveraging all design and maintenance knowledge. This technology enables quantitative assessment of future risks for power facilities, even in cases of limited accumulated reliability data, by applying RCM analysis that gathers knowledge about equipment and operations based upon RCM implementation guidelines.

The method was applied to aging gas circuit breakers, with RCM used to optimize retrofit Internet of Things (IoT) installation and maintenance plans. The result showed that maintaining reliability and extending equipment life was possible while using periodic inspections and migrating to maintenance condition monitoring to lower maintenance costs. Through improvement proposals for maintenance, IoT systems, and equipment based upon this technology, Hitachi hopes to contribute to supporting electric utilities in adapting to the revenue cap regulatory framework.

［03］ **Promoting RCM through Co-creation between Customers and Manufacturers in Electric Substation Equipment**

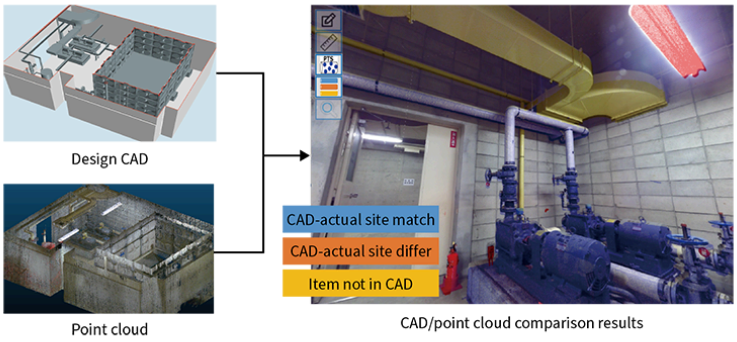


4. Digital Maintenance Supporting Stable, High-efficiency Operation of Nuclear Power Plants

The reliable restart and subsequent high-capacity operation of low-carbon nuclear power plants is essential to achieve carbon neutrality. However, a challenge is that more than a decade of shutdowns has resulted in a shortage of personnel experienced in start-ups, with a pressing need to handle plant anomalies and to respond quickly if these occur.

To address this, Hitachi is developing a metaverse system to enable smooth communication regardless of physical location or knowledge levels. Constructing a virtual model of the power plant using point cloud data and images captured by laser scanners and other devices makes it easy to inspect the site remotely from a workstation. Furthermore, by comparing this virtual model with the design computer-aided design (CAD) data, this can visualize discrepancies between the design and the actual site, supporting virtual inspections in the digital space. When trialed as part of a comprehensive on-site inspection for plant restart preparations, the system enabled personnel to inspect areas from office buildings within the plant premises. This streamlined the sharing of inspection results with designers who did not accompany the site inspection, as well as improving efficiency of corrective measures for indicated issues. The system is expected to be applied to periodic inspection planning after plant restart in the future.

［04］ **Metaverse System Supporting Comprehensive On-site Inspections**

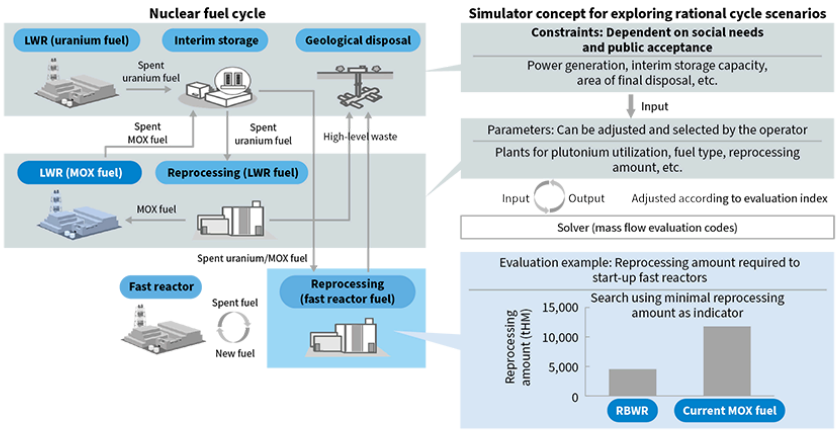


5. Initiatives toward Achieving Sustainable Nuclear Power

To establish nuclear energy as a sustainable energy source, Japan—like France—intends to maximize use of existing light water reactors (LWRs) while ultimately transitioning to fast reactors, which can recycle plutonium extracted from spent LWR fuel and use it repeatedly as a fuel source. However, the practical deployment of fast reactors is not expected until the latter half of this century, and from the perspective of nuclear non-proliferation, until then the reduced amounts of plutonium recovered during reprocessing of spent fuel must be burned in LWRs.

In this context, in order to clarify how reprocessing and plutonium use should be handled during the light water reactor phase, Hitachi is developing a tool that can search for the most economical scenario while responding to various requests. This treats socially dependent factors—such as spent fuel interim storage capacity and final disposal site areas—as constraints, and considers parameters which can be adjusted and selected by operators such as reprocessing volume, reactor types for plutonium burning, and fuel options. The tool is expected to serve both as a means to clarify the ideal form of the LWR phase, and as a basis for identifying technologies that need to be developed along with objectively evaluating development strategies. Hitachi is developing the Resource-renewable Boiling Water Reactor (RBWR), a next-generation BWR suited for plutonium burning in LWRs. The simulation tool will also be used to objectively evaluate the impact of introducing RBWRs, and to contribute to co-creation with operators.

[05] Simulator Concept for Exploring Nuclear Fuel Cycles and Rational Cycle Scenarios



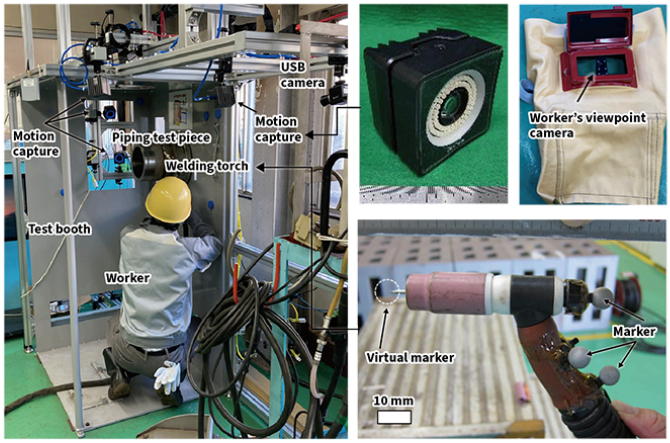
MOX: mixed oxide

6. Welding Education System

The shortage of skilled workers in manufacturing is not only a challenge at production sites, but also poses a significant risk to business continuity, meaning there is an urgent need for the efficient transfer of skills. High reliability is required in nuclear plant pipe welding, and the wide variety of pipe diameters and welding positions makes automation of welding difficult. As a result, the process has relied on the many years of experience of skilled welders.

To address this issue, Hitachi has used motion capture and AI-based image processing to visualize the correlation between expert welder movements (at a precision of 0.1 mm) and welding phenomena. Based upon this, the system quantitatively analyzed various welding motions to formalize the heat input control techniques developed by skilled welders through years of experience. Furthermore, Hitachi has developed an education system incorporating these formalized welding skills. This system will contribute to alleviating the shortage of skilled welders in industries such as nuclear plant manufacturing, and to improving productivity.

[06] View and Components in Welding Education System

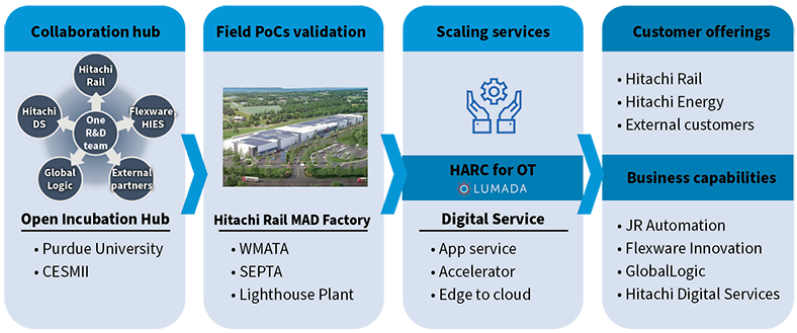


USB: universal serial bus

7. The Most Advanced Digital Factory

Hitachi Rail was awarded a $2.2 B contract with Washington Metropolitan Area Transit Authority to design and build railcars. To deliver this, Hitachi Rail established a new factory in Maryland and wants to make this the Most Advanced Digital (MAD) factory in the world with the twin goals of maximizing operational efficiency and showcasing next-gen technologies. In the future, this factory will also serve other customers such as the Southeastern Pennsylvania Transportation Authority and Ontario Line. Hitachi R&D has been entrusted with two unique opportunities in this project. The first is to facilitate the One Hitachi approach and architect overall solution by leveraging the wider Hitachi ecosystem such as R&D, GlobalLogic, Hitachi Digital, Hitachi Digital Services, Flexware, and the Control System Platform Division (CSPD). Secondly, R&D is developing a unified data layer (UDL) to orchestrate inter-system connectivity between legacy business operations and new digital transformation (DX) technologies and using generative artificial intelligence (AI) to model the associated multimodal data without explicit schema input. As an additional value add, R&D is also developing new DX technologies around industrial omniverse, robotics, and automation over UDL.

［07］Harnessing of Collaborative Innovation to Drive Customer Growth



R&D: research and development
CESMII: Clean Energy Smart Manufacturing Innovation Institute
PoC: proof of concept
HARC: Hitachi Application Reliability Centers

8. Future of Transit: Transformation of Sustainable Mass Transit Planning through Digital Twin Technology

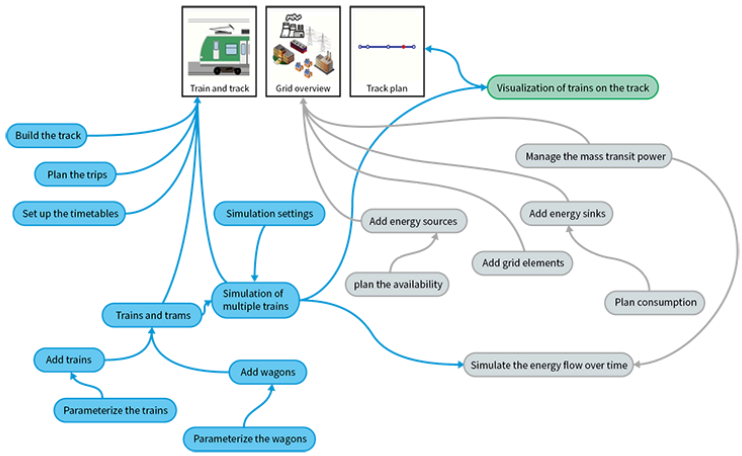
Hitachi’s innovative digital twin for mass transit systems is a game-changer in sustainable transit planning. Designed for ultimate flexibility, it accommodates any route configuration, fleet size, schedule, and energy source. By simulating real-world vehicle dynamics and energy demands, it pinpoints precise power requirements, enabling effective resource management and better grid optimization.

Key features include real-time energy optimization, simulation of exact energy needs for efficient resource use, and with the built-in AI-driven driver support system, the digital twin promotes energy-efficient driving, potentially reducing energy usage by 10-30%. Additionally, it allows operators to test multiple scenarios, instantly visualizing the impact on energy consumption. This not only speeds up data-driven decision-making, but also helps reduce operational costs and energy waste.

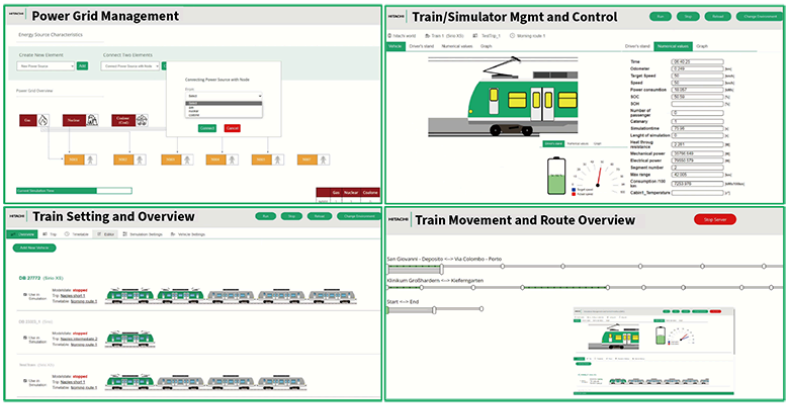
Addressing major transit challenges—like the need for adaptability, energy efficiency, and faster decision-making—Hitachi’s digital twin empowers transit operators with tools to plan new schedules, adapt to expanded fleets, and anticipate power grid demands. By integrating advanced simulation and sustainable practices, this solution represents a vital step toward a greener, more efficient future in mass transit.

(Hitachi Europe Ltd.)

［08-1］ Digital Twin Overview and Main Features



［08-2］ Digital Twin Components



9. Rail Metaverse – A System of Railway Digital Twins

The Rail Metaverse is a system of railway digital twins accessible through a unified interface that will provide various benefits such as improved operational efficiency and safety. Through market research, and by considering the latest trends in generative AI technologies, Hitachi identified six use cases for the Rail Metaverse: 1. Co-pilot, 2. Near-future scenario simulation, 3. Sustainable and eco-friendly operations, 4. Virtual first deployment, 5. Training for humans and artificial intelligence (AI), 6. Communication and stakeholder engagement. It evaluated these and concluded that the co-pilot, acting as a trusted advisor to rail operations and maintenance personnel, offers the fastest route-to-market and the highest potential value.

Hitachi developed two co-pilot solution prototypes, the “Rail-expert bot,” which provides access to railway data using natural language, and “Train-as-a-Sensor visualization,” which identifies the location of assets or issues along the rail track with 2D/3D contextual visualization.

Hitachi exhibited the use cases and the prototype solutions at InnoTrans 2024, alongside Hitachi Rail, leading to discussions with the business units about proposals for customers in Europe.

［09］ Rail Metaverse Use Cases and Prototype Solutions for Co-pilot

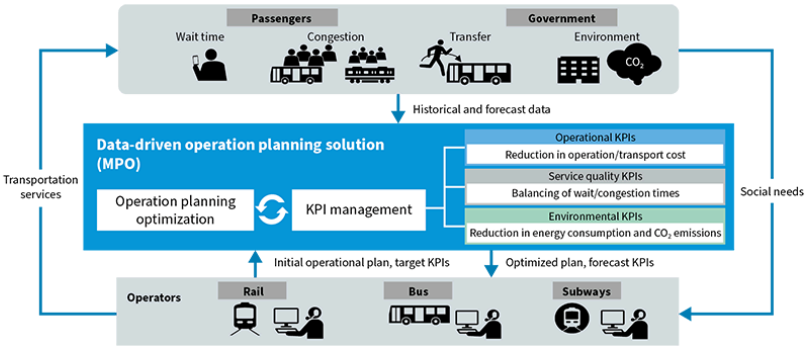
10. Multimodal Planning Optimizer to Create Transportation Plans Balancing Multiple KPIs

Public transport operators, such as railway and bus operators, are facing a challenging business environment. They aim for sustainable growth while responding to changing passenger mobility demands in the wake of the COVID-19 pandemic and addressing social requirements like environmental considerations in line with Sustainable Development Goals (SDGs). In response to this situation, Hitachi is developing Multimodal Planning Optimizer (MPO), a data-driven operation planning solution which enables the provision of flexible transportation services capable of adapting to changes in the business environment surrounding customers.

MPO visualizes important key performance indicators (KPIs) crucial for operational planning, including those related to operation, service quality, and the environment. By combining Hitachi's advanced planning optimization technologies and data analytics, MPO proposes operational timetables that meet the customer's target values for each KPI while maintaining a balanced trade-off between these indicators. Using MPO, operators can flexibly improve operational timetables, which are key to transportation services. This includes achieving a timetable that balances reducing the operational cost of train and bus vehicles and equalizing congestion, in a manner that suits the customer's management environment.

Moving forward, Hitachi aims to globally expand MPO and other evidence-based policy making (EBPM) solutions. This will position Hitachi as a digital transformation (DX) partner for public transportation operators, contributing to business growth that aligns with evolving societal needs and aiding in the revitalization of cities and areas along public transportation lines.

［10］ Overview of Multimodal Planning Optimizer



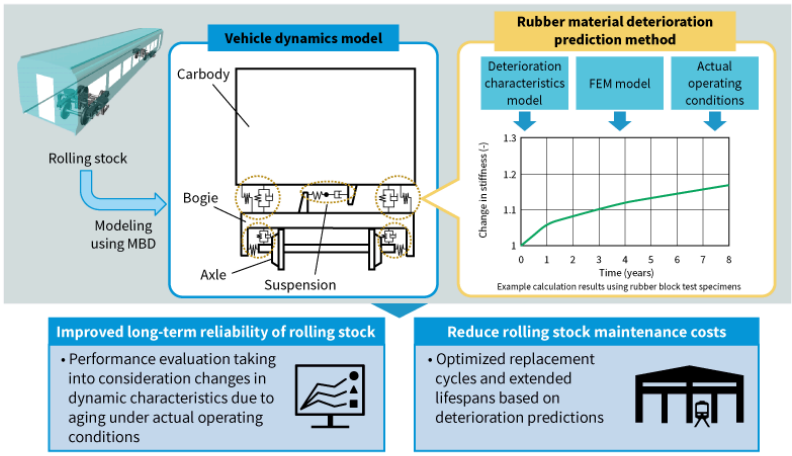
11. Vehicle Dynamics Technology Supporting Railway Vehicle Running Safety and Ride Quality

For products such as railway rolling stock that are operated over long periods of time, it is essential to ensure running safety and ride comfort not only immediately after delivery but also throughout the entire product lifecycle, taking into consideration operation and maintenance (O&M). Hitachi is therefore focusing on the suspension system—a critical factor in dynamic performance—giving special attention to rubber components, which are particularly prone to deterioration over time, and are developing a method for predicting the deterioration of rubber components in advance under actual operating conditions.

This involves conducting accelerated heat aging testing on rubber components to obtain basic characteristics data on the progression of degradation. This deterioration characteristics model, formulated through statistical analysis of this data, is combined with a finite element method (FEM) model of the suspension to analytically predict the progress of degradation. A basic verification was performed by comparing calculations and testing results for rubber block test specimens, with this method validated to replicate heat oxidation deterioration progress in rubber stiffness (hardening characteristics of rubber).

The application of this method to actual products will contribute to enhancing the long-term reliability of rolling stock, as well as reducing maintenance costs through optimized component replacement cycles based on degradation predictions and extended component lifespan.

［11］Vehicle Dynamics Technology Supporting Rolling Stock Running Safety and Ride Quality through the Life Cycle



MBD: multibody dynamics

Hitachi Review

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The *Hitachi Review* website contains technical papers written by Hitachi engineers and researchers, special articles such as discussions or interviews, and back numbers.

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