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Zen and the Art of Commuter Rail Operations:
Taiwan Railways Administration's Design, Operations, and Philosophy
通勤列車運轉的藝術：台灣鐵路管理局的系統設計，作業，與哲學

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Taiwan's railways are like the City of New York – both great melting pots of culture, philosophy, and technologies from all over the world. Quite unlike home-grown railways in Europe and North America – incrementally re-designed and improved upon since the Industrial Revolution – Taiwan's railways reflects accumulated results of changing procurement policies, whimsy of international diplomacy, and continuing worldwide search for best-value technology and practices. The Taiwan Railways Administration (TRA) operates and maintains Swedish and Japanese signal systems, a Franco-English electrification system, a Taiwanese-designed tunnel originally envisioned by Japanese and German planners through Taipei, American and South African locomotives, Indian and Taiwanese coaches, Japanese, English, Italian, and South Korean trainsets). Because of Taiwan (Formosa)'s history as a Spanish, Dutch, Japanese, and Chinese colony, and recipient of significant American and British assistance after the Second World War (WWII), Formosa's islanders have shown an exceptional tolerance and openness to different ideas, and demonstrated great flexibility and resilience under a smorgasbord of outside influences. This willingness to entertain alternatives is reflected in their railway system. A brief survey of TRA's designs and operating practices is offered, demonstrating how TRA has melded diverse technologies and utilized a mixture of manual operations and automation.

KEY OBSERVATIONS

TRA's operations are rooted in classic railroads of yesteryear, and are likely familiar to commuter rail audiences. Many railroads utilize similar designs and practices, especially in isolated cases where capacity or geographic constraints require non-standard solutions, or historical workarounds at specific locations ("hacks") continue. In a rush to automate and standardize, some railroads have inadvertently lost much of once-commonplace multi-disciplinary operating skills. Ingenious low-tech solutions slowly disappear, whether or not automated replacements add much value. Labour crafts often have narrowly defined functions, while "broadbanding" efforts are fraught with difficulties. The industry sometimes hesitates to think outside the box, is fearful of exceptions, and is concerned with repercussions. Systemwide compromises attempting to accommodate all situations sometimes result in complex machines that still don't quite meet all requirements. Fragmented and inflexible job functions could easily reduce organizational capabilities to respond to operational problems in an integrated, commonsense fashion.

Conversely, TRA's management embraced these "hacks" and updated them with modern technology. Designs make more cost-feature tradeoffs for one specific application (value-engineering) rather than follow systemwide standards. Staff is tolerant of diverse working methods and equipment, requiring human skills and initiatives while keeping machines simple. Over time, a nimble and multi-skilled workforce prepared to react to day-to-day operational snafus (incidents) with efficiency and speed has developed, perhaps attributed to daily interaction with a diverse range of problems. TRA is like a diner short-order cook, producing a big menu from a large collection of simpler (but varied) equipment – and quite unlike a fast food worker, who relies on complicated (but regimented) machines to produce standard offerings.

FURTHER RESEARCH NEEDS

The U.S. commuter rail industry has undergone record growth within last thirty years. Ridership reached new heights on revitalized older systems. Entirely new systems were created in smaller cities. Some railroads introduced innovative business models and operating practices from Europe and airlines, while established systems maintained traditional but nonetheless effective operations. Specifically, how could TRA's philosophy contribute to North American practice?

Designing to Expect Disciplined Operations: TRA's infrastructure is not foolproof. Track layouts are designed for a limited set of normal operations, simplifing service recovery decisionmaking by reducing ambiguity and constraining available choices. Accurate train planning and operational precision is expected. Designs neither accommodate simple working methods nor tolerate sloppiness, allowing less wiggle-room for errors. The unforgiving plant and appropriate training seem to create a "getting it right the first time" culture amongst staff.

Scheduling for Priority and Reliability: TRA designed plant and schedules to require en-route "checkpoints" and absorb uncontrollable disruptions. Where capacity constrains express operations in America, third tracks are often proposed, but TRA's two tracks with local station sidings might be considered instead. Scheduled holds improve local service reliability, serving as "recovery time," allowing trains to regain scheduled paths.

Empowering Local Supervision with System Responsibility: Effective use is made of constrained infrastructure through significant on-site supervision, teamwork, peer camaraderie, interpersonal communications, and hands-on operations. Although CTC covers most TRA lines, increasingly remote control did not lead to local personnel's functional obsolescence or centralized micro-management. Operations are precisely choreographed, but their execution requires greater range of responses and broader knowledge base. The greater sense of personal responsibility amongst field employees is evident from observing their attitude and approach towards operational problem-solving.

Appropriate Standardization: TRA's standardization efforts are tempered by specific local adaptations and procurement policy. Rather than rigidly define historic business practices and require vendor compliance, TRA seem flexible in adopting foreign industry standards while ensuring its functional needs are met, as evidenced by 'oddball' solutions and varying designs found systemwide. Tolerating some diversity and purchasing off-the-shelf products may reduce overall costs and improve effectiveness. TRA's smaller orders produced designs tailored for specific applications and incremental improvements between each equipment generation. Station designs and scheduling seem sensitive to passenger volumes and adapted to individual communities. Trade-offs between design, construction, and ongoing operating and maintenance costs should be explicitly considered, including costs of maintaining consistent designs and policy service.

Technology as Workplace Assistance, not Functional Replacement: TRA's automation seem to be accomplished without compromising employees' skills or flexibility. Rather than seeking to replace field personnel, machines enable employees to perform duties better, faster, to multi-task, or backstop inevitable human errors without allowing complacency. Employees with more automated job functions focused on actively troubleshooting, maintaining, monitoring new technology, and assisting customers. TRA also seem willing to accept incremental or partial (probably cheaper) automation solutions, where machines provide "computer assist" not full functional replacement.

Prioritizing Investment Based on Technology Characteristics: TRA's capital projects are ranked by each technology's specific impacts on operations. Double-tracking and electrification began in busy suburban areas, followed by farmland, completing difficult and expensive mountainous sections last. CTC was first installed in farming regions where freight switching moves were once frequent. Alternating single- and double-track mainline sections where overruns could cause dangerous head-on collisions got cab signals first. Branch lines with low train densities retain simple-yet-effective token signalling, which take longer to issue movement authorities but are almost as successful at collision prevention.

Fare Control Automation: U.S. commuter railroads have deadlocked over fare control automation for 30 years because of technology and staffing issues, even though Illinois Central Railroad (now Metra Electric) implemented fare barriers in 1966 with some success. Taiwan and Japan implemented faregates to improve passenger throughputs rather than to remove human presence. Conductors and ticket examiners continue to manage fare collection, while low-volume stations remain barrier free. TRA's willingness to tolerate fare system complexities by mixing smartcard, magnetic, paper, onboard tickets, and turnstile/manual validation contributed to a successful and incremental Automated Fare Collection (AFC) system implementation on a limited capital budget.

Metropolitan Terminals: Although pioneered by the Pennsylvania Railroad, run-through railroad services remain rare in U.S. cities. Taipei's downtown tunnel offers insight into how such projects can be environmentally and politically justified – not for reduced journey times or improved equipment utilization, but for grade-crossing elimination, property development, and civic pride.

Integrated Transportation Planning: TRA's seamless passenger experience across jurisdictions demonstrate an island-wide, strategic, "joined-up" thinking that provided benefits to many stakeholders. Contrarily, project delivery was phased to make scope, funding, and environmental impacts more manageable, enabling sustained expansion, reconstruction, and modernization during the last forty years. It's as if Robert Moses' powerful visions as "master builder" of New York's parkways were applied to Taiwan's railways!

THE FAR EASTERN PHILOSOPHY

TRA tends to favour simple, robust, single-purpose machines – like separate power generation cars for air-conditioning in diesel territory, and power changes instead of dual-mode locomotives. Complex functions are modularized, like having separate faregates for magnetic tickets and smartcards. Operating and maintaining these machines requires a multi-skilled, multi-tasking workforce. Expectations of system knowledge extend to customers; users must find the right machine for their needs. This philosophy results in a generally more quirky railway, with steeper learning curves for the public and employees alike. Customers and staff have clearly "learned the plant," as evidenced by precise and speedy regular operations. This approach makes railway hardware fairly basic, while implementing much of service delivery and recovery "in software" with operating practices. The idea that different procedures can permit higher and more flexible utilization of infrastructure is evident throughout TRA's designs.

The Oriental philosophy isn't always right, and may not be applicable in the New World, but it's interesting and different. While multiple standards, vendors, designs, workarounds, and complex operating processes might seem complicated and confusing, over-automation can result in barely maintainable machines operated by human drones. Without compromising safety, is there room in North America for a little within-system technological diversity?