**Rail Technology Adoption**

Technology adoption by freight railroads has a long history, driven by internal business agendas, external regulation, and shipper requirements. Existing technologies can either be improved incrementally or replaced completely by new technological advances. This dynamic pace of change is challenging to manage, exacerbated by organizational silos and varying perspectives among vendors and in-house developers. Technology, especially software and communications, is increasingly relied on for safe and efficient operations and business processes. There is an inclination to replace human labor with technology because of technology’s superior ability to handle some types of complexity consistently. However, human intelligence is broader and more nuanced. The goal must be to optimize the interaction between technology and humans in complementary systems that empower situationally aware decisions.

**Core Question:**

What level of cooperative interaction among stakeholders is required to implement technologies that effectively balance business drivers, increase safety, increase capacity for growth, and improve customer service while promoting a culture of empowerment and inclusion for railroad staff at all levels, from executive management to craft labor?

**Stakeholders**

* + - Railroad investors
    - Railroad executive management, particularly the CFO, COO, and CTO
    - Railroad subject matter experts
      * Department Management:
        + Operations
        + Mechanical
        + Dispatching
        + Engineering (track, B&B, IT, Signaling and Communications)
        + Marketing and Sales
      * Field management
      * Craft labor:
        + Train, Yard, and Engine
        + Dispatchers
        + Mechanical
        + Signaling/Communications
        + Maintenance of Way
    - In-house R&D and systems architecture staff
    - In-house software and network developers
    - Equipment and rolling stock vendors
    - Information technology vendors
    - Shippers and BCOs
    - Logistics Businesses (3PLs, IMCs, other supply chain management)
    - Other carriers (steamship, truck, barge)

***Round 1***

**Current State of Technology**

1. How do the following aspects of the railroad business benefit from technological advances and improvements, and are there others that need to be identified?
   * + Managing the complexity of multiple thousands of origin-destination pairs in service design.
     + Improvements to locomotive power, cost, flexibility, and maintainability.
     + Improvements to rolling stock efficiency, capacity, load/unload cost, and safety.
     + Safe train control and location awareness for:
       - Train speeds beyond what a human locomotive engineer can manage alone.
       - Operation of longer and heavier trains over demanding grade and curvature profiles.
       - Expanding a dispatcher’s ability to control greater volumes with variable priorities effectively.
       - Shipment tracking and schedule adherence.
     + Improvements to track load bearing, longevity, rolling friction, safe operating speed, and maintainability.
2. What are the most important aspects of technological capability and change that influence decisions to fund, deploy, and refine post-deployment?
   * + Timing relative to the technology’s maturity curve
     + Expected effectiveness of the improvement
     + Minimum effectiveness level to be deployed at scale
     + Identification of unintended consequences and functionality gaps that lead to further refinements
3. How are projects to correct intentional or accidental functionality gaps to already adopted technologies identified and funded?
4. How does the technology adoption lifecycle from inception to obsolescence differ when:
   * + Mandated by regulation?
     + Driven by cost reduction?
     + Driven by train service improvements and revenue growth?
5. How does the technology adoption lifecycle from inception to obsolescence differ for:
   * + Information and communications technologies applied to railroad operating and business processes such as (but are not limited to):
       - Train service planning
       - Train consists
       - makeup and terminal automation
       - Power assignment to train services
       - Crew and yard personnel assignment
       - Train dispatching location detection, conflict prevention, and operating authority communication
       - Mechanical defect detection
       - Locomotive operating health management and telematics
       - Locomotive throttle and braking management
       - Car and shipment location tracking
       - Other railcar telematics such as location, health, load stability, and temperature
       - Billing
     + Locomotive energy cost efficiency, emissions management, maintainability, or operational flexibility?
     + Railcar capacity, weight, aerodynamics, maintainability, or ease of loading/unloading?
     + Locomotive and railcar air brake performance improvements?
     + Trackage friction, stability, longevity improvements?
6. How is technological obsolescence identified and corrected?

***Round 2***

**Organizational Impact on Technology Adoption**

1. How do the following aspects of the railroad business benefit from technological advances and improvements, and are there others that need to be identified?
2. What success measures and methods are used for a potential technological improvement to a railroad application to evaluate feasibility, funding, implementation, testing, and approval for in-service deployment at scale?
3. Are all parts of the organization involved in the definition of the success measures and methods identified above when the adoption of new or improved technologies crosses organizational boundaries?
4. How can any unforeseen costs and unintended consequences of a new or modified technology solution be identified as early as possible, and how are additional measures to correct these shortcomings funded, implemented, tested, and approved for deployment in railroad operations?
5. In order for adopted technologies to achieve promised benefits, how can stakeholders more effectively evaluate the need for improvements?
6. How are different technological solutions prioritized, given finite funding and implementation resources:
   * + Among solutions that address the same problem domain?
     + Among solutions whose problem domains partially overlap?
     + Among solutions where one solution is a subset of another? Is there a “minimum viable solution” that implies a more comprehensive one?
     + Among solutions to completely different problems?
7. How does the technology adoption lifecycle from inception to obsolescence differ when:
   * + Obtained from an outside vendor?
     + Designed and implemented in-house?
8. When considering the adoption of information and communication-based technologies, to what degree do components of those solutions satisfy multiple higher-level goals or functions (e.g., precise and timely train, locomotive, car location tracking, or train consist makeup)?
   * + Should these components be sharable and integrated into a common system architecture to:
     + Guarantee consistent behavior across functions?
     + Reduce testing, modification, or procurement costs?
     + Provide a “single source of data truth” such that contradictory answers or system responses do not result from inconsistent behavior?
     + When do varying quality-of-service requirements or the lifecycles of already adopted technologies drive separately implemented components that perform the same general function?

***Round 3***

**Optimizing Human and Digital Technology Interaction**

1. What are the strengths of technological capabilities compared to human capabilities?
2. What are the strengths of human capabilities compared to technology?
3. When identifying, evaluating, and testing new technology solutions, how can human decision-making be incorporated to leverage the technological strengths?
4. When identifying, designing, evaluating, and testing new technology solutions, how does the proposed solution keep human operators engaged and alert for situations the machine isn’t able to handle?
5. How can intentional or accidental functionality gaps in already adopted technologies be efficiently mitigated with human intervention?