DRAFT

A DEMONSTRATION PROJECT FOR LOCOMOTIVE ENGINEER TRAINING

PHASE I

L&N-BLE
DEMONSTRATION
TRAINING PROJECT

APRIL 1982
FINAL REPORT
VOLUME I

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16. Abstract

This report presents the findings of the joint venture demonstration training project conducted by the Louisville & Nashville Railroad and the Brotherhood of Locomotive Engineers.

Volume I contains a survey of the literature, a job task inventory and a set of guidelines for instructional systems design. The report also describes the training practices, techniques and materials of formal Locomotive Engineer Training (L.E.T.) programs at six class-one railroads.

Volume II presents suggested short term additions to the L&N's L.E.T. program; three model L.E.T. programs of low, middle and high costs (implementation and operation) and a cost-benefit analysis plan for the models.

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TABLE OF CONTENTS

TABLE OF CONTENTS
(Cont'd)

TABLE OF CONTENTS
(Cont'd)

LIST OF TABLES

1. INTRODUCTION

1.1 BACKGROUND

There is a great diversity of training in the railroad industry. Training may be conducted in the railroads' classrooms, at a suppliers school, at a technical school, by correspondence, on the job, or through an apprenticeship. Some railroads have formal training programs, while others rely heavily on on-the-job training.

Since 1968, the National Transportation Safety Board has issued recommendations to the Federal Railroad Administration and the railroad industry directed toward correcting training deficiencies in order to improve railroad safety. In their report NTSB-SIR-79-1, the Safety Board recommended that railroad training programs be reviewed to ensure that relevant training be provided for the skilled railroad crafts. The report also noted that the railroad industry has apparently relied primarily on operational experience to establish the content of training programs and has not used a systems approach to curriculum development.

1.2 PROJECT GOALS

As recommended by the NTSB, this study undertook a systems approach to the assesment of existing locomotive engineer training programs and to development to inprove curricula and training alternatives. The primary goal of the study was to develop three long-range alternatives for improving the safety, productivity, and efficiency of current programs for the training of locomotive engineers. A second goal was to recommend interim changes in the present L&N training program which could be implemented in a short time period. Three additional goals were established as necessary steps in support of the first two goals. First, development of an inventory of the basic items of knowledge, and of performance capabilities necessary for the safe and effective performance of the job of locomotive engineer; second, the adoption of a set of guidelines for use as criteria in analyzing the design of locomotive engineer training programs, and, third, generation of a detailed task analysis of the job of locomotive engineer.

1.3 THE PROJECT AND PROJECT TASKS

The systems approach was applied to the problem of locomotive engineer training through four tasks, Initial Planning Analysis, Stage I Implementation, and Design.

The initial planning included a review of relevant literature and a collection of data on the locomotive engineer training programs of six railroads through site visits and the submission of training documentation.

Analysis of the data thus obtained yielded an inventory of job knowledge and performance requirements for locomotive engineers. From the literature, instructional design criteria were derived, which were then used to evaluate the documented training programs.

Phase I implementation involved application of the results of the preceding analyses to the L&N locomotive engineer training program. L&N operating practices were represented by a detailed task analysis of the locomotive engineers job, used as a criterion for evaluating current training practices. Short-range changes in L&N training techniques were recommended and long-range objectives were identified for inclusion for the design of improved programs.

The design task yielded three model L.E.T. programs, including objectives, schedules, and recommended training techniques. The first design alternative (Model 1) represented a relatively low cost approach to improved training through changes in course content and record keeping and a formal organization of OJT. Model 2 included all the features of Model 1 plus the use of train dynamics analyzers and required a moderate capital investment. Model 3 expanded on the investments of Model 2 with the addition of a full-scale, dynamic, locomotive cab simulator. Guidelines were developed to assist an individual railroad in comparing the relative costs and benefits of the three programs for its specific needs in locomotive training and the cost-benefit analysis was demonstrated by applying it to the requirements of a hypothetical national training program.

1.4 THE SYSTEMS APPROACH

The systems approach is simply an orderly sequence of steps applied to the solution of problems involving a system (i.e., an aggregate of people and equipment that must work together to accomplish a common purpose). Basically, these steps involve a thorough analysis of what is known, a determination of what is needed, the development of solutions to the needs, implementation of the solutions, and evaluation of the effectiveness of the solutions. The tasks of the present project follow this approach, progressing through analysis and determination of requirements for locomotive engineer training (Tasks 1 and 2), to development of recommended solutions (Tasks 3 and 4). For the process to be complete, however, the implementation and evaluation for the proposed programs (as planned for a later phase of this project) must be accomplished.

1.5 ORGANIZATION OF THE PROJECT

The Federal Railroad Administration, cognizant of the need to improve the quality (and possibly the quantity) of locomotive Engineer Training in America established the Demonstration Project For Locomotive Engineer Training under a cooperative agreement with the Louisville and Nashville Railroad (L&N) and The Brotherhood of Locomotive Engineers (BLE).

A Steering Committee, comprised of senior officer representatives from the L&N and the BLE, was established to monitor and give overall administrative directions to the project. An Advisory Committee on Locomotive Engineers, Training, composed of an equal number of representatives from the L&N and the BLE, was also appointed, to be responsible to the Steering Committee for reporting of problems encountered and insuring comformance with program objectives. A project team, including L&N and BLE members, a system management contractor, and subcontractors as needed, accomplished the project tasks, with periodic review and approval by the Steering Committee as required.

1.6 ORGANIZATION OF THE REPORT

The details of the literature survey are reported in Section 2 of this report. Section 3 describes the selection of five railroads for analysis, the site visits to these railroads and to the L&N, the data obtained, and the general nature of the training programs observed. Section 4 covers the development of inventory derived from the literature and a revised inventory based on the data collected from the six cooperting railroads. Section 5 reports the results of analyzing the data collected against a set of criteria developed by the American Society for Training and Development (ASTD). The ASTD criteria is included as Appendix A.

1.7 PRINCIPAL RESULTS

The survey and analysis of relevant data failed to reveal any L.E.T. programs that were wholly developed through the systems approach. However, some railroads had used the systems approach in development of portions of their programs, notably the design and implementation of full-scale locomotive cab simulators.

The project to date has succeeded in developing a job task inventory (Section 4) that will be used as a basis for development of training objectives, course modules, and evaluation procedures in the model program of L.E.T. In addition, the efforts described in this report have led to a series of recommendations to enhance the L&N's present L.E.T. program.

In response to another project recommendation, the L&N with some support of the project undertook and completed a thorough job task analysis of L&N locomotive engineer practices which will be an invaluable starting point for the project's model L.E.T. program and further L&N training improvements. The recommended aids and the job task analysis will be covered in a subsequent report.

2. LITERATURE SURVEY

2.1 APPROACH

The Project team surveyed the following sources of relevant information: The RRIS (Railroad Research Information Service); AAR (Association of American Railroads); USRA (U.S. Railway Association); FRA (Federal Railroad Administration); TSC (Transportation Systems Center); Dept. of Labor, Bureau of Apprenticeship and Training; BLE (Brotherhood of Locomotive Engineers) and SAI (Science Applications Incorporated) Comsystems. A computer search of NTIS (National Technical Information System) and TRIS (Transportation Research Information System) through Lockheed Information System's DIALOG data bases was also performed. From all these sources, 66 documents were acquired.

Four categories of information were identified:

- LOCOMOTIVE ENGINEER TRAINING (14)
- HUMAN FACTORS/MAN MACHINE INTERFACE (30)
- SAFETY/ACCIDENTS (15)
- PRODUCTIVITY (7)

A brief introduction to each category summarizes the materials in the group. Following each introduction are abstracts of key documents in the category.

2.2 LOCOMOTIVE ENGINEER TRAINING LITERATURE

Several surveys have been conducted of current training practices in the railroad industry. Included in these studies is the training of locomotive engineers. The findings indicate that a small number of railroads (probably less than 10) have 'formal' locomotive engineer training programs in operation.

Several documents contain locomotive engineer training program guidelines and time allocations. These guidelines suggest the topics, depth of coverage, and the order in which they should be presented (scope & sequence).

2.2.1 Abstracts of key documents

Hale, A., Jacobs, H. H., Proposed Qualification Requirements For Selected Railroad Jobs, Dunlap and Associates, Report No. FRA-OR&D-75-44, May 1975.

This report proposes minimum, safety-related knowledge, performance and training requirements for the jobs of railroad engineer, conductor, brakeman and train dispatcher. Analyses performed were primarily based upon job and task analysis documentation already in existence, and were critically reviewed by government and civilian railroad specialists. Recommendations are also offered for the conduct of job training and for techniques to measure and evaluate job knowledge and performance. Sponsored by the Federal Railroad Administration, U.S. DOT.

Sterling Systems Incorporated, Locomotive Engineer Training Program Requirements and Cost-Benefit Analysis, Brotherhood of Locomotive Engineers, April 14, 1978.

This is a study of the need for the type of training programs necessary to develop locomotive engineers for future railroad requirements. The current status of such training in the railroad industry is also examined. Cost-benefit analyses are made of training systems needed to produce 2000 apprentice locomotive engineers annually. It was concluded that productivity and safety goals mandate more efficient centralized training system.

Stewart, D. A., Proposed Research Plan To Improve Railroad Employee Training, Department of Transportation, Federal Railroad Administration, Report No. DOT-FR-75145, December 1977.

The purpose of this study was to present an overall plan for consideration by the Federal Railroad Administration which would aid the railroad industry in fulfilling its employee training needs. A sample of eight railroads, including both rail labor and management representatives were interviewed to determine the extent of existing training and to gain insights as to the possible role of the Federal Railroad Administration.

The major recommendation was that the FRA consider the development of a Basic Core Curriculum which would have universal applicability over the railroad system. This recommendation and the thirteen other research recommendations are under consideration by the FRA.

U.S. National Transportation Safety Board, Results Of A Survey On Occupational Training In The Railroad Industry, Report No. SIR-79-1.

This report is a brief factual description of the training the majority of the Class I Railroads provide employees working in operations, maintenance, and inspections. The report is based on information provided to the Safety Board by 28 of the Class I Railroads, the railroad unions, the Federal Railroad Administration, the Department of Labor, and the Interstate Commerce Commission in response to questions on the subject of training.

Association of American Railroads, Track Train Dynamics To Improve Freight Train Performance Thru: Train Handling, Train Makeup, Track and Structure, Engineer Education, 1973.

This manual consists of guidelines for improved freight train operation. The guidelines are a composite of the best of current North American railway operating practices. This standardization and documentation of successful practices provided a valuable basis for the development of a program for locomotive engineer training. The major emphasis is on effective train handling and those elements which insure this: proper train makeup, track and structure considerations, and locomotive engineer training and/or retraining. The manual has six major sections: 1--Definitions and Functions of Equipment; 2--Train Handling; 3--Train Make-up; 4--Track and Structures Considerations; 5--Education of Locomotive Engineers; 6--Implementation of Guidelines.

This manual is intended for officers who have responsibility for policy making as it pertains to train operations and for all levels of supervision involved in such functions.

Transportation Research Board, Railroad Research Study Background Papers, Woodshole, Mass., July 1975.

This publication contains all of the papers presented at a conference that was a part of the Railroad Research Study Conference. The papers discuss research requirements for the next fifteen years in the following areas: railroad marketing, railroad economics, information systems and data, railroad management, railroad labor relations and employee training, railroad facilities, railroad equipment, and railroad operations.

2.3 HUMAN FACTORS/MAN MACHINE INTERFACE LITERATURE

Industry, labor and government have sponsored research in the area of Human Factors including: The research and the identification of environmental conditions contributing to accidents; the redesign of the locomotive cab for improved engineer performance; the identification of psychomotor indicators of locomotive engineer simulators. The McDonnell Douglass Study is one of the pioneering efforts in this area with its report on locomotive engineer job tasks. Human factors are an important parameter in the design of a training system.

2.3.1 Abstracts of key documents

Devoe, D. B., et al., Human Factors In Railroad Operations: Activities In Fiscal Year 1973, Department of Transportation, Transportation Systems Center, Report No. FRA-OR&D-74-32, February 1974.

This is an interim report covering human factors services rendered by TSC to the FRA under the project: "Human Factors in Railroad Operations," during fiscal year 1973. It reviews all activities briefly and contains more detailed reports on a research plan for use with a locomotive cab simulator, a training survey, studies of train handling, and fault-tree analysis of railroad accident data.

McDonnell Douglas Corporation., Railroad Engineman Task and Skill Study, Department of Transportation, Federal Railroad Administration, Report No. FRA-OPP-73-2, August 1972.

This report describes the principal tasks performed by a locomotive engineer during over-the-road freight operations utilizing diesel electric locomotive equipment. Sixty-four basic tasks are identified and classified into seven task groupings. Each step is described in terms of input to the locomotive engineer (rules, signals, displays, and other infor- mation), information processing and decision making by the locomotive engineer the output of the locomotive engineer (control action, communication and the like), feedback of action consequences to the locomotive engineer and interactions with other crew members. Each task is also given ratings for difficulty, hazards and criticality for safe operation of the train. The report is intended to provide data in support of further efforts toward relating the locomotive engineer skill requirements (aptitudes, proficiency, training) and working environment to the safety of railroad operations.

Hulbert, S., et al., Research Locomotive And Train Handling Evaluator Definition-Concept 1 Volume I-Evaluator Performance Specifications, MBAssociates, Report No. FRA/ORD-77/47,I, September 1977.

Performance specifications for a train handling and locomotive research evaluator are set forth in Volume I. These are based upon a study of design concept trade-offs to create a research facility capable of eliciting realistic behavior from railroad train engineers. Results of these studies are presented in Volume II along with examples of research programs that could be carried out. Initial cost, operating staff and costs, buildings and utilities, test subject logistics and downstream improvements are included in Volume III. The overall research needs that can be met uniquely by such a research evaluator facility are presented along with a schedule for design, procurement, delivery and installation of such a simulator.

2.4 SAFETY/ACCIDENT LITERATURE

Much has been said in the literature regarding the impact of training upon the safe operation of the railroads. Employees that have been fully trained in the proper performance of their jobs should be safer workers. Studies have established that inadequate training is a contributing factor in too many railroad accidents. Training costs can be repaid many times over by the savings in lives, injuries, property damage and time that would be effected by improved training. The need for improved training of locomotive engineers is cited in a 1979 survey of training in the industry performed by the National Transportation Safety Board. Of 28 Class I Railroads responding, only four reported a 'formal' training program for locomotive engineers.

2.4.1 Abstracts of key documents

Bureau of Surface Transportation Safety, Special Study: Signals and Operating Rules as Causal Factors in Train Accidents, National Transportation Safety Board, Report No. NTSB-RSS-71-3, December 1971.

Railroad signal systems, even though performing as designed, do not compensate for human failure and prevent accidents. Many collisions attributable to negligence of employees result from lack of compliance with operating rules which do not relate compatibly with the signal systems. A relationship is developed between signal systems, operating rules, and the human element that is responsive to both. Specific cases are sited in which the discrepancies are exposed and examined within the context of the foregoing. Recommendations are directed to the Federal Railroad Administration that they take steps under the increased scope of authority of the Federal Railroad Safety Act of 1970, to develop a comprehensive program for future requirements in signal systems and operating rules that will reduce or eliminate the present ambiguities and lax, ill-defined operating rules.

Bureau of Surface Transportation Safety, Special Study: Train Accidents Attributed To The Negligence Of Employees, National Transportation Safety Board, Report No. NTSB-RSS-72-1, May 1972.

The report identifies and ranks the leading causes of train accidents attributed to the negligence of employees for the period 1961-1970. Analyses of the leading accident causes are performed to explore contributory factors such as rules, rule enforcement procedures, equipment design or maintenance, and environment. The relationship between accidents attributed to employee negligence and employee training, railroad safety efforts, the financial condition of the industry, and organized labor's role in advancing safety is discussed. A recommendation is directed to the Federal Railroad Administration to analyze the identified leading accident causes and to take appropriate corrective action. Safety Board recommendations from previous accident reports and special studies are reiterated as applicable to the circumstances identified in this report.

Shulman, A. E., Taylor, C. E., Analysis Of Nine Years Of Railroad Accident Data, Association of American Railroads, Report No. R-233, April 1976.

This report presents an analysis of Train Accident and Train Service Accident data for the years 1966 through 1974. The analysis was designed to identify the effects of such factors as inflation, reporting thresholds, changes in railroad traffic and bankrupt carriers on the trends of accident statistics. Accident cause categories were then ranked year by year based on an index which took account of both the frequency of number of accidents in each cause category and the severity of the accidents in that category.

National Transportation Safety Board, Rear End Collision Of Conrail Commuter Train No. 400 And Amtrak Passenger Train No. 60, Seabrook, Maryland, June 9, 1978, National Transportation Safety Board, Report No. NTSB-RAR-79-3, March 1979.

About 6:40 p.m., on June 9, 1978, Conrail commuter train No. 400 struck Amtrak passenger train No. 60, which was slowing to stop at a grade crossing at Seabrook, Maryland. Eight cars of train No 60 and the three head cars of train No. 400 derailed. Sixteen crewmembers and 160 passengers were injured, and damage was estimated to be $248,050. The National Transportation Safety Board determined that the probable cause of this accident was the failure of the engineer of train No. 400 to perceive the train ahead and to properly apply the brakes in sufficient time to prevent a collision. Contributing to the accident was the failure of Amtrak to assure that the train crews were adequately trained. The causes of the large number of injuries in this relatively low-speed collision were the failure to maintain and service seats on the Amfleet equipment, and the injury-producing fixtures designed into the commuter cars.

2.5 PRODUCTIVITY LITERATURE

The improvement of locomotive engineer training programs has numerous implications for railroad productivity. It has been estimated that as many as 2000 new locomotive engineers will need to be trained annually. Training systems should be designed and implemented which should efficiently meet this need. These training systems should have built-in self-assessment subsystems for 'fine tuning' the training process; advanced record keeping practices should be employed to help maintain engineer proficiency through recurrent training; and state-of-the-art instructional technology should be integrated with traditional classroom instruction and on-the-job training.

2.5.1 Abstracts of key documents

Task Force on Railroad Productivity, Improving Railroad Productivity, The National Commission on Productivity and the Council of Economic Advisors, Washington D. C., November 1973.

The report is concerned with the railroads primarily as transporters of freight rather than passengers. It suggests innovations in corporate structures and freight handling procedures to improve service and make the railroads run profitably without large infusions of new capital or public monies. The report discusses the origins of the railroad problem, alternative measures to improving railroad productivity, the financial circumstances of the railroad industry, the potentialities and inhibiting factors of containerization, approaches to relieve railroads of the burdens of light density lines, the case of regulatory modernization, work rule and seniority district complaints, restructuring the industry to give individual railroads greater control, and innovations to help reduce costs, improve service, and stimulate traffic growth. This report did not address the impact of personnel management practices (including training) on productivity.

2.6 FORMAL TRAINING PROGRAMS

The existence of L.E.T. programs is documented in the referenced literature; however, the actual program documents are not available except from the railroads. During visits to the cooperating railroads L.E.T. program documentation in various degrees of completeness was acquired. These programs are reported in Section 3.

2.7 JOB TASK INVENTORY

Job tasks were identified by the Literature Survey. Locomotive engineer job tasks are usually presented in two categories: knowledge and performance (skills). The McDonnell Douglas Study (Aug., 1972), presents a detailed list of procedural skills necessary for proper over-the-road train handling. The Hale and Jacobs study (May, 1975), modified the McDonnell Douglass performance requirements and also presents minimum knowledge requirements for the job of locomotive engineer. The Sterling Report (April, 1978), modifies the Hale and Jacobs study by adding Yard and Transfer Operations to the list of skill and performance requirements. The knowledge requirements are essentially the same in Hale and Jacobs and the Sterling Report.

The job tasks were compiled from the above-mentioned documents into a preliminary* listing, to be refined further on the basis of observations at site visits and documentation supplied by the cooperating railroads. This listing is tabulated as follows: Preliminary Knowledge requirements are presented first for each task as Table 2-1, followed by a list of performance (skill) requirements, Table 2-2.

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*Subject to further refinement in Phase II of the Project as well.

TABLE 2-1 PRELIMINARY KNOWLEDGE REQUIREMENT TOPICS

A. Railroad Organization
   1. Functions performed by various departments
   2. Duties and authority of key operational personnel

B. Equipment and Facilities
   1. Locomotives
      a. Locomotive types
      b. Diesel-electric power generating equipment
      c. Braking equipment
         1. Air brakes
            a. Function and location of the operating controls.
         2. Dynamic brake
            a. Function and location of the operating controls.
         3. Handbrakes
            a. Location and operation of various types of handbrakes in service.
      d. Sanding Equipment
         1. Function, location and requirements for safe operation.
         2. Situations requiring automatic or manual sanding.
      e. Safety and communications equipment
         1. Function, location and operation.
   2. Cars
      a. Types of cars
   3. Trackage and associated equipment
      a. Common types of trackage
   4. Terminals, yards, enginehouses, turntables
   5. Signals
      a. Meanings of hand, flag, and lamp signals
      b. Meanings of horn/whistle signals
   6. Train Control Systems

C. Physical Characteristics of the Road
   1. Location of significant terrain features
   2. Location of various railroad facilities and landmarks

D. Rules and Regulations
   1. Operating rules
   2. Timetable and special instructions
   3. Work rules and hours of service regulations
   4. Power brake law
   5. Special and bulletin notices
   6. Radio operation rules
   7. Federal regulations governing locomotive inspection, safety appliances and handling of hazardous materials.

E. Operational Procedures
   1. Trip preparation
      a. Required trip information
      b. Procedures for communicating with yard personnel and crew members.

   c. Procedures for performing inspections of locomotive consist.

2. Initial movement
   a. Required conditions prior to starting the locomotive.
   b. Starting the locomotive
   c. Post-start inspections
   d. Accelerating, running, stopping, and backing forming locomotive consist
   f. Coupling the locomotives to cars, verification of coupling and air brake test.
3. Over-the-road operations
   a. Basic handling
      1. Factors affecting the use of power and braking
         a. Train and track considerations affecting tractive and braking forces.
         b. Environmental considerations
         c. Time and distance considerations
         d. Handling considerations
      2. Slack control
         a. Conditions which promote slack development and its location within the train.
         b. Procedures for controling slack
         c. Consequences of ineffective slack control
   b. Intermediate handling
      1. Grade and curve territories
      2. Power assistance
         a. Remote control equipment
         b. Pusher and helper equipment
      3. Braking assistance
   c. Special handling
      1. Procedures following loss of the dynamic brake
      2. Procedures after emergency brake application
      3. Procedures after unintentional brake release
      4. Procedures after break-in-two
      5. Procedures after derailment
      6. Procedures for correcting and/or reporting operating difficulties.
   d. Communications
      1. Procedures for operating train radio in communications to and from the dispatcher, outside crew, and caboose.
      2. Procedures for telephone communication
      3. Forms of train orders
      4. Requirements for completion of work order or defect report.
4. Trip completion
   a. Requirements for securing and shutting down the power consist.
   b. Procedures for completing and filing operational and maintenance reports.

TABLE 2-1 PRELIMINARY KNOWLEDGE REQUIREMENT TOPICS (CONT'D)

F. Effective Job Performance
   1. Factors affecting engineer performance
      a. General fitness requirements
      b. Major sources of performance decrements

   2. Injury avoidance
      a. Types and locations of potential hazards and injuries
      b. Precautions when moving on or about tracks

G. Railroad Terminology Required for Reliable Communication
   1. Standard railroad terms
   2. Local railroad terms

TABLE 2-2 PRELIMINARY PERFORMANCE REQUIREMENT TOPICS

A. Trip Preparation
   1. Registering
   2. Perform locomotive inspections

B. Starting and Initial Movement
   1. Start the engine
   2. Post-start inspection
   3. Preparation for initial movement of train
   4. Forming the consist
      a. Couple the locomotive to the cars and verify the coupling
      b. Pumping up air
      c. Brake pipe leak test
   5. Obtain a departure clearance
   6. Start movement
   7. Move the train through the yard to the designated main track.

C. Over-the-Road Operations
   1. Basic handling tasks
      a. Accelerating
      b. Decelerating
      c. Automatic braking
      d. Independent braking
      e. Braking with power
      f. Dynamic braking
      g. Backing up
      h. Sanding

   2. Intermediate Handling Tasks
      a. Speed and slack control
         1. Control the throttle and brakes so as to avoid wheel slip and wheel slide.
         2. Control slack within the train avoiding excessive buff action and coupler or draft gear strain.
      b. Approaching crossing
      c. Entering and leaving siding
      d. Pickup and set off cars
      e. Negotiating turnouts and crossovers
      f. Passing equipment adjacent to tracks
      g. Passing train adjacent to track
      h. Receiving wayside messages
      i. Power assistance
         1. For operations involving remote control equipment (RCE), perform the following activities:
            a. Set up and check out the configuration prior to use.
            b. Employ brake and power functions.
            c. Switch between independent unit, and multiple.
         2. Operate with a pusher or helper unit
         3. Operate as a pusher or helper unit

j. Maintanence requirements

3. Special Handling and Operating Difficulties
   a. Respond to obstructions on tracks
   b. Respond to torpedoes and fuses
   c. Respond to temporary restrictions and slow boards
   d. Respond to improper signals
   e. Respond to degraded dynamic braking
   f. Respond to degraded traction motor operation
   g. Respond to diesel engine defects
   h. Respond to no throttle response
   i. Respond to engine shutdown
   j. Respond to loss of sand
   k. Respond to battery discharge
   l. Respond to alarm bell
   m. Respond to locomotive overspeed
   n. Respond to brake warning
   o. Respond to wheel slip
   p. Respond to open PCS
   q. Respond to automatic train control warning
   r. Respond to safety control devices
   s. Respond to emergency braking
   t. Correcting derail condition
   u. Replacing broken knuckle
   v. Setting out damaged cars
   w. Respond to known locomotive defects
   x. Respond to natural hazards
   y. Respond to hot journal bearings
   z. Respond to low oil or water pressure
   aa. Respond to high cooling temperature
   ab. Respond to low main reservoir pressure

4. Communications
   a. Employ the train radio in communications from the locomotive to dispatcher, and the locomotive to the caboose or outside crew.
   b. Execute a work order defect report.

D. Yard and Transfer Operations
   1. Operate and control the locomotive with or without cars in various types of yard operations, including but not limited to the following:
      a. Hump receiving yards
      b. Classification yards
      c. Flat general switching yards
      d. Car repair and storage yards
      e. Passenger train yards
      f. Industrial yards
      g. Livestock yards
      h. Transfer or interchange yard
   2. Start cuts of cars when either bunched or stretched.

3. Hump or shove cars in hump yard operations in accordance with signal indications, including instructions via the radio, and controlling the speed for the hump operations as required.
4. Kick and drop cars in flat switching operations.
5. Pick up, set out and spot cars on industrial, shop and repair tracks.
6. Couple-up and double cuts of cars to various tracks to make up road trains.
7. Switch passenger cars with and without passengers.
8. Handle work trains and wrecker equipment.
9. Identify, understand and comply with hand signals given, both day and nighttime, such as:
    a. Normal and emergency stops
    b. Back up and back away
    c. Go ahead or proceed
    d. Kick cars, slow or fast
    e. Drop kicks
    f. Cut off
    g. Apply air brakes
    h. Release air brakes
    i. Track number
    j. Clearance
    k. Easy and slow
    l. Car length signs for identifying distance between cars.
10. Identify, understand and comply with other signal systems such as:
    a. Hump yard
    b. Interlocking plant
    c. Centralized train control
    d. Automatic block
    e. Manual block
11. Handle placarded and other cars of hazardous materials, such as explosives, poisons, liquidified gases and molten metal, safely and in accordance with all regulations, including Federal regulations.
12. Execute a work report, defect report and accident report when applicable.

E. Trip Completion
1. Move the train from the main track or the yard, through the yard, to the designated track.
2. Stop the train at the appropriate destination and secure the locomotive consist; shut down the locomotive consist, if appropriate.
3. File any required operational and maintenance reports with proper authorities.

F. Auxiliary Equipment Operating Tasks
1. Operation of air horn
2. Operation of train bell
3. Operation of radio/telephone
4. Use of windshield wipers and/or defogger

TABLE 2-2 PRELIMINARY PERFORMANCE REQUIREMENT TOPICS (CONT'D)

5. Use of locomotive cab heater
6. Use of light controls
7. Use of attendant call button
8. Use of fire extinguisher
9. Use of RMU equipment
10. Use of retainers

3. SELECTION OF RAILROAD TRAINING PROGRAMS

3.1 PURPOSE AND APPROACH

The project's statement of work calls for "..the assessment of existing training programs (for) the development of improved curricula and training alternatives." A systematic approach to the selection of training programs for analysis and the collection of data describing those programs was adopted, consisting of the following steps:

a. Determination of criteria for selection of programs
b. Selection of railroads for study
c. Site visits to selected railroads

Throughout the process of selection and data collection, procedures and progress were reviewed by the Steering Committee to assure an approach mutually agreed upon by all participants.

3.2 SELECTION PROCESS

3.2.1 Selection Criteria

Since the goal of the project was to distill the best elements from current railroad L.E.T. programs the sampling criteria were aimed at identifying those programs most likely to contain useful elements. After review of proposed sampling criteria by the Steering Committee, the following criteria were adopted:

a. Capital commitment to training
b. Attitude toward training
c. Types of training
d. Types of railroad service provided
e. Geographical characteristics of areas served
f. Willingness to participate

3.2.2 Rationale for Selection Criteria

a. Capital Commitment to Training. To be selected for evaluation, a railroad had to have funds in its operating budget specifically committed to training. Without this degree of commitment, a railroad was considered unlikely to be a source of training elements of potential value to other railroads.

b. Attitude Toward Training. To be selected for analysis, a railroad had to show evidence of a positive attitude toward training. This criterion was not easy to exercise and relied heavily on the experience and expertise of both the Steering Committee and the project personnel. However, it was agreed that evidence of a lack of interest in improving existing training programs implies a poor source for training alternatives.

c. Types of Training. This criterion was less restrictive than the others. Recognizing that all railroads selected could not be expected to exercise all types of training that merited study, an attempt was made to assure that certain elements were contained in one or more of the railroads sampled. Characteristics that were required for the sample included both centralized and decentralized classroom training facilities and the use of either a train dynamics analyzer or a high-fidelity, dynamic, locomotive cab simulator.

d. Types of Railroad Service Provided. To be selected for analysis, a railroad had to provide at least the following services: long haul, unit train, local and terminal. Since the focus of the project was on railroads whose principal source of revenue is freight, provision of passenger service was not a requirement for selection.

e. Geographical Characteristics. To be selected for analysis, a railroad had to operate over a wide range of geographical and climatological conditions. Each railroad was required to include both level and mountainous territories and hot-weather and cold-weather operations. Although all railroads selected could not be expected to meet extremes of these conditions, it was desired that the total sample include extremes. Only on such railroads could the specialized techniques needed for these difficult operations be expected to be included in the training programs.

f. Willingness to Participate. Any railroad indicating a reluctance to participate in the project was no longer considered for further study.

g. Excluded Criterion. Consideration was given to using accident data as a selection criterion, since safe operation of trains is certainly a reason for training locomotive engineers. The literature survey (Section 2) disclosed evidence of costly train accidents in which inadequate training was identified (or could be inferred) as a contributing cause. However, hard data could not be found to justify selection of meritorious training programs on the basis of their direct contribution to safety records; so this criterion was excluded.

3.2.3 Selection Of Railroads

Guidance for selection of training programs was sought in the literature (Section 2). The only detailed data relevant to this process was contained in the survey conducted by the National Transportation Safety Board.* The NTSB data were combined with the experience, knowledge of the industry, and expertise represented by the Steering Committee in an informal matching of railroads to the selection criteria.

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* U.S. National Transportation Safety Board, Results of a Survey On Occupational Training in the Railroad Industry, Report No. SIR-79-1.

This process resulted in the identification of ten railroads, which met the criteria, five of which agreed to participate in the study when contacted by the Steering Committee.

The Louisville and Nashville Railroad (L&N), as a member of the joint-venture group supporting this study, was accorded the same analysis as the five selected railroads, thus providing a sample of six programs for analysis, as follows:

Louisville and Nashville Railroad	(L&N)
Southern Pacific Transportation Company	(SP)
Consolidated Rail Corporation	(Conrail)
Atchison, Topeka and Santa Fe Railway Company	(AT&SF)
Burlington Northern	(BN)
Canadian National Railways	(CN)

3.3 DATA COLLECTION PROCEDURES

3.3.1 Site Visits

A team including representatives of the BLE, the L&N, the FRA, and project personnel visited the training facilities of each of the six participating railroads. Activities of this Demonstration Project Team included:

a. Briefing. One purpose of the visits was to acquaint each participating railroad with the purposes of the project. Group discussions were held with the host principals, including both management and instructional staff members.

b. Observation. At each site, a tour of facilities was made to observe training support systems and the instructional process. Class sessions were observed unobtrusively; particular attention was directed to the integration of instructional resources in the instructional delivery system.

c. Interviews. Individual (one-on-one) interviews were held with training managers, instructors, and students to obtain candid opinions on the quality of the training program.

d. Review of Documentation. All documentation made available on the L.E.T. programs (guides, manuals, texts, tests, etc.) was scanned. Lists of pertinent documents desired for further analysis were generated.

3.3.2 Submission of Documentation

From the lists of desired documents prepared during the site visits, requests for loan of documents were sent to the participating railroads. Table 3-1, 2, 3, 4, 5 and 6 list the documents received from the participating railroads and analyzed.

3.4 CHARACTERISTICS OF SELECTED TRAINING PROGRAMS

Combining the selection process with the information gathered on site visits and the documents subsequently received and reviewed yielded a detailed picture of each participating railroad's training program for locomotive engineers. Highlights of these programs are summarized in the following paragraphs.

3.4.1 Louisville and Nashville Railroad

The L&N differs from the other railroads studied in two respects: first, classroom training of engineers is conducted at a number of different sites (decentralized) rather than at a central training location, and, second, the student is cycled between classroom training and OJT during the first phase, 9 weeks, of training. All L&N employees are eligible to apply for L.E.T. programs; preference is given to those with train service experience. A selection committee screens all applications, makes an initial selection of candidates, individually interviews those selected, then makes a final selection of those best qualified.

Training is conducted in two phases. The first phase (9 weeks) alternates between classroom and OJT in 2 to 4 day units. While learning rules, air brakes, and mechanical knowledge in class, the student is also developing increasingly complex skills. If the trainee passes a job knowledge test, the second phase of training is started. This phase is strictly OJT and is continued until the trainee is considered qualified by the Road Foreman of Engines on the basis of a 60 item checklist which is used to give the trainee a qualitative rating on knowledge of the function, location and operation of equipment controls.

Classroom training employs slides, films, rule books, manuals, and an air brake rack. A train dynamics analyzer is on hand in a mobile unit, but it is used mainly for recurrent training of locomotive engineers. Although the TDA is not programmed as an integral part of the basic L.E.T. schedule, trainees may use it when available. Trainees may total anywhere from two to ten hours of TDA experience. Instructors are selected according to attitude, personality, efficiency, performance and willingness.

3.4.2 Southern Pacific Transportation Company

The classroom L.E.T. program for the SP is conducted at its Engine Service Training Center, which features a full-scale, dynamic locomotive cab simulator.

Trainees are selected from qualified firemen*, who have already attended a six week firemen's school and met further qualification requirements, including at least 60 road trips.

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*The Southern Pacific uses the title "fireman" to imply "apprentice locomotive engineer". Thus the fireman's school prepares an employee for locomotive engineer training rather than to become "fireman".

If promoted to engineer trainee, the student spends 90 days studying rule books, manuals, and other instructional materials. After 45 days the engineer trainee must pass an exam to retain firemen seniority. After this preparation period, the trainee enters the Engine Service Training Center.

Center training is a 5 week course in classrooms and on the simulator. Slides, tapes, and films, are used as training aids. Simulator training consists of ten two hour operating sessions on a standardized series of simulated road trips, during which the trainee is exposed to a variety of train handling problems.

Graduation from the center requires passing written exams on rules, air brakes, and mechanical knowledge, plus a final check ride on the simulator. After leaving the center, the trainee undergoes 2 weeks of OJT on home territory under supervision of road foremen. During this two week period, the Road Foreman decides whether the trainee should be promoted to a Locomotive Engineer.

3.4.3 Consolidated Rail Corporation

All Conrail trainees are selected by seniority from the ranks of firemen*. The program consists of three (3) phases. The first phase is nine (9) weeks of classroom instruction and hands-on-experiences at a training center. Rules, air brakes and mechanical content are covered. A train dynamics analyzer may be used by trainees if it is available, but its use in basic L.E.T. is not scheduled. Written final exams are given in rules, air brakes and mechanical content. The final examination, given the ninth week, measures the trainee's operating skill. This test requires actual operation of the equipment (performance).

Phase 2 is instruction and OJT at the trainee's home division. The initial training covers physical characteristics of the area. A final exam is given. The second portion of OJT is actual over-the-road trips. A final qualifying trip is made under the supervision of a road foreman.

Phase 3 is home territory training. A final exam on the characteristics of the trainee's territory is then given. Successfully passing the test qualifies the trainee as an engineer.

3.4.4 Atchison, Topeka and Santa Fe Railway Company.

The Santa Fe operates a Locomotive Simulator Training Center that has, in addition to a full-scale, dynamic locomotive cab simulator, two air-brake demonstrators, air brake and mechanical component cut-aways, slides and other visual aids, and one large and two small classrooms. The Santa Fe program differs from the SP and CN in that it uses classroom instruction and the simulator to fine-tune trainees who have already had extensive OJT on locomotives. In contrast, the SP and CN introduce train handling on the simulator and follow it with OJT.

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*Conrail uses the title "fireman" to imply "apprentice locomotive engineer."

Applicants must have been railroad employees for at least a year, must be able to read and write, and must meet physical qualifications. Selection is determined by interview with a road foreman. Once accepted as an engineer trainee, the applicant's status becomes that of "locomotive fireman."

The 25-week program is in three phases. Phase I involves 18 weeks of OJT in the trainee's home territory under engineer supervision. Phase II combines classroom and simulator training for 6 weeks, covering operating rules, mechanical knowledge, and air brakes. There are weekly tests and a final exam. Each trainee operates the simulator for seven 2-hour sessions. The trainees are paired; one operates, one observes.

Phase III is a week of road trips in home territory, operating locomotives under supervision. At the end of the week, the supervisor may designate the trainee as a qualified locomotive engineer. One makeup test is permitted after Phase II and one after Phase III; if requirements are not completed, the trainee's employment in engine service is terminated.

3.4.5 Burlington Northern

Applicants for the L.E.T. program at the BN must be selected from the rosters of locomotive firemen. Each applicant is interviewed, and if judged qualified, is put on a candidate's list for the home region. As the need for additional engineers arises in a region, trainees are selected from the candidate list, subject to meeting physical qualifications.

Training is in four phases. First, pre-requisite training for 30 days is accomplished in the home region, consisting of orientation through supervised train rides and study of basic rules. A check-off list is used to determine readiness for classroom training.

The second phase is conducted at the BN Engineer Training Center, consisting of 3 weeks of instruction in air brakes, operating rules, and mechanical-electrical aspects of locomotives. Extensive use is made of an operative control stand, models and cut-aways of equipment, television, slides and films, as well as student guides, texts, and manuals. The BN Engineer Training Center has a TDA. L.E.T. trainees are encouraged to use the TDA during their free time, but formal instruction using the TDA is not scheduled. Written examinations are given for guidance rather than qualification.

The third phase of the BN L.E.T. program is OJT in the home region under supervison of engineer instructors. This training continues for three to four months, with periodic review classes.

The fourth phase is a 2 day final examination, successful completion of which, if approved by a qualifying officer, results in certification as a locomotive engineer.

3.4.6 Canadian National Railways

To apply for LET, a CN employee must have been a yardman or conductor for at least 32 months and must be qualified on the Uniform Code of Operating Rules. Applicants are screened for job performance, discipline, and attitude towards being a locomotive engineer and must pass standard tests on mechanical aptitude, abstract reasoning, and learning ability. Based on seniority and each region's demands, applicants are then selected for L.E.T. at the CN Rail Transportation Training Centre.

The Centre course lasts eight weeks, comprised of six weeks of technical training and two weeks of rules training, with alternate days of classroom and hands-on instruction. The technical training covers air brakes, motive power, track train dynamics, and simulated train operation. The Centre has working mockups, slides, television, manuals, rule books, and copies of regulations are also used as training aids. There are also four full-scale dynamic locomotive cab simulators. Students are scheduled for 20 hours of programmed train handling instruction and practice on the simulators. Students are evaluated by periodic multiple-choice tests and instructor observation.

After completion of the Centre course, students return to their home terminals for a period of OJT, under an assigned regular engineer and periodic observation by a supervisor. Supervisors are the final judge as to whether a trainee qualifies as an engineer or must be removed from the training program.

Centre instructor candidates are selected from trainmen, yardmen and locomotive engineers. Following an individual interview, each accepted candidate receives detailed training in instructional duties. Some instructors must be able to teach in both English and French.

TABLE 3-1 INSTRUCTIONAL AND REFERENCE MANUALS RECEIVED FROM THE LOUISVILLE AND NASHVILLE RAILROAD COMPANY

FREIGHT BRAKE EQUIPMENT WITH ABDW CONTROL VALVE
New York Air Brake

AB SINGLE CAPACITY FREIGHT CAR AIR BRAKE EQUIPMENT WITH ABD CONTROL VALVE
Westinghouse Air Brake

26 TYPE BRAKE EQUIPMENT FOR LOCOMOTIVES
Westinghouse Air Brake

24 RL LOCOMOTIVE BRAKE EQUIPMENT
Westinghouse Air Brake

DIESEL LOCOMOTIVE MANUAL-QUESTIONS & ANSWERS
Railway Fuel & Operating Officers Association

NEW SERIES DIESEL ELECTRIC LOCOMOTIVE MANUAL
General Electric

GP 38-2 OPERATORS MANUAL
EMD-General Motors

GP 40-2 OPERATORS MANUAL
EMD-General Motors

SD 40-2 OPERATORS MANUAL
EMD-General Motors

MANUAL OF SPECIAL RULES GOVERNING TRAIN HANDLING, AIR BRAKES, AND DYNAMIC BRAKES
L & N Railroad

RULES OF THE OPERATING DEPARTMENT
L & N Railroad

MANUAL OF SAFETY RULES
L & N Railroad

CONDENSED ROSTER OF LOCOMOTIVES
L & N and SCL Railroads

LOUISVILLE DIVISION TIMETABLE
L & N Railroad

EVANSVILLE DIVISION TIMETABLE
L & N Railroad

LOCOMOTIVE ENGINEER TRAINING PROGRAM MANUAL
L & N Railroad

TRAIN DYNAMICS ANALYZER OPERATORS MANUAL
Freightmaster

FORM 227 - EMPLOYEES EXAMINATION ON RULES OF THE OPERATING DEPARTMENT
L & N Railroad

TABLE 3-2 INSTRUCTIONAL AND REFERENCE MANUALS RECEIVED FROM THE SOUTHERN PACIFIC TRANSPORTATION COMPANY

ENGINE SERVICE TRAINING CENTER
Southern Pacific

TABLE 3-3 INSTRUCTIONAL AND REFERENCE MANUALS RECEIVED FROM THE CONSOLIDATED RAIL CORPORATION

POSITION LIGHT SIGNALS
Penn Central

RULES OF THE TRANSPORTATION DEPARTMENT
Conrail

NORTHERN REGION TIMETABLE
Conrail

HANDBRAKES
Penn Central

HAZARDOUS MATERIALS REGULATIONS
Conrail

THE ABC'S OF CAB SIGNALS
Conrail

DEFINITIONS THE RAIL WAY
Conrail

BRAKE AND TRAIN AIR SIGNAL INSTRUCTIONS
Conrail

COLOR LIGHT SIGNAL ASPECTS
Conrail

POSITION LIGHT SIGNAL ASPECTS
Conrail

LEARNING SIGNAL INDICATIONS
Conrail

THE ABC'S OF MANUAL BLOCK; YARD LIMITS AND SECONDARY TRACKS
Conrail

SAFETY RULES; TRAIN, LOCOMOTIVE AND OTHER TRANSPORTATION EMPLOYEES
Conrail

INSTRUCTIONS FOR COMPLETION OF TIME AND DELAY REPORT FOR ENGINE CREWS
Conrail

TABLE 3-3 INSTRUCTIONAL AND REFERENCE MANUALS RECEIVED FROM THE CONSOLIDATED RAIL CORPORATION (Cont'd)

ENGINEMAN TRAINING SCHOOL TRACK CHART CENTRAL REGION
Conrail

EMPLOYEE COUNSELING SERVICE
Conrail

THE RULES: WHAT HAPPENS WHEN THEY ARE NOT FOLLOWED
Conrail

NEW SERIES DIESEL-ELECTRIC LOCOMOTIVE
General Electric

GP40-2 OPERATORS MANUAL
EMD-General Motors

GP38-2 OPERATORS MANUAL
EMD-General Motors

THE MODERN LOCOMOTIVE HANDBOOK
Railway Fuel and Operating Officers Association

OPERATING RULES
Conrail

DIESEL ELECTRIC HANDOUTS; WORK EXERCISES; QUIZZES
Conrail

STUDENT CLASSROOM TESTS
Conrail

STUDENT FORMS AND CERTIFICATES
Conrail

MANAGEMENT OF TRAIN OPERATION AND TRAIN HANDLING
Air Brake Association

TABLE 3-4 INSTRUCTIONAL AND REFERENCE MANUALS RECEIVED FROM THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY

RULES OPERATING DEPARTMENT
Santa Fe Railroad

AIR BRAKE & TRAIN HANDLING RULES
Santa Fe Railroad

DIESEL ELECTRIC LOCOMOTIVES
Santa Fe Railroad

STUDY GUIDE FOR LOCOMOTIVE ENGINEMEN
Santa Fe Railroad

TABLE 3-4 INSTRUCTIONAL AND REFERENCE MANUALS RECEIVED FROM THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY (Cont'd)

STUDY GUIDE FOR PROMOTION TO LOCOMOTIVE ENGINEER
Santa Fe Railroad

YEARBOOK OF RAILROAD FACTS 1981 EDITION
Association of American Railroads

TABLE 3-5 INSTRUCTIONAL AND REFERENCE MANUALS RECEIVED FROM THE BURLINGTON NORTHERN

LOCOMOTIVE ENGINEER INSTRUCTORS GUIDE
BN Railroad

LOCOMOTIVE ENGINEERS TRAINING PROGRAM
BN Railroad

LOCOMOTIVE ENGINEERS TRAINING PROGRAM TRAINEE'S GUIDE
BN Railroad

MECHANICAL AND ELECTRICAL
BN Railroad

ENGINEER TRAINING AIDS
BN Railroad

LOCOMOTIVE ENGINEERS TRAINING PROGRAM MECHANICAL TRAINING AIDS
BN Railroad

LOCOMOTIVE ENGINEERS TRAINING PROGRAM TRAIN HANDLING AIDS
BN Railroad

TABLE 3-6 INSTRUCTIONAL AND REFERENCE MANUALS RECEIVED FROM THE CANADIAN NATIONAL RAILWAYS

ENGINE SERVICE TRAINING-AIR BRAKES
Volume 1-Instructor's Lesson Plan Books 1 to 6
CN Railways

ENGINE SERVICE TRAINING
AIR BRAKES-Volume 1-Instructor's Lesson Plan Books 7 to 12
CN Railways

ENGINE SERVICE TRAINING-AIR BRAKES
Volume 1-Locomotive Engineer Lesson Plan Book
CN Railways

ENGINE SERVICE TRAINING-AIR BRAKES
Volume 2-Students Tests 1 to 8
MT-AB-MP-TH Final, AB-MD-TH
CN Railways

TABLE 3-6 INSTRUCTIONAL AND REFERENCE MANUALS RECEIVED FROM THE CANADIAN NATIONAL RAILWAYS (CONT'D)

ENGINE SERVICE TRAINING
Engine Service Training Mod 1 to 13
CN Railways

REVIEW QUESTIONS-CN 48-01-057
CN Railways

LOCOMOTIVE ENGINEER MANUAL
CN Railways

STUDENT MOCK-UP WORK BOOK
CN Railways

INSTRUCTOR'S MOCK-UP BOOK
CN Railways

STEAM GENERATOR EQUIPMENT
CN Railways

STUDENT WORK BOOK - MODS 1 to 8
CN Railways

TRAINING CENTRE STUDY MATERIAL
CN Railways

BASIC TRAIN HANDLING GUIDELINES
CN Railways

MOTIVE POWER MANUAL
CN Railways

AIR BRAKE MANUAL
CN Railways

INSTRUCTIONS ON THE USE OF CN RADIO
CN Railways

FUEL CONSERVATION IN TRAIN AND YARD OPERATIONS
CN Railways

CANADIAN NATIONAL SAFETY RULES
CN Railways

REGULATIONS FOR THE PROTECTION OF TRACK UNITS AND MAINTENANCE WORK
CN Railways

OPERATING MANUAL FOR LOCOMOTIVE ENGINEERS
CN Railways

STUDENT CLASSROOM TESTS
CN Railways

4. JOB TASK INVENTORY

4.1 INTRODUCTION

As noted above (Section 1.2), the analysis step in determining training requirements may yield a comprehensive listing of the items of knowledge and skill necessary for the safe and effective performance of the job of locomotive engineer. Development of such an inventory was specified as a project objective to provide a common reference among the L.E.T. programs studied. As such, it would aid in identifying commonalities and differences among these programs. The inventory would also serve as a basis for developing the core modules of the model training programs.

4.2 INITIAL INVENTORY EFFORTS

4.2.1 General Description of the Locomotive Engineer's Job

The following general description (exerpted from the Hale and Jacobs Study) of the locomotive engineer's job is given to provide a context for appreciating the contributions of the individual tasks.

> "The railroad engineer is the individual in immediate, direct control of the motion of a train. He is responsible for obeying all directions and signals, and controlling train movements (stopping, starting, backing, etc.) and speed between stops; beyond this, he must always exercise discretion, care and vigilance in moving the train so as to prevent injury or damage.
>
> In carrying out his duties, several basic functional capacities clearly must be within the repertoire of the engineer. He must have perceptual/motor coordination. This is the ability to perceive information which affects the safe control of the train and to integrate this information into the smooth, effective and safe control of the train via the brake and power systems. Control information comes from the entire visual surround (outside information, and information from the dials and gauges within the cab) auditory cues and vestibular cues produced by train motion.
>
> This information must be processed in a timely manner to account for the substantial control lag and great inertial forces of a modern freight train (150 or more cars in length, possibly 15,000 tons in weight). The engineer must have the ability to take control actions (throttle, brake) sufficiently in advance of such territorial features as curves, grades, grade crests, etc. so as to safely control the train at all times. He should possess a sound capability for clear and concise oral communication, via the train radio, with the dispatcher and the train crew.

Long term memory for railroad operating rules, the layout of controls and displays in locomotives to be operated, and the physical features of the operating territory is also needed. Short term memory for weather advisories, changes in the load consist, train orders received enroute, etc. is also required.

The engineer must possess observational skills required to conduct the inspections of the cab, engine room, and exterior of the locomotive and to promptly detect malfunctions and breakdowns within the locomotive consist.

Foremost among his many talents, the engineer must demonstrate vigilance or the capacity to be attentive to all critical, information inputs throughout a several hour trip within a relatively confined workspace (the locomotive cab)."*

4.2.2 The Preliminary Inventory

A preliminary inventory of tasks comprising the job of a diesel-electric locomotive engineer in local and road freight operations was derived from reports obtained in the literature survey (Section 2). Three efforts were identified, each of which resulted in at least one published list of engineer tasks. Historically,each of these three efforts built upon the preceding work.

Incidental to the development of the Southern Pacific's locomotive cab simulator, the McDonnell Douglas Corporation compiled an inventory of engineer tasks to be taught with the simulator. In 1972, the Federal Railroad Administration (FRA) commissioned McDonnell Douglas to organize and categorize these tasks in a format that could be used as a basis for study of regulatory needs under the Federal Railroad Safety Act of 1970. The results of this effort were published as a technical report.**

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* Hale, A., Jacobs, H.H, Proposed Qualification Requirements For Selected Railroad Jobs, Dunlap and Associates, Report No.FRA-OR&D-75-44, May 1975

** McDonnell Douglas Corporation., Railroad Engineman Task and Skill Study, Department of Transportation, Federal Railroad Adiministration, Report No. FRA-OPP-'#-2, August 1972

The FRA later contracted with Dunlap and Associates, Inc., to integrate additional material with the McDonnell Douglas list and produce a set of minimum knowledge and skill requirements commensurate with safe train operation along with estimates of the minimum amount of training needed to achieve these requirements. The results of this effort were published in a report, authored by Hale and Jacobs.*

In support of initiatives being advanced by the Brotherhood of Locomotive Engineers (BLE), BLE experts used the aforementioned task inventories to develop and adopt a set of minimum skill and performance requirements for locomotive engineers. These requirements were published in full in a study by Sterling Systems Incorporated.**

4.2.3 The Revised Preliminary Inventory

The preliminary job task inventory was submitted to the Project Steering Committee for review. The modifications to the list provided by this review constituted still one more refinement and improvement of the inventory.

4.3 ANALYSIS OF TASKS IN SELECTED TRAINING PROGRAMS

4.3.1 Purpose of the Analysis

It was hoped that by matching the training objectives provided by the participating railroads with the revised preliminary job task inventory, certain useful information would be derived. First, subsets of tasks were expected to be identified which appeared in all the selected programs. These groups of tasks (called "commonalities"), would constitute core modules for the model training program. Second, those tasks unique to a particular railroad (or a few railroads)--the "differences"--could be organized into optional modules in the model program, for use by those needing them. Third, it was hoped that new tasks might be uncovered that could lead to additional core or optional modules in the model program.

4.3.2 Results of the Analysis

The aims of the task inventory analysis proved to be too optimistic. Railroad training programs have been developed almost completely without the aid of the techniques and theories associated with system-oriented training development.

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* Hale and Jacobs op. cit.

** Sterling Systems Incorporated, <u>Locomotive Engineer Training Program Requirements, and Cost-Benefit Analysis</u>, Brotherhood of Locomotive Engineers, April 14, 1978

Therefore, the curriculum sought in the training material submitted by the participating railroads simply did not exist. In particular, "training objectives" were not available for direct comparison with the items in the job task inventory.

This however did not prevent the analysis of the training programs, but it did change the nature of the analysis. The presence of a task item in a training program now had to be inferred from the materials available. Therefore, if a task item was addressed by course outlines, lesson plans, instructor guides, tests, student guides, handouts, or workbooks, it was recorded as being a part of that training program. It should be emphasized that absence of a task item in a program as analyzed in no way implies that that item is not covered in the training. It simply means that its presence could not be inferred directly from the materials provided.

Tables 4.1 and 4.2 summarize the results of this analysis. Each table is basically a portion of the revised preliminary job task inventory. Table 4.1 lists the job knowledge items of the inventory. When a number appears to the right of an item, it refers to the number of railroads training programs (of the participating six railroads) in which evidence of training on that item could be inferred. Table 4.2 constitutes the job performance items of the inventory. Again, the numbers show the number of programs judged to cover that item, with the addition of a letter to indicate the training method used, as follows: D - indicates use of a demonstrator/mock-up, O - indicates on-the-job training, T - indicates use of a train dynamics analyzer, and S - indicates training on a "full-task" locomotive train simulator.

4.3.3 Discussion of Results

a. Numerical Data. The sparsity of entries under "Number of Programs" in Tables 4-1 and 4-2 has several explanations. First, because all railroads in the sample draw their trainee candidates from the railroad's employees, all trainees start the engineer program after having received basic training in railroad organization and operating and safety rules. Thus such items may not appear in the documentation of engineer training programs. Second, the documented descriptions of training programs often are at a more general level of organization than the detailed job task items; so numerous task items may have been implied under a single heading in the documents but could not be recorded for tabulation. Third, the documents supplied for analysis may not have represented all of a given railroad's training documentation, because of either a misunderstanding of the project's proposed analytical procedures or a reluctance to release proprietary material. Review of the documents listed in Tables 3-1 through 3-6 suggests that this may be the case.

Still another reason both for overall sparsity of data and for an imbalance of data between Tables 4.1 and 4.2 is the fact that the documentation received was primarily on classroom training, thus more likely to yield data for knowledge items than performance items. Even though models, train dynamic analyzers, and simulators permit some performance training in the classroom, much of the development of performance skills still occurs during hands-on experiences in OJT.

Because of these reasons, the lack of a number to the right of any item in Tables 4-1 and 4-2 in no way implies that the item is not taught in the six L.E.T. programs. In fact, the observations of training in progress and the interviews with instructors and trainees provided ample undocumented evidence that most, if not all, of the items in the job task inventories are addressed in at least some of the training programs sampled.

b. Commonalities and Differences. The differences among the participating railroads training programs in addressing the various items in the job task inventory are more a matter of content than intent. That is, the difference between two railroad's programs for training in knowledge of operating rules is not due to any difference in educational philosophy, but rather to the fact that the rules themselves are different. Each railroad has its own rules, perhaps patterned after the AAR "Standard Code of Operating Rules", but unique in content because of the unique complex of regulations, organization, geography and climate that determine how an individual railroad must operate.

Similarly, if two L.E.T. programs differ in their emphasis on a performance task item; the difference is most likely to reflect a difference in the railroads' operational requirements rather than in educational theory. For example, a railroad operating in northern climates simply must devote more training resources to cold weather operations than one operating in a more temperate climate.

It is concluded, then, that observed commonalities are at a general level, differences at a more specific level. All of the railroads surveyed addressed most all of the job tasks in the inventory. The way that they addressed these tasks, necessarily differed because of different operating conditions.

This conclusion suggests that a model training program must use a "concept" approach to its modular structure, concentrating on the why and what. The details of when and how must be addressed by the individual railroads.

c. Adequacy of Job Task Inventory. Comparing the results of this analysis with information in the literature, particularly the NTSB study*, gives us confidence in concluding that the revised preliminary job task inventory covers most if not all of the tasks that should be addressed in creating a model training program and should be so used.

d. Further Analysis. The job task analysis is only the first step in the proposed analyses of training programs. Appendix A and Section 5 describe the procedures and findings of additional analyses.

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* U.S. National Transportation Safety Board, Results of a Survey On Occupational Training in the Railroad Industry, Report No. SIR-79-1.

TABLE 4-1 MINIMUM KNOWLEDGE REQUIREMENT TOPICS

	Number of Programs
A. Railroad Organization	
1. Functions performed by various departments	
a. Safety	
b. Signal and Communication	
c. Mechanical	
d. Engineering	
e. Maintenance of Way	
f. Car Department	
g. Bridge and Building	
h. Police and Fire	
i. Transportation	
2. Duties and authority of key operational personnel	
a. Division Engineer	
b. Master Mechanic	
c. Trainmaster	
d. Road Foreman	
e. Engineer	
f. Pilot	
g. Fireman	
h. Brakeman (front, rear)	
i. Conductor	
j. Train Dispatcher	
k. Tower Operator and Train Order Operator	
l. Car Inspector	
m. Crew Dispatcher	
n. Yard Master and Agent	
B. Equipment and Facilities	
1. Locomotives	
a. Locomotive types; horsepower or tonnage ratings	6
b. Diesel-electric power generating equipment	
1. Function, location, interrelationships and general requirements for safe operation of major components, i.e., engine, generator and traction motors.	6

TABLE 4-1 MINIMUM KNOWLEDGE REQUIREMENT TOPICS (CONT'D)

Topic	Number of Programs
2. Function and location of the operating controls and displays for the power and electrical control systems (e.g., selector lever, reverse lever, throttle lever, load current meter, speedometer, wheel slip indicator) for each type of locomotive to be operated.	6
3. Function and location of auxiliary controls and displays (i.e., indicators, switches, circuit breakers and fuses on engine control and circuit breaker panels) for each type of locomotive to be operated.	6
4. Concepts of operation; Multi-unit operation, causes and effects of engine overspeed, generator and traction motor overload.	6
c. Braking equipment	
1. Air brakes	
a. Function, location, interrelationships and general requirements of safe operation of major components, i.e., air compressor, main and equalizing reservoirs, brake valves, brake cylinders, rigging and shoes.	6
b. Function and location of the operating controls and displays for the air brakes (e.g., automatic brake lever, independent brake lever, main and equalizing reservoir pressure gauges, brake pipe and cylinder gauges, brake pipe flow indicator) for each type of locomotive to be operated	6
c. Concepts of operation	
* Requirements for charging and maintaining air pressure	6
* Causes of overcharged and undercharged brakes; procedures for correction	6

TABLE 4-1 MINIMUM KNOWLEDGE REQUIREMENT TOPICS (CONT'D)

Topic	Number of Programs
* Effects of train length and ambient temperature on brake application and release time; brake pipe gradient	6
* Causes and prevention of penalty brake applications	6
* Causes and prevention of unintentional brake releases	6
* Conditions for which independent brakes are recommended and not recommended	6
* Conditions for which automatic brakes are recommended and not recommended	6
2. Dynamic brake	
a. Function, location, interrelationships and requirements for safe operation of major components, i.e., generators, traction motors, cooling grids.	6
b. Function and location of the operating controls and displays (e.g., control lever, load current meter) for each type of locomotive to be operated	6
c. Concepts of operation.	
* Conditions under which the dynamic brake is available and useful	6
* Conditions under which the dynamic brake is not recommended	6
* Advantages and disadvantages of using the dynamic brake in conjunction with air brakes; interlock with air brakes	6
* Limitations on use of the dynamic brake, e.g., maximum permitted application time at certain voltages, use over extended distances	6

TABLE 4-1 MINIMUM KNOWLEDGE REQUIREMENT TOPICS (CONT'D)

Topic	Number of Programs
3. Handbrakes	
a. Location and operation of various types of handbrakes in service.	6
b. Situations requiring operation of handbrakes and blocking of wheels	6
d. Sanding equipment	
1. Function, location and requirements for safe operation of major components for manual and automatic sanding systems.	6
2. Concepts of operation	
* Situations requiring automatic or manual sanding * Benefits of and precautions for sanding	6
e. Safety and communications equipment	
1. Function, location, and operation of all such equipment, to include safety control pedal, emergency brake valve, automatic train stop, automatic train control, overspeed control, train radio auditory signals (e.g., whistles, bells, horns), flares, fusees, torpedoes.	6
2. Situations requiring use of safety and communications equipment	6
2. Cars	
a. Types of cars	1
b. Function, location, and requirements for safe operation of couplers and draft gears, air brake components, (i.e., reservoirs, brake valves, brake pipe, and connectors, brake cylinders, rigging and shoes, retainers and caboose valve), and handbrakes.	6
c. Concepts of operation	
1. Performance characteristics of loaded versus unloaded cars	6

TABLE 4-1 MINIMUM KNOWLEDGE REQUIREMENT TOPICS (CONT'D)

Topic	Number of Programs
2. Requirements for handling special cars or hazardous materials	6
3. Performance characteristics of friction and roller bearings	
4. Potential for thermal cracking of wheels due to excessive braking	1
3. Trackage and associated equipment	
a. Common types of trackage, e.g., main, siding, single and multiple	1
b. Functions of trackage associated equipment, i.e., towers, switches, derails and component parts, detectors and transmitters for information on overheated journals and train speed.	
4. Terminals, yards, enginehouses, turntables	
a. Function	1
b. Requirements for safe operation within or near these facilities	6
5. Signals	
a. Aspects, indications, and typical locations of various types of wayside signals and cab signals	6
b. Meanings of hand, flag, and lamp signals	6
c. Types and meanings of horn/whistle signals	6
6. Train Control Systems	
a. General design and operational features of the train control system(s) in service e.g., train order, manual and automatic block systems, automatic cab signals, centralized traffic control (CTC)/traffic control system(TCS), and verbal train control.	6
b. Territory where each system is in operation, if more than one is employed	

TABLE 4-1 MINIMUM KNOWLEDGE REQUIREMENT TOPICS (CONT'D)

	Number of Programs
C. Physical Characteristics of the Road	
1. Location of significant terrain features, such as ascending and descending grades, curves, undulating territory, bridges, tunnels, and potential hazards (e.g., slides, washouts, vandalism).	1
2. Location of various railroad equipment and landmarks, such as stations, yards, interlockings, sidings, crossovers, track crossings, highway grade crossings, and emergency telephones.	1
D. Rules and Regulations	
1. Operating rules and instructions covering topics such as:	
* General rules	6
* Signals and their use	6
* Movement of trains and engines	6
* Superiority of trains	6
* Movement by train order	6
* Movement by manual and automatic block signals	6
* Movement by automatic cab signals	6
* Movement by CTC/TCS	6
* Movement by verbal train control	6
* Equipment operation, e.g., air brakes, dynamic brake, telephone, etc.	6
* Train handling	6
* Safety	6
2. Timetable and special instructions	6
3. Work rules and hours of service regulations	6
4. Power brake law	6
5. Special and bulletin notices	6
6. Radio operation rules	6
7. Federal regulations governing locomotive inspection, safety appliances and handling of hazardous materials.	6

TABLE 4-1 MINIMUM KNOWLEDGE REQUIREMENT TOPICS (CONT'D)

	Number of Programs
E. Operational Procedures	
1. Trip preparation	
a. Required trip information, i.e., train orders, timetable and rules, special notices, official railroad time, and load consist information (e.g., location of heavies, empties, high/wide loads, hazardous cargo, train length).	6
b. Procedures for communicating with yard personnel and crew members prior to movement.	6
c. Procedures for performing inspections of locomotive consist, i.e., exterior from ground, engine room(s), lead unit cab, trailing unit cab(s).	6
2. Initial movement	
a. Required conditions prior to starting the locomotive engine.	6
b. Starting the locomotive engine.	6
c. Post-start inspections	6
d. Accelerating, running, stopping, and backing	6
e. Forming locomotive consist and changing operating ends, to include lead or trail setup requirements, air brake application and leakage tests.	6
f. Coupling the locomotives to cars, verification of coupling and air brake test	6
3. Over-the-road operations	
a. Basic handling	

TABLE 4-1 MINIMUM KNOWLEDGE REQUIREMENT TOPICS (CONT'D)

		Number of Programs
1.	Factors affecting the use of power and braking	
a.	Train and track considerations affecting tractive and braking forces, i.e., friction (rolling resistance, wind resistance, rail adhesion, wheel-shoe resistance, track curvature and alignment), grade, type and location of locomotive consists; train length, speed, weight and weight distribution.	6
b.	Environmental considerations, i.e., moisture, snow, and visibility restrictions.	1
c.	Time and distanct considerations, i.e., required stopping distances for various grades, curves, and train lengths and weights.	6
d.	Handling considerations which affect the development of lateral and vertical forces which may cause wheel lift, rail spread, roll over and possible derailment.	6

TABLE 4-1 MINIMUM KNOWLEDGE REQUIREMENT TOPICS (CONT'D)

	Number of Programs
2. Slack control	
a. Conditions which promote slack development and its location within the train.	6
b. Procedures for controlling slack, i.e., bunching and stretching	6
c. Consequences of ineffective slack control, i.e., run-in, drawbar pull	6
b. Intermediate handling	
1. Grade and curve territories	
a. Procedures for negotiating, stopping and restarting trains on:	
* Level territory with curves	6
* Straight territory with light (less than 1.5%) and heavy (more than 1.5%) ascending grade(s)	6
* Straight territory with light and heavy descending grade(s)	6
* Light and heavy, ascending and descending grades with curves	6
* Cresting grades	6
* Undulating territory	6
* Sag or dip territory	6
* Hump, knoll or hogback territory	6
b. Procedures for controlling train by such methods as cycle braking (where permitted), dynamic braking coupled with automatic braking, throttle modulation, and retainers (when required).	6
c. Precautions for avoiding wheel slip, wheel slide, traction motor commutator stall burns, flashover, and excessive drawbar forces.	6

	Number of Programs
d. Effects of certain actions on grades and curves, e.g., stopping on a cresting grade: speed changes within, near the beginning or end of curves, excessive use of throttle or brakes on curves, dynamic braking on crossovers, turnouts and heavy curves.	6
2. Power assistance	
a. Remote control equipment (RCE)	
* Available modes of operation and associated advantages and precautions	2
* Procedures for setting up and checking out RCE configuration	2
* Procedures for combined power and braking operations	2
b. Pusher and helper equipment	
* Situations requiring pusher and helper assistance	6
* Procedures and precautions for operating with, or as a pusher or helper	6
3. Braking assistance	
a. Procedures for setting up and checking out the repeater relay system	1
b. Procedures for operating with the repeater relay system	1
c. Special handling	
1. Procedures following loss of the dynamic brake	6
2. Procedures after emergency brake application	6
3. Procedures after unintentional brake release	6
4. Procedures after break-in-two	6
5. Procedures after derailment	6

Topic	Number of Programs
6. Procedures for correcting and/or reporting operating difficulties, e.g., engine malfunction and shutdown, excessive air pressure leakage, overcharged brakes, broken brake pipe, sticking brakes, sanding malfunction or failure, traction motor malfunction or failure, overheated journal bearing, open ground relay, low oil or water pressure, high coolant temperature, low main reservoir pressure.	6
d. Communications	
1. Techniques for providing clear and concise oral and written communications.	6
2. Procedures for operating train radio in communications to and from the dispatcher, outside crew, and caboose.	6
3. Procedures for telephone communication	6
4. Forms of train orders	6
5. Requirements for completion of work order or defect report.	6
4. Trip completion	
a. Requirements for securing (engine running) and shutting down the power consist.	6
b. Procedures for completing and filing operational and maintenance reports.	6
F. Effective Job Performance	
1. Factors affecting engineer performance	
a. General fitness requirements	6
b. Major sources of performance decrements, i.e., attitude, distraction, fatigue and physical impairments (i.e., alcohol, drugs, injury, disease and sensory or motor impairment).	6

TABLE 4-1 MINIMUM KNOWLEDGE REQUIREMENT TOPICS (CONT'D)

	Number of Programs
2. Injury avoidance	
a. Types and locations of potential hazards and injuries, i.e., electrical, thermal, chemical, acoustical, and physical force (e.g., being struck, falling).	6
b. Precautions when moving on or about tracks, getting on or off locomotives and cars, inspecting or maintaining the locomotive, operating handbrakes, using tools or appliances, working near rotating equipment and working near high voltage equipment.	6
G. Railroad Terminology Required for Reliable Communication	
1. Standard railroad terms	
2. Local railroad terms	

TABLE 4-2 MINIMUM PERFORMANCE REQUIREMENT TOPICS

	Number of Programs*
A. Trip Preparation	
1. Registering	
a. Register on duty	
b. Pre-plan mission	
c. Preparation of paperwork	
d. Verify time piece	
e. Report to receive consist	
2. Perform locomotive inspections	
a. Walk-around inspection	
b. Lead unit cab inspection	1-O
c. Trailing unit cab inspection	1-O
d. Engine room inspection	1-O
B. Starting and Initial Movement	
1. Start the engine	
a. Engine starting sequence	3-O,T,S
b. Lube oil and cooling level check	
2. Post-start inspection	
a. Engine room inspection	
b. Lead cab inspection	
3. Preparation for initial movement of locomotive	
a. Place unit on line	2-T,S
b. Preparation for initial movement	2-T,S
c. Initial movement	2-T,S
4. Forming the consist	1-O
a. Couple the locomotive to the cars and verify the coupling	
b. Pumping up air	3-D,T,S
c. Brake pipe leak test	3-D,T,S

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* D - indicates use of demonstrator/mock-up
O - indicates on-the-job training
T - indicates use of a train dynamics analyzer
S - indicates use of a "full-task" locomotive-train simulator

TABLE 4-2 MINIMUM PERFORMANCE REQUIREMENT TOPICS (CONT'D)

	Number of Programs
5. Obtain a departure clearance	
a. Starting the train	2-T,S
b. Initial control positions	2-T,S
c. Releasing air brakes	2-T,S
6. Start movement	
a. Observation of load current	2-T,S
b. Train velocity determination at slow speeds	2-T,S
c. Confirmation of caboose movement	
d. Operation of auxiliary equipment	
e. Under special situations (descending grade)	2-T,S
f. Under special situations (ascending grade)	2-T,S
7. Move the train through the yard to the designated main track.	1-S
C. Over-the-Road Operations	1-0
1. Basic handling tasks	
a. Accelerating	2-T,S
b. Decelerating	2-T,S
c. Automatic braking	3-D,T,S
d. Independent braking	3-D,T,S
e. Braking with power	2-T,S
f. Dynamic braking	2-T,S
g. Backing up	
1. Brake control from locomotive	
2. Brake control from rear end car	
h. Sanding	1-T

TABLE 4-2 MINIMUM PERFORMANCE REQUIREMEMT TOPICS (CONT'D)

	Number of Programs
2. Intermediate handling tasks	1-0
a. Speed and slack control	2-T,S
1. Control the throttle and brakes so as to avoid wheel slip and wheel slide.	
2. Control slack within the train avoiding excessive buff action and coupler or draft gear strain.	2-T,S
3. Knowledge of train consist and territory	2-T,S
4. Automatic braking	3-D,T,S
5. Dynamic brake mode	2-T,S
6. Power reapplication	
7. Maintain schedule	
8. Response to signal aspects	1-S
9. Undulating territory operation	1-S
b. Approaching crossing	
c. Entering and leaving siding	
d. Pickup and set off cars	
e. Negotiating turnouts and crossovers	
f. Passing equipment adjacent to tracks	
g. Passing train adjacent to track	
h. Receiving wayside messages	
i. Power assistance	
1. For operations involving remote control equipment (RCE), perform the following activities:	
a. Set up and check out the configuration prior to use.	1-S
b. Employ brake and power functions.	1-S
c. Switch between independent unit, and multiple.	
2. Operate with a pusher or helper unit	
3. Operate as a pusher or helper unit	
j. Maintenance requirements	

TABLE 4-2 MINIMUM PERFORMANCE REQUIREMENT TOPICS (CONT'D)

	Number of Programs
3. Special Handling and Operating Difficulties	
a. Respond to obstructions on tracks	
b. Respond to torpedoes and fusees	
c. Respond to temporary restrictions and slow boards	
d. Respond to improper signals	
e. Respond to degraded dynamic braking	
f. Respond to degraded traction motor operation	
g. Respond to diesel engine defects	
h. Respond to no throttle response	
i. Respond to engine shutdown	
j. Respond to loss of sand	
k. Respond to battery discharge	
l. Respond to alarm bell	
m. Respond to locomotive overspeed	
n. Respond to brake warning	
o. Respond to wheel slip	
p. Respond to open PCS	
q. Respond to automatic train control warning	
r. Respond to safety control devices	
s. Respond to emergency braking	
t. Correcting derail condition	
u. Replacing broken knuckle	
v. Setting out damaged cars	
w. Respond to known locomotive defects	
x. Respond to natural hazards	
y. Respond to hot journal bearings	
z. Respond to low oil or water pressure	
aa. Respond to high cooling temperature	
ab. Respond to low main reservoir pressure	
ac. Respond to no power	
ad. Respond to high voltage ground	
ae. Respond to excitation limit	

TABLE 4-2 MINIMUM PERFORMANCE REQUIREMENT TOPICS (CONT'D)

Number of Programs

4. Communications

   a. Employ the train radio in communications from the locomotive to dispatcher, and the locomotive to the caboose or outside crew.
   b. Execute a work order defect report.

D. Yard and Transfer Operations

1. Operate and control the locomotive with or without cars in various types of yard operations, including but not limited to the following:

   a. Hump receiving yards
   b. Classification yards
   c. Flat general switching yards
   d. Car repair and storage yards
   e. Passenger train yards
   f. Industrial yards
   g. Live stock yards
   h. Transfer or interchange yard

2. Start cuts of cars when either bunched or stretched.
3. Hump or shove cars in hump yard operations in accordance with signal indications, including instructions via the radio, and controlling the speed for the hump operations as required.
4. Kick and drop cars in flat switching operations.
5. Pick up, set out and spot cars on industrial, shop and repair tracks.
6. Couple-up and double cuts of cars to various tracks to make up road trains.
7. Switch passenger cars with and without passengers.
8. Handle work trains and wrecker equipment.
9. Identify, understand and comply with hand signals given, both day and nighttime, such as:

   a. Normal and emergency stops
   b. Back up and back away
   c. Go ahead or proceed
   d. Kick cars, slow or fast

TABLE 4-2 MINIMUM PERFORMANCE REQUIREMENT TOPICS (CONT'D)

	Number of Programs
e. Drop kicks	
f. Cut off	
g. Apply air brakes	
h. Release air brakes	
i. Track number	
j. Clearance	
k. Easy and slow	
l. Car length signs for identifying distance between cars.	
10. Identify, understand and comply with other signal systems such as:	
a. Hump yard	
b. Interlocking plant	
c. Centralized train control	
d. Automatic block	
e. Manual block	
11. Handle placarded and other cars of hazardous materials, such as explosives, poisons, liquidified gases and molten metal, safely and in accordance with all regulations, including Federal regulations.	
12. Execute a work report, defect report when applicable.	
E. Trip Completion	
1. Move the train from the main track or the yard, through the yard, to the designated track	
2. Stop the train at the appropriate destination and secure the locomotive consist; shut down the consist, if appropriate.	
3. File any required operational and maintenance reports with proper authorities.	
F. Auxiliary Equipment Operating Tasks	
1. Operation of air horn	1-S
2. Operation of train bell	1-S
3. Operation of radio/telephone	1-S
4. Use of windshield wipers and/or defogger	
5. Use of locomotive cab heater	
6. Use of light controls	
7. Use of attendant call button	
8. Use of fire extinguisher	
9. Use of RMU equipment	
10. Use of retainers	

5. ANALYSIS OF THE DESIGN OF L.E.T. PROGRAMS

5.1 PURPOSE AND APPROACH

One of the goals of the project was to identify effective training practices, techniques and methods currently being used by the railroads. To do this, a systematic method for analyzing the elements of the cooperating railroads' programs was required. Also, based on this analysis, possible improvement in the L&N railroad's existing L.E.T. program would be recommended. The ASTD Checklist for Technical, Skills and Other Training, identified during the literature survey, was selected as meeting the requirements of this project. Using the checklist, the various elements of the cooperating railroads' training programs could be analyzed for possible inclusion in a recommended model program. This checklist is included in its entirety as Appendix A of this report (separately bound). Information gathered during the visits to the cooperating railroads and the formal program documentation they provided formed the data base for this analysis.

The following results are presented in keeping with the order outlined in Appendix A.

5.2 PHILOSOPHY AND GOALS

5.2.1 Functions

The philosophy of the training unit is a set of fundamental beliefs about training. The goals of the training unit are the general objectives of the training. Statements of philosophy and goals serve as a set of standards for the development of training.

5.2.2 Philosophy and goals statements

Although formal published statements of L.E.T. program philosophy and goals were not a part of the documentation provided by the cooperating railroads, it is evident that there is a committment to training and is an integral part of the operations of the railroads visited.

A model training program must describe, in general terms, the level of committment to training that philosophy and goals statements should address. The actual philosophy and goals of an individual L.E.T. program, however, must be developed by each railroad.

5.3 MANAGEMENT

5.3.1 Functions

The ASTD definition of training management (See Appendix A) specifies planning, organization, staffing, directing and controlling as important functions. The management staffs of the six participating railroads clearly performed these functions, although the documentation provided did not spell out the details of some of these activities.

5.3.2 Management Structures

The ability to perform training management functions effectively is dependent on the placement of training within the total management structure of the railroad. The six participating railroads were exceptionally similar in this respect.

In five of the six railroads, the responsibility and authority for managing the formal locomotive engineer classroom training program is vested in a full-time person designated "Training Manager" or an equivalent title. In the sixth railroad, managing training is a duty of the General Road Foreman of Engines. Three of the training managers report directly to managers at a department level and three to departmental Assistant Vice Presidents. The departments overseeing locomotive engineer training show a little more variance, with the Personnel Department being responsible in three railroads, the Transportation/Operating Department in two, and the Mechanical Department in one.

The training staffs supporting the Training Manager are at two levels--Supervisor and Instructor--in five of the six railroads. In the sixth railroad, instructors report directly to the General Road Foreman of Engines.

In five of the six participating railroads, OJT was the responsibility of the Road Foreman of Engines within the trainee's home territory or divisions. Management of OJT was independent of the manager and staff conducting the classroom training. In the sixth railroad, both classroom training and OJT were managed by the General Road Foreman of Engines.

It cannot be determined whether the level at which engineer training is located in the management structure is or is not the most effective level. The similarities observed, however, indicate that in these six railroads there is consistency in attitude and dedication to the training of engineers.

5.3.3 Training Support

The logical source of support data is the training budget. However, because of differences in accounting procedures and the reluctance of management to release confidential business data, we were unable to develop a cost comparison for the six participating railroads.

One railroad reported an annual budget of 3 million dollars to operate its formal training center, but the center trains other crafts in addition to locomotive engineer. Another railroad spends 18 thousand dollars per trainee (including trainee salaries) at its center. Since they have processed about 1600 trainees in a ten-year period, we can infer an average annual expenditure of 2.88 million dollars over that period. A third railroad has ranged from 139 to 318 trainees per year over a nine-year period, with a mean value of 190 trainees per year, at a current average cost of over 15 thousand dollars per trainee (not including trainee salaries), thus averaging over 2.85 million dollars per year.

Although these figures are based on different accounting methods and are not directly comparable, they demonstrate a substantial budgetary commitment to locomotive engineer training.

In general, specific training budgets provide for the classroom phases of training, including maintenance and improvement of facilities, salaries of staff, and subsistence for trainees. In all six railroads surveyed, trainee salaries were paid by the home division.

Another indicator of the level of a railroad's commitment to training is the amount of time (including unstructured OJT time but not including prerequisite/preparatory time) allocated for training. Among the six railroads surveyed, training for locomotive engineers ranges from 600 to over 1100 hours, with a mean of 850 to 900 hours.

A definite mean could not be established, because some programs call for an indefinite period of OJT for final qualification. Classroom (including simulator) time ranges from 120 to 440 hours, with a mean of about 280 hours. OJT training time ranges from 240 to 900 hours, averaging in the range of 590 to 644 hours. Thus there is roughly an average of twice as much time spent on OJT as is spent on classroom and simulator activities. This ratio varies considerably among the six railroads, however, ranging from 1.3 to 5.6.

Still another index of support for engineer training is the investment in simulation equipment. One of the six participating railroads has three multi-million-dollar full-task dynamic simulators, two others have one such simulator, and the other three have part-task simulators*.

In general, the six participating railroads all demonstrate a substancial dedication of money, resources, and manpower to the training of locomotive engineers.

5.3.4 Criteria for Evaluating Training Effectiveness

A function of training management that is too often overlooked in formalized statements of management goals is the regular evaluation of how well the program is performing. None of the documentation acquired in the survey addressed this function. However, evaluation should be a major function of any model program to be developed by this project and merits some introductory remarks here.

Three criteria will be discussed: productivity, efficiency, and safety.

Productivity. Two aspects of productivity should be noted: Throughput and quality.

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*A part-task L.E.T. simulator duplicates only selected elements of the locomotive cab environment. For example, the train dynamics analyzer duplicates locomotive controls and instruments, but not the external world as seen through the cab windows.

Throughput can be most simply measured by the rate at which students are processed -- for example, number of trainees per year. Just turning out classroom graduates is not enough evidence of productivity, quantity as well as quality should be considered. An indication of quality can be added by considering the number of graduates per year who qualify as engineers within a given period. Effectiveness of the throughput rate can be evaluated by comparing it with the needs of the railroad for additional locomotive engineers. It should be noted here that all six surveyed railroads have locomotive engineer training programs that are currently keeping up with demands.

A longer range evaluation of quality is also required. Evaluation of a specific L.E.T. program should ask: how well do program-trained locomotive engineers perform on the job as compared to locomotive engineers who have qualified outside the program? How well do the graduates perform in an absolute sense? A well thought-out follow-up process must be developed to provide for periodic feedback to the training manager of supervisors' evaluations, performance records, knowledge/ skill review tests, and the like. Only with such data can a training staff plan and justify the efforts required to maintain and improve the quality of the training.

Efficiency. Effeciency of a training program is the value received for the effort invested. Many of the techniques of economic benefit/cost evaluation can be applied here. In the simplest sense, efficiency of a training program can be measured by matching the productivity measures against the dollar costs of the program. The challenge in designing such a program of evaluation is to define criteria that can be measured within the railroad's existing operating standards and controls.

One simple index of training efficiency is the pass/fail ratio. Too many failures may be an indication that either the training techniques require improvement or that selection criteria need to be tightened. In either case, the earlier such inefficiency can be detected, the less costly it is. On the other hand, a high passing ratio is not necessarily an indication that the program is good; it may be efficiently meeting unrealistic or unnecessary training objectives.

Safety. A universal justification for training engineers to high skill levels is that it reduces the risk of costly accidents caused by ineffective train handling. It has already been noted (Section 3.2.2g) that the combination of circumstances and events leading to any single accident is so complex that the specific relationship of the engineer's training to the cause of the accident is virtually impossible to determine in a statistically reliable sense. On the other hand, on a case-by-case basis, it is often possible to infer that if training had been different, the accident might have been avoided.

To the extent that the training staff can get feedback on the accident records of their graduates, they can gain invaluable insights into ways of avoiding future such accidents through improvements in the training program. Such evaluation must be specifically provided for. Regulations regarding the reporting of relevent accident information to the training manager will be required. Allowance must be made for the management time required to evaluate accident data. In certain instances, provision should be established for a member of the training staff to participate in accident investigations. This kind of evaluation is difficult to justify, since it is costly, and if it is effective, the benefit is not evident (how do you evaluate the accidents that didn't happen?)

Despite the lack of a safety measure for comparing railroads, the survey team was provided with some estimates of this aspect of training effectiveness. One railroad attributes a 40 percent reduction in accidents to its training program. Another notes that, although the program graduates constitute 50 percent of their active locomotive engineer force, they cause only 18 percent of reported break-in-twos.

In summary then, difficult though it may be to evaluate training effectiveness in terms of safety improvement, such evaluation is possible and should receive attention in the development of any model program for L.E.T.

5.4 PLANT AND FACILITIES

5.4.1 Functions

The facilities that house and support the training program are factors in its success. Understanding this, the six railroads have developed facilities best suited to their L.E.T. programs.

5.4.2 Facilities

Centralized training facilities are found on five of the railroads. The sixth railroad employs regional classroom facilities. Four of the five centralized facilities are dedicated to locomotive engineer training. While the size of the facilities varies, each one (centralized & regional) contains the equipment deemed necessary for the particular program. The largest training center observed also included recreational and dormitory facilities. A description of the variety of equipment used is included in Section 6.6.5, Training Aids. Two of the railroads use converted passenger rail cars as part of their facilities.

One railroad houses a TDA and air brake rack in its car; a locomotive cab full task simulator, classrooms and offices are housed in the other railroad's converted passenger cars.

Motor homes have been converted for use as an integral part of the L.E.T. program on two railroads. Freight Master Train Dynamics Analyzers have been installed in these mobile units. Both railroads use their mobile units primarily for scheduled pre-service training, with refresher training being handled as opportunity permits.

5.5 STAFF AND INSTRUCTORS

5.5.1 Functions

The A.S.T.D. Checklist defines instructors as all personnel who actively instruct or teach. For railroad programs, this group is comprised of classroom instructors and those engineers serving as OJT instructors. These individuals carry the major responsibility for the success or failure of training programs. Therefore, selection of qualified personnel to be instructors is critical.

5.5.2 Instructor Selection

The criteria for selection as a classroom instructor are consistent among the six railroads. All individuals are chosen on the basis of job knowledge, experience, and commitment to training.

With a few differences, the source from which instructors are selected is consistent. Present or former locomotive engineers are used as instructors by all railroads. On 5 of the railroads, these individuals, once selected, become dedicated instructors. Road foremen are the basic source for instructors on 3 of the railroads.

On two of the three surveyed railroads, road foremen selected become dedicated instructors. On the third railroad, the road foremen serve as instructors as well as retaining road foreman responsibilities.

On one railroad, trainmen and yardmen as well as engineers are included in the source. A unique situation is present on one railroad. For each subject area; air brakes, rules, and locomotive mechanical-electrical systems, instructors are recruited from the responsible department. Two other railroads are similar in that rules instructors are provided by the rules department. Selection of OJT instructors is consistent among all of the railroads. The selection criteria are job knowledge, experience and a willingness to serve as an OJT instructor.

5.6 CURRICULUM

5.6.1 Functions

The curriculum of a training program is generally the most visible part of the instructional system, since this is where the design is put into practice. It is the combination of content, training methods, media, and systems of trainee-instructor organization needed to conduct the training program.

5.6.2 Qualification standards for assignment to duty

The method by which a locomotive engineer trainee becomes qualified for assignment to duty as a locomotive engineer is:

- successful completion of all oral and written examinations of the knowledge requirements learned in the classroom instruction.

- successful demonstration to the Road Foreman of the ability to integrate the correct manipulation of the locomotive controls based on environmental cues and in accordance with the operating rules.

Written final exams are given in the areas of operating rules, air brakes and locomotive mechanical-electrical systems. The range of test scores for each subject area is:

- Operating and Safety rules 80%-95%
- Air brakes 80%-85%
- Locomotive mechanical-electrical 80%

One railroad also requires the trainee to pass a written exam on his home territory terrain characteristics as part of the qualifying standards.

All of the surveyed railroads place heavy emphasis on the judgement of the road foreman in making a final decision as to whether the trainee is qualified. The road foreman accompanies the trainee during a final qualification road trip on all selected railroads. One railroad, in addition to the road trip, requires the trainee to make a final check run on its locomotive cab simulator.

There was no evidence or documentation found to indicate that any norm (job tasks) - referenced pretest was administered to a prospective locomotive engineer trainee in any of the surveyed training programs.

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*Norm-referenced testing. This type of test produces a score that tells us how the individual locomotive engineer trainee's performance compares with other trainees taking the same pretest.

5.6.3 Evaluation Practices

Program evaluation is the least-understood, most ill-practiced (if practiced at all) training management function of most training programs - including railroad L.E.T. programs. Evaluation design requires no less a systems approach than does the design of a good training program. In fact, they go hand-in-hand.

A L.E.T program should be based on: (1) a locomotive engineer job task inventory, and (2) the specifying of instructional objectives against the job tasks. The next logical element in the order of the 'system' is testing (or evaluating) the output of the trainee. In other words: develop, implement, test. The observation and analysis of the selected railroads' training programs produced neither job task inventory documentation nor a comprehensive set of instructional objectives. What was found was an abundance of testing materials.

5.6.4 Testing Materials

These testing materials are of the convential types: oral and written quizzes and examinations with multiple-choice, matching, completion and essay questions. The tests are adminstered during classroom instruction at regularly scheduled times.

Checklists for the evaluation of skill performance are used in the OJT portion of the training programs to test the trainees' level of performance against previously established qualification standards.

All of the six surveyed railroads have established locomotive engineer trainee selection criteria. In five of the programs, these criteria are based primarily on length and type of railroad service, quality of work, record and requisite knowledge (operating and safety rules). Because the labor pool within the remaining railroad from which trainees have traditionally been recruited has not been able to consistently provide viable candidates for L.E.T, the railroad accepts a trainee with a high school diploma as a pre-requisite for admission to its preparatory school for locomotive engineer trainees. The trainee receives the requisite knowledge and skills to become a locomotive engineer trainee. There was no evidence provided by any of the cooperating railroads indicating the administration of (objectives) written test to select potential L.E.T. trainees.

5.6.5 Content Scope and Sequence

The content of the selected training programs was consistent in that all programs provided the knowledge and skills training for safe and efficient performance as an engineer. Classroom content centers on the knowledge requirements, on-the-job training provides the opportunity for practical application of knowledge as well as skills development. Classroom content consists of four subject areas.

These areas are:

- Operating and Safety Rules
- Air Brakes: Operation, Rules and
- Train Handling Procedures
- Locomotive Mechanical-Electrical Systems
- Track Train Dynamics

Of these classroom subject areas, operating rules has the largest amount of time devoted to it. The overall or basic content of rules instruction is consistent among the railroads. The rule is identified by number and title, the rule is read verbatim, and then followed by an explanation of its application and intent. Specific rules content varies considerably between the programs because of the unique complex of regulations, organization, geography and climate that determines how each railroad must operate.

The content of air brake instruction is fairly consistent between the training programs. This was to be expected since regulatory agencies, such as the Association of American Railroads, have required standardization of air brake design, operation and equipment.

Air brake content consists of these areas:

- Locomotive/Freight Cars
  - Function and Operation
  - Components
  - Troubleshooting
  - Corrective Procedures
- Air Brake Rules
  - Tests
  - Procedures
- Train Handling Procedures

Emphasis is placed on troubleshooting and the corrective procedures the engineer may utilize to remedy problems which may delay or stop his train.

Within air brake rules instruction, the trainee learns how to perform required tests, such as the Initial Terminal Test, and specific procedures for using the air brakes under a range of operating conditions. Air brake test racks, test equipment, TDAs and locomotive cab simulators provide the opportunity for the trainee to practice tests and procedures.

Train handling content provides an awareness of procedures the engineer will use when operating the locomotive. The content usually consists of describing the terrain (grades, curves, etc.), the train makeup and what the engineer must do in order to start, stop or maintain speed. Locomotive cab simulators and TDAs provide the trainee the opportunity to practice and demonstrate his knowledge of train handling procedures in a controlled environment with no risk to equipment or personnel.

Locomotive mechanical-electrical systems content is very consistent through-out the selected programs. Without exception, locomotive content covers:

- Fuel System
- Lube Oil System
- Cooling System
- Air System
- Excitation System
- Protective Devices

For each of the operating systems of the locomotive, the training programs cover: function and operation, components, troubleshooting, malfunction recognition and corrective procedures. Heavy emphasis is placed on malfunction recognition and corrective procedures for (1) enabling the engineer to restore power promptly and (2) allowing the engineer to provide a clear description of problems, he is unable to correct, to the appropriate department to insure proper repairs.

There were however specific content differences within locomotive mechanical-electrical systems. These differences are accounted for by either manufacturer's and model differences or design and equipment specifications by a railroad to meet its operating characteristics. An example is that one railroad requires dynamic brakes on its locomotive, while another railroad has little or no use for dynamic brake equipped locomotives.

Track Train Dynamics focuses on the motion and resulting physical forces that are caused by the interaction of the locomotive consist and cars with the track, climate conditions, grades, curves and operating procedures. In order for the trainee to gain an awareness of the dynamics, the content consists of:

- Train makeup/speed
- Terrain characteristics
- Wheel to rail adhesion factors
- Coupler forces
- Lateral forces

In the past, the trainee learned track train dynamics strictly through on-the-job training. With the development of TDAs, the trainee now gains this critical knowledge in the classroom. The CRT display graphically represents the dynamics of the train as it is being operated.

The "full-task" locomotive-train simulator is another means by which dynamics are being learned in the classroom environment. When operating this device, the trainee receives visual and motion feedback representative of train dynamics.

While the four classroom content areas are consistent between the surveyed training programs, variations exist in the sequencing of the content and the duration of classroom instruction in each content area.

Sequencing of classroom content ranged from an integration of the subject areas within a given classroom week to a sequential order of presentation. Two of the surveyed railroads teach air brake/train handling first, followed by locomotive mechanical electrical systems. A third railroad presents the content in a similar way with one key difference. Operating rules preceeds instruction in air brakes and locomotives. Without exception, track train dynamics is included in the air brake/train handling portion of classroom content. Five of the selected programs teach operating rules, in a single block, as the final segment of classroom instruction.

Classroom time ranged from 120 hours of instruction to 440 hours of instruction, with the mean 281 hours. Air brake/train handling content ranged from a low of 30 hours to a high of 84 hours. The mean for this content is 55 hours. Locomotive mechanical-electrical systems reflected a similar range of hours; 32 hours to 88 hours. The mean for locomotive systems is 48 hours. Operating rules showed the smallest range of hours for any content area; 40 hours to 87 hours. The mean for teaching operating rules is 63 hours, the highest for any of the classroom subject areas.

Classroom time also includes hours spent using the locomotive cab simulator or TDA. For the 3 railroads having cab simulators, trainee operation ranges from 14 hours to 40 hours.

In addition to the time the trainee operates the simulator, an equal amount of time is spent observing another trainee. Only one railroad equipped with a TDA formally incorporates its use into classroom time. The trainee operates the TDA for 2.5 hours and observes for 5 hours. This activity lasts 3 days. The same railroad utilizes its TDA during on-the-job training, with an identical number of hours spent operating and observing as before. However, the trainee spends only 1 day working with the TDA during his on-the-job training.

On-the-job training content was difficult to determine. The informal structuring of OJT does not facilitate the gathering of accurate documentation. Also, the bulk of the documentation received from the selected railroads was primarily on classroom content; thus the documentation was not adequate to effectively identify OJT content.

However, analysis was performed on the documentation that was made available concerning OJT, and as well on any undocumented evidence gathered during the on-site visits and interviews with instructors and trainees. From this, several facts may be inferred about on-the-job training.

OJT content includes the performance requirements found in Table 4-2. The basic intent of OJT is (1) the practical application of knowledge gained from classroom instruction and (2) the development of engineer skills. On-the-job training provides the trainee with practical experiences in these areas:

- Operation of air brakes
- Use of locomotive controls and associated equipment
- Application of operating and safety rules
- Train handling over a range of train makeups, terrain and operating characteristics

Seqeuncing of content within OJT was also difficult to determine. One railroad did provide documentation which illustrated the content sequence as progressing from simple to complex tasks. It may be inferred that this seqeunce is typical of all OJT portions of the other selected programs.

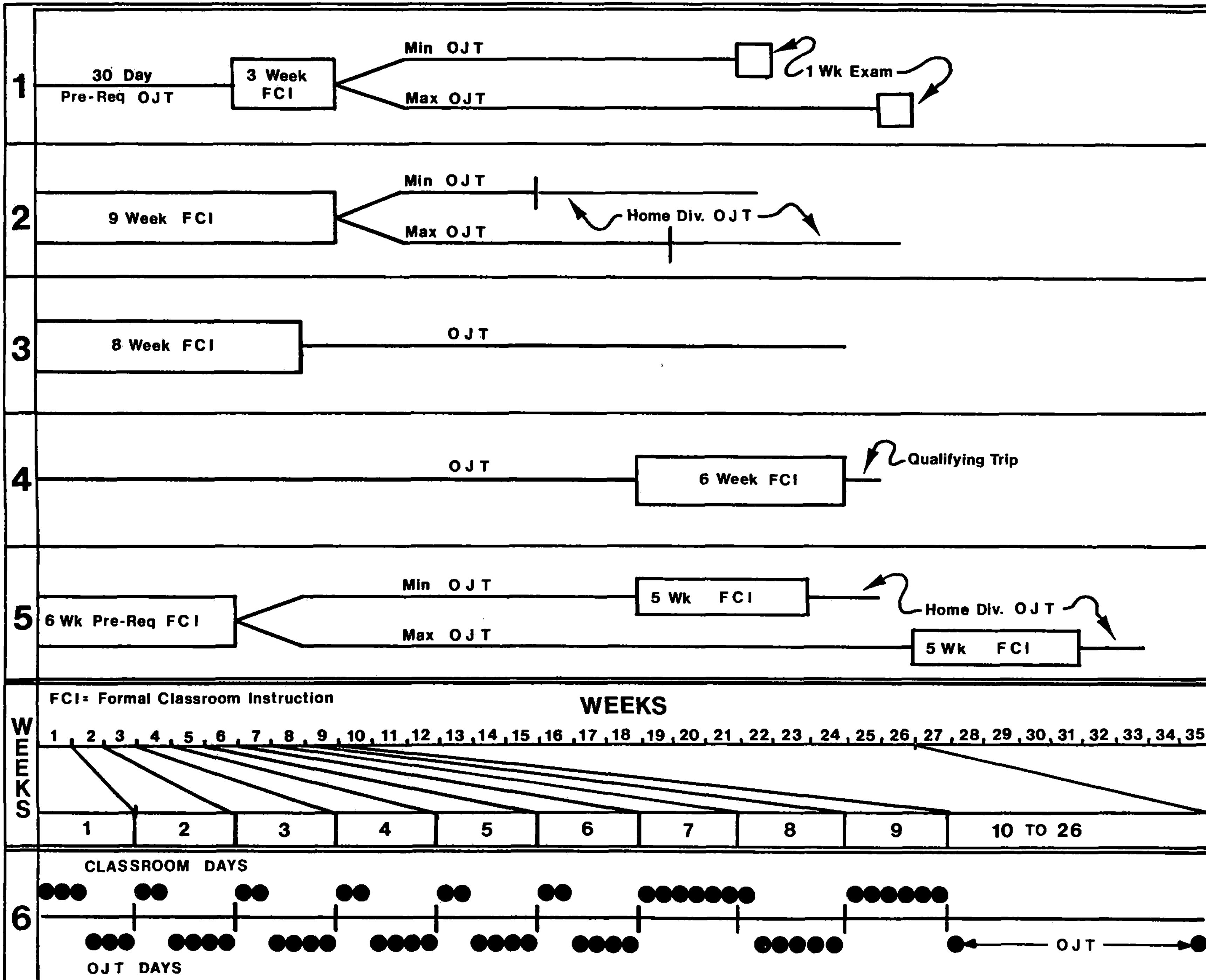
The length of OJT varies considerably among the railroads. Two programs have a specific number of hours for OJT; 904 hours and 720 hours. Two other railroads have OJT periods with a minimum and maximum number of hours. These programs range from (1) 240 to 400 hours and (2) 480 to 640 hours. The remaining two programs specify that a minimum number of road trips be made during the OJT period. 60 trips are required on one railroad, 160 trips are specified by the other railroad. Besides this difference, another key difference exists in that one railroad requires the trips be made within a specific number of hours, 640 (160 trips) and the other program has a range of hours, 480 to 800 (60 trips).

The sequencing of classroom instruction and on-the-job training of the selected programs is somewhat consistent. Four of the surveyed railroads have their programs sequenced in two parts. Two of the four programs have classroom instruction preceeding on-the-job training. A third program has just the opposite, with OJT preceeding the classroom instruction. An unique mixture of classroom instruction and OJT preceeding a period a strictly OJT is found on the fourth railroad.

The remaining two programs consist of a three part sequence and a four part sequence. The three part sequence has a pre-requisite OJT period preceeding classroom instruction, which in turn is followed by another period of OJT. The four part program consists of pre-requisite classroom instruction, followed by OJT, which is followed by a second period of classroom instruction. The fourth part of the program is another period of OJT.

Table 5-1 graphically represents the sequencing of the selected programs.

TABLE 5-1 CLASSROOM-OJT SEQUENCING PRACTICES



5.6.6 Training Aids

Training aids can be organized into 5 basic groups. (1) still pictures, (2) moving pictures, (3) audio materials, (4) printed materials and (5) objects are typical to the teaching/learning process regardless of subject. Training aids serve to fill the gap between verbalization and direct, real-life experiences; their effective use complements and/or supplies the basic instructional strategy and objectives. The railroads' L.E.T. programs, in general, make use of a variety of aids from all 5 groups. Within the group of objects, are several training aids which should be defined.

5.6.6a Simulator

The term, simulator, has been very narrowly applied in L.E.T. program jargon to describe a "full-task" locomotive and train simulating device, which accepts trainee input from a locomotive control stand and provides visual (instrumentation and a filmed view of the territory), aural and motion feedback to the trainee, thus creating an environment which closely approximates real life. Three of the six cooperating railroads make use of "full-task" locomotive-train simulators.

5.6.6b Train Dynamics Analyzer

In recent years, an additional locomotive and train simulating device was introduced. The Train Dynamics analyzer (TDA) differs from a locomotive simulator in that it does not provide sound feedback and in place of a filmed view of the territory and the sensation of motion, the TDA substitutes a cathode ray tube (CRT) display which graphically represents the dynamics of the train as it is being operated.

The TDA, because of its relatively small size, can be easily transported to provide on-site in-service and/or recurrent training and is used in this way by two of the three cooperating railroads with TDAs. The other railroad uses its TDA in a classroom. The TDA does not provide the additional sound, motion and visual cues of a "full-task" simulation, however, the costs associated with acquisition and operation of the TDA are less. No data exists which compares the two devices from a cost-effectiveness standpoint.

One of the three railroads using "full-task" simulators is unique in that it operates two "full-task" simulators and a hybrid simulator. This hybrid device combines a filmed view of the territory with a CRT display of locomotive-train-territory dynamics in place of motion feedback.

The number of railroads using training aids (by type) for instructor presentation, trainee practice and trainee evaluation is presented in the following table.

TABLE 5-2 TRAINING AIDS

	PRESENTATION	PRACTICE	EVALUATION
STILL PICTURES			
35mm slides	6		
Overhead transparencies	4		
Maps (track charts)	4		
Charts	6		
Photographs	6		
Bulletin board materials	6		
MOTION PICTURES			
16mm film	6		
Videotape	3		
AUDIO MATERIALS			
Tape cassettes (w/slides)	5		
PRINTED MATERIALS			
Books	6		
Reference books	6	6	
Handouts	6	6	6
Pamphlets	6		
OBJECTS			
Single objects	6		
Collections of objects	6		
Models	6		
Demonstrators (function)*	6	6	
Mock-ups (operation)**	6	6	
TDA'S (part-task)	3	3	3
Simulators (full-task)	3	3	3
People (locomotive engineers)	6	6	6

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*Function: the service a component or subsytem performs for a system, - What it does.

**Operation: how a component or sub-system performs the service for a system, - How it does it.

5.6.7 Recurrent Training

One railroad has an on-going, two week structured recurrent training program. This program is for those engineers who were qualified prior to the inception of their formal L.E.T. program. Content is in the areas of operating and safety rules, locomotive mechanical-electrical systems, air brakes and train handling.

The six railroads visited periodically retest engineers on operating rules. Five railroads indicated that it is the responsibility of the Road Foreman to informally, i.e., non-structured train engineers on new equipment and/or changes in operating rules. These activities were not reported as part of their formal L.E.T. programs.

5.6.8 Minimum Entry Requirements

Trainee entry requirements were somewhat consistent among the railroads. Five railroads limit entry to their L.E.T. programs to railroad employees only. Within these five however, differences exist. Three railroads only accept firemen into the programs. Employees having one or more years of train service are given preference on another railroad. Entry on the fifth railroad is limited to either yardmen or conductors who are qualified in operating rules. One railroad does take people off-the-street (with a high school diploma). These people are, however, put through a pre-requisite training program and OJT before entering the L.E.T. program. 5.6.9

5.6.9 Recruitment/Selection Procedure

The procedure for recruitment or enrollment of trainees is consistent only in one area. Recruitment is based on immediate or projected regional or division needs for locomotive engineers. The actual procedure for recruitment varies considerably among the railroads. Three railroads post or formally announce trainee openings. Interested personnel then apply for entrance into the L.E.T. program. Another railroad accepts applications from firemen every 6 months. Once the individual has applied, his name is entered on a list for his home division. Potential trainees are chosen from this list as locomotive engineer needs arise. If not chosen from the list in 6 months, the applicant must reapply. A fifth railroad uses a somewhat similar approach, however this railroad has several key differences in the procedure. First, applications are accepted from firemen at anytime. The potential trainee then goes through the selection process and if it is determined he is qualified, the trainee's name is entered on a list. As locomotive engineer openings arise in his home division, those applicants on the list maybe chosen. One railroad recruits individuals off-the- street, (with a high school diploma).

While recruitment procedures vary, the selection criteria are generally consistent among the railroads. Health, work records, personal interviews, and supervisors' recommendations are part of the prevelant selection methods. One railroad also includes aptitude tests in its selection procedure.

5.7 INSTRUCTIONAL SUPPORT

5.7.1 Functions

Instructional support includes instructor training, library and information services, training literature and administration of student services. With the exception of instructor training, little documentation was available. This was to be expected since these railroad L.E.T. programs were developed without the aid of the techniques and theories associated with a systems approach to training development.

5.7.2 Instructor Training

Instructor training is present in three of the surveyed railroads' L.E.T. programs. Two railroads provide training for classroom instructors, one railroad provides training for OJT instructors. The scope of this training varies considerably among the three railroads.

An organized instructor training program is provided by one railroad. Detailed training in instructional techniques and subject matter forms the content of the program. All instructors for this railroad are required to have had this formal training before commencing their instructional duties.

A second railroad has defined their instructor training as providing instruction in regard to following proper procedures and the development of good work habits. It can be inferred that training in instructional techniques is given during instructor training.

The third railroad is the only one surveyed that has an OJT instructor training program. A booklet is provided to those engineers serving as OJT instructors; detailing OJT instructional techniques and the importance of properly filling out trainee OJT evaluation forms.

5.8 SUMMARY

Although the L.E.T. program documentation provided by the cooperating railroads (Tables 3-1 to 3-6) varied considerably in quantity, detail and consistency, valuable information was extracted from it.

Training program practices, techniques and materials were identified which, after analysis, formed the basis for recommendations to the L&N for modifications of their L.E.T. program. Twelve recommendations were made to the L&N, eight of which dealt with the use of a variety of training aids. The inclusion of any or all of the training aids could be accomplished in a relatively short period of time and at low to moderate cost. The remaining four recommendations (management planning, structuring OJT, developing training objectives and training instructors) are long term, labor intensive activities with considerably greater potential benefits. The details of these recommendations are contained in Volume II, Section 6.

Current training practices, a variety of training techniques and, to some extent, training materials were identified for possible inclusion in the model L.E.T. programs to be developed in Task 4a. The availability of these materials, is however, questionable as the railroads consider them to be proprietary documents. This does not in any way diminish the value of the information and insights about L.E.T. programs gained through the analysis process.

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APPENDIX A

Instructional Design Criteria

(ASTD Checklist)

APPENDIX A: INSTRUCTIONAL DESIGN CRITERIA

(ASTD CHECKLIST)

1. PURPOSE

A set of guidelines was required for use as criteria in analyzing the design of Locomotive Engineer Training (L.E.T.) programs in Task 2c. A search of the training literature was conducted for a standard set of guidelines that would meet the four major requirements.

1. That the guidelines be based on the systems approach
2. That they be intended for use in skills training
3. That they were developed to meet real world needs
4. That they include the specific training areas addressed by the Demonstration Project

2. A.S.T.D. CHECKLIST

The literature search disclosed The American Society for Training and Development (ASTD) Checklist for Technical, Skills and Other Training which was selected as meeting the requirements of the project. The American Society for Training and Development, as an association of training professionals, has been responsible for a number of activities aimed at collecting, revising and distributing materials to help improve training in government and industry. This instrument is representative of those activities and materials.

The checklist was originally developed as a planning document for governmental technical and skills training facilities. It has also been used (wholly or in part) for evaluating training programs for establishing training centers and for developing training programs. The selected version (1979) of the checklist has been edited and published as a service of the Technical & Skills Training Division of ASTD.

3. TRIAL APPLICATION

The ASTD Checklist was introduced and tentatively accepted at the initial meeting of the L&N-BLE Demonstration Project at the L&N Railroad in Louisville, Kentucky. This meeting was held to describe the purpose and procedures of the project to representatives of the cooperating railroads, the L&N Railroad and the Brotherhood of Locomotive Engineers. Following this meeting, the Checklist was reviewed in depth with a working group made up of Project Advisory Committee members (L&N and BLE), and L&N instructors, trainees and locomotive engineers. The checklist was applied to the L&N's L.E.T. program as an integral part of this review over a two day period, and was found to cover all aspects of the L&N program. It was therefore adopted as a formal set of instructional design criteria for the analysis of railroad training programs under this project.

4. ORGANIZATION OF THE ASTD CHECKLIST

The checklist is organized into six categories, which together are essential for an effective training system. The ASTD defines each of the categories as follows:

I. Philosophy and Goals

Philosophy: The set of fundamental beliefs or the way of thinking about the functional areas of training.

Goals: Objectives of the functional areas of training.

II. Management

Management of the Training Unit: Involves the coordination of the efforts of a group so that their individual needs and objectives are consistent with and complement the requirements and goals of the training activity they serve. The managerial functions of particular importance in training are those of planning, organizing, staffing, directing and controlling.

III. Plant and Facilities

Plant and Facilities: The site, building, and administrative spaces, that house and support a training unit, together with its equipment and services.

IV. Staff and Instructors

Staff: All personnel who function in direct support of the instructor group, including class assistants, clerical workers, writers, training aids specialists, consultants, and maintenance personnel.

Instructors: All personnel who actively instruct.

V. Curriculum

Curriculum: The combination of content, training methods, media, and systems of trainee-instructor organization needed to conduct the training program.

VI. Instructional Support

Instructional Support: Refers to instructor training and upgrading, library and information services, scheduling, training equipment, training literature and administration of student services.

5. TRAINING PROGRAM CHARACTERISTICS

The items contained in the request for information sent to the cooperating railroads can all be subsumed under the six categories of the ASTD checklist, as follows:

I. Philosophy and Goals
II. Management
- Training budget
III. Plant and Facilities
- Facilities (classrooms, dedicated hands-on equipment.)
IV. Staff and Instructors
- Instructor selection and qualifications
V. Curriculum
- Qualification standards for assignment to duty
- Evaluation practices
- Test materials
- Content scope/sequence
- Training aids, devices and materials
- Recurrent training
- Minimum entry requirements
- Trainee recruitment/selection procedure
VI. Instructional Support
- Instructor training