Chapter 2

BACKGROUND

RAIL RAPID TRANSIT

Rail rapid transits is an old and established part of the national transportation system. It carries large numbers of people at high speeds within central business districts and to and from outlying areas. The patronage in Chicago, for example, is over half a million people on a typical weekday; in New York City as many as 3-1/2 million riders are carried daily. Nationwide, rail rapid transit serves about 2 billion passengers per year. In the newer systems, top speeds of 70–80 miles per hour are attained, with average speeds of 30–40 miles per hour for an entire trip. In cities where there is an existing rail rapid transit system, it is difficult to conceive how they could function properly, or at all, without this mode of transportation.

Most rail rapid transit systems in this country were built over 30 years ago. The New York, Boston, and Chicago systems date from the turn of the century. In recent years, other major cities have turned to rail rapid transit as a solution to the problems of urban transportation and automobile traffic congestion. The Lindenwold Line (PATCO) in New Jersey and BART in San Francisco were built within the last 10 years, and rail rapid transit systems are planned or under construction in Atlanta, Baltimore, and Washington, D.C. The major cities with existing systems (New York, Chicago, Boston, Philadelphia, and Cleveland) have undertaken programs to extend and improve their service.

Along with the new attention to rail rapid transit has come an increased concern with technology. The basic technology of rail rapid transit, which derives largely from railway engineering, is quite old. Propulsion and braking systems, for example, are products of the late nineteenth century. The electric track circuit, used to detect the presence of trains and to assure safe separation of trains, was developed over 100 years ago. The cam controller (a mechanism for controlling the application of power to d.c. propulsion motors) was first used in the Chicago subway system in 1914. Cab signaling systems, functionally similar to those of today, were in use in the 1930's. While this technology has been refined and improved over years of operational experience, many transit system planners and engineers believe that new and more sophisticated forms of technology need to be applied in order to achieve systems of higher safety, performance, and efficiency,

Generally, two avenues of technological innovation are proposed for rail rapid transit: substitution of electronic for electromechanical components and more extensive use of automation, One such application of new technology is in the area of train control, where the replacement of men with electronic monitoring and control mechanisms is thought to offer several advantages--greater consistency of performance, safeguarding against human error, more extensive and precise control of train operations, and reduced labor costs in operating the system. However, some transit engineers have misgivings about the ability of the newer automatic train control systems to perform as safely and efficiently as manual systems, There is also some doubt about the cost-benefit of automation. Automated control systems are more expensive to design and produce, and their complexity may make them less reliable and more costly to maintain. Automatic train control is, thus, a controversial matter in rail rapid transit, especially as a result of the difficulties encountered by the BART system in San Francisco. BART is the newest and most technologically advanced transit system in the United States, but it has not yet lived up to the levels of performance and service predicted during its planning and development, or even to the standards set by older and technologically less advanced transit systems now in operation. Some critics contend that problems of BART stem from its extensive use of unproven innovative technology for train operation and control,

A part of the controversy over automation may stem from a common misconception that it is synonymous with computers. Electronic data processing is certainly one way to achieve automatic operation, but there are others. The track circuit, the electromechanical relay, the emergency air brake, the trip stop, and recorded passenger information announcements are all automatic devices; and none involves a computer in the usual sense of the term. Another misconception is that automation is something new, a product of aerospace technology. While it is true that automated equipment has been employed extensively in advanced aviation and space systems, the birthplace was certainly not there. Automation has been with us since the beginning of the industrial revolution. All of the

[5]Rail rapid transit is an electrified rail system operating in urban areas on exclusive rights-of-way, Rail rapid transit is considered here to exclude commuter railroad systems and light rail systems, although the technology of train control is similar for all three.

automatic devices mentioned above have been in use in rail rapid transit for many years.

Thus, the issue is not whether automation should be applied in rail rapid transit train control. Automatic train control devices of various types have been used in rail rapid transit for many years. The real concerns are where should automation be applied, how far should the train control process be automated, and what technology should be used. As phrased by the OTA staff in planning this assessment of automatic train control in rail rapid transit, the central question is: "What degree of system automation is technically feasible, economically justifiable, or otherwise appropriate for rail rapid transit?" The answer, which entails examination of safety, performance, and cost, is crucial to the future development of rail rapid transit and its value as a public transportation system.

OBJECTIVES

This study was undertaken with the following objectives:

1. to examine the design characteristics of automatic train control systems and evaluate the state of automatic train control technology;
2. to assess the operating experience and performance of transit systems which employ various forms of automatic train control;
3. to analyze the process by which automatic train control systems are planned, developed, and tested;
4. to examine the policy and institutional factors that influence the application of automatic train control technology in rail rapid transit.

Thus, the emphasis of this report is not on technology as such. While there is considerable attention given to technical matters in the early chapters, it is intended as background for subsequent examination of the results and implications that ensue from the application of automation in rail rapid transit systems. The bulk of this report is devoted to an assessment of the practical results of ATC in operating transit systems and to the practical results of ATC in operating transit systems and to an evaluation of the planning and development process by which ATC systems evolve in the context of public institutions and government policy.

SCOPE

The scope of this report is limited to automatic train control technology in rail rapid transit systems. No attempt has been made to deal either with rail rapid transit technology as a whole or with the application of ATC to small-vehicle fixed-guideway systems.[6] The parts of this report that deal with the planning and development process are confined to matters relating to the evolution of the train control system. It is recognized that ATC design and development does not occur in isolation, but as a part of the larger process by which the entire transit system is planned and built. A more general assessment of mass transit planning is the subject of a separately published report.[7]

Five operating rail rapid transit systems are examined in this report:

- Bay Area Rapid Transit System (BART) in the San Francisco area,
- Chicago Transit Authority (CTA),
- Massachusetts Bay Transportation Authority (MBTA) in the Boston area,
- New York City Transit Authority (NYCTA),
- Port Authority Transit Corporation (PATCO), the Lindenwold Line, in Philadelphia and suburban New Jersey.

These systems were selected for study because they embrace a broad range of system characteristics. They vary from a simple one-line system (PATCO) to complex and dense transit networks (CTA and NYCTA). They represent a range of automation, from predominantly manual (NYCTA and CTA) to highly automated (BART). They differ greatly with respect to age--NYCTA, MBTA, and CTA being the oldest and PATCO and BART the newest. They also employ several forms of train control technology--conventional (CTA, MBTA, NYCTA), advanced (PATCO), and innovative (BART).

---

[6] An assessment of the technology of transit systems employing automatically operated small vehicles on fixed guideways was issued by OTA in June 1975 under the title, Automated Guideway Transit (Report No. OTA-T-8).

[7] An Assessment of Community Planning for Mass Transit, Office of Technology Assessment, February 1976 (Report Nos. OTA-T-16 through OTA-T-27).

In addition to these five operating systems, others in the planning and development stage are considered in the parts of the report that deal with the process by which transit systems are conceived, designed, and built. The principal rail rapid transit systems under development are:

Metropolitan Atlanta Rapid Transit Authority (MARTA)

Mass Transit Administration (MTA) in Baltimore

Washington Metropolitan Area Transit Authority (WMATA)

STUDY METHOD

This assessment was a joint undertaking by the OTA Transportation Program Staff and the Urban Mass Transit Advisory Panel, an 11-memher group made up of representatives of the transit industry, State department of transportation, planning consultants, organized labor, and public-interest groups. Battelle Columbus Laboratories acted as technical consultants and provided major assistance in collecting data and conducting interviews with transit system officials, planning organizations, and equipment manufacturers. The OTA staff also carried out an independent program of visits to interview transit system officials at five sites and to collect data on their operational experience with ATC equipment. The findings of the Battelle investigation were presented to the panel in a series of background and technical documents. This material was combined with the results of the OTA staff effort to form the basis for this technology assessment.

ORGANIZATION

This report is organized to accommodate readers of different interests and technical backgrounds, The next two chapters, entitled “Automatic Train Control” and “Transit System Descriptions,” are intended to acquaint the reader with basic train control technology and the operational characteristics of the rail rapid transit systems selected for study. These chapters are written with a minimum of technical detail and provide a general background for the subsequent examination of operational, planning, and policy issues. Those already familiar with train control technology and transit operations may wish to skim this material or to pass on directly to chapters 5, 6, and 7, which deal with operational experience, planning and development, and policy issues relating to automatic train control technology. As an accommodation to differing reader interests, these chapters are organized in three levels of detail. The first level is a summary of the major issues at the beginning of each chapter. Next is a presentation of the individual issues, each headed by a capsule statement and a synopsis of the principal findings and conclusions. The third level consists of supporting detail and discussion of the implications for each issue. Thus, the reader can pursue each topic to whatever depth desired.

At the end of the report are various technical appendices, intended primarily for those who wish more specific information on train control technology and system engineering features. Appendix D—Glossary of Terms, and Appendix E—Chronology of Train Control Development, may also be of interest to the general reader.