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Decision No. 91846 JUN 3 1980

ORIGINAL

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Application of the SAN FRANCISCO BAY AREA RAPID TRANSIT DISTRICT for authority to institute revenue passenger service utilizing the Automatic Train Control System for train separation over its lines without the present computer enforced train separation procedures provided under the Computer Automated Block System.	Application No. 57727 (Filed December 6, 1977; amended September 15, 1978)

Malcolm Barrett, by Sherwood Wakeman, Attorney at Law, for San Francisco Bay Area Rapid Transit District (BART), applicant.
James P. Jones, for California State Legislative Board, United Transportation Union, and Willard H. Wattenburg, for himself, interested parties.
Robert C. Cagen, Attorney at Law, and Alex E. Lutkus, for the Commission staff.

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Subject

INTERIM OPINION

By this application the San Francisco Bay Area Rapid Transit District (BART) requests Commission authorization to change BART's method of operation from one utilizing the present computer automated block system (CABS)[1/] for train separation and control to a system using the primary automatic train control system (ATC) supplemented by the sequential occupancy release system (SORS), a system that also is sometimes described as "close headways".

Introduction and Summary

State law provides that BART is "subject to regulations of the Public Utilities Commission relating to safety appliances and procedures and the Commission...may make such further additions or changes necessary for the purpose of safety to employees and the general public." (Public Utilities Code Section 29047.)

In carrying out its responsibilities under the law, the Commission strongly supports and encourages safe and efficient public transit, which is particularly necessary as fuel costs rise making it increasingly expensive to use a private automobile. The Commission seeks not to hamper BART's operations but to minimize safety hazards. The Commission recognizes that safety is not an absolute--there is some risk in almost every aspect of everything people do. The Commission further recognizes that reasonable people may disagree about what is needed to minimize safety hazards, and if BART is to reach its full potential in attracting riders, those riders must have confidence that every reasonable step is being taken to provide for safety.

In this spirit the following decision will allow BART trains to run closer together than they now do, which will provide more frequent, and thus, more attractive service to riders. But

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1/ Appendix A is a glossary of terms used in this decision.

the order attaches two important conditions to this improvement in service. First, on a temporary basis the number of trains which may be in the transbay tube at one time will be limited to two under normal operation with up to four possible on occasion when operating procedures require such spacing in order to maintain optimum system operation. This condition will remain in effect until BART has replaced the seats on its cars with new seats containing much less flammable material. Second, BART and the Commission staff will jointly develop and recommend to the Commission operating procedures which would, after the seat replacement program is completed, replace the temporary restrictions mentioned above.

Linking close headways to seat replacement is justified because, under conditions that may not happen often but could clearly happen at times, as many as 9,900 BART passengers could, under close headways operation, be on trains in the transbay tube at one time. At present, the greatest number on trains in the tube at one time is about 3,300. Should there be fire on a train under these worst-case conditions, requiring not only evacuation of that one train but perhaps of others as well, clearly there would be substantially greater dangers with the present seats than with the much less flammable seats that will soon be installed. In other respects the new system should not affect the safety of BART's operations and, in fact, may reduce some of the potential hazards on the system.

The new system is the culmination of four years of development, installation, and testing by BART and the Commission staff and consideration by the Commission through hearings held over the last two years. The system was conceived by engineers at Hewlett-Packard Corporation and designed and installed by Westinghouse Corporation and BART's own staff. It will enable BART to cut almost in half its present train headways of about seven minutes. This will allow BART to operate 16 to 17 trains per hour through its heaviest traffic corridor in lieu of the ten operated today. BART's

passenger-handling capabilities will be increased significantly and train load factors should be reduced so that fewer passengers will be without seats during the peak hours.

An extensive monitoring program recommended by the Commission staff will be used to check on the reliability and safety of the SORS and provide information to determine the cause of any system malfunctions which might occur, malfunctions which may affect safety and could cause delays on the system.

Proceeding History

An explanation is in order as to why the Commission has taken over two years to come to a decision on this matter. The application was filed on December 6, 1977 and the first hearing was held on April 7, 1978. Twenty-four days of hearings were held during April, May, June, and July of 1978 before Administrative Law Judge (ALJ) Carol T. Coffey. During August and September 1978 additional detection tests requested by ALJ Coffey were performed by BART. On September 15, 1978 BART amended the application to revise the close headways start-up plan and to indicate to the Commission its plans for operations during wet weather conditions. An additional 23 days of hearings were held in November and December 1978, and the case was first submitted on December 21, 1978 subject to a briefing schedule running through the end of February 1979. On January 17, 1979 the transbay tube fire occurred[2/] and on February 7, 1979 the staff filed a motion to suspend the briefing schedule pending resolution of some of the issues surrounding the fire. This was granted by ALJ Coffey on February 13, 1979. Shortly thereafter ALJ Coffey retired and this matter was assigned to ALJ Albert C. Porter, who on June 28, 1979 ordered BART to submit an analysis of the effect of close headways operations on fire safety. This analysis was filed by BART on August 15, 1979 and four additional days of hearings were held before ALJ Porter in

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2/ See Decision No. 90144 dated April 4, 1979 in Case No. 9867.

October 1979. At those hearings BART's general manager, Keith Bernard, testified that after the January 17, 1979 fire, BART and the Commission staff agreed to defer the close headways program for an unspecified period of time. He stated that BART did not rush back into the program once it was back in operation after the fire because it wanted to spend time addressing points in the Commission's orders as well as mandates of BART's Board of Directors regarding improved fire and emergency safety; BART did not request further hearings on close headways until it was sure the program on fire safety and emergency procedures was well in hand. Mr. Bernard stated that BART spent a lot of extra time on its own volition examining closely the relationship between fire safety and close headways; this led to a program to change certain speed profiles on the system and modify the SORS protection system so that only one train could ever be between any pair of underground air vents. Only when that was completed did BART come back to the Commission seeking approval to implement SORS.

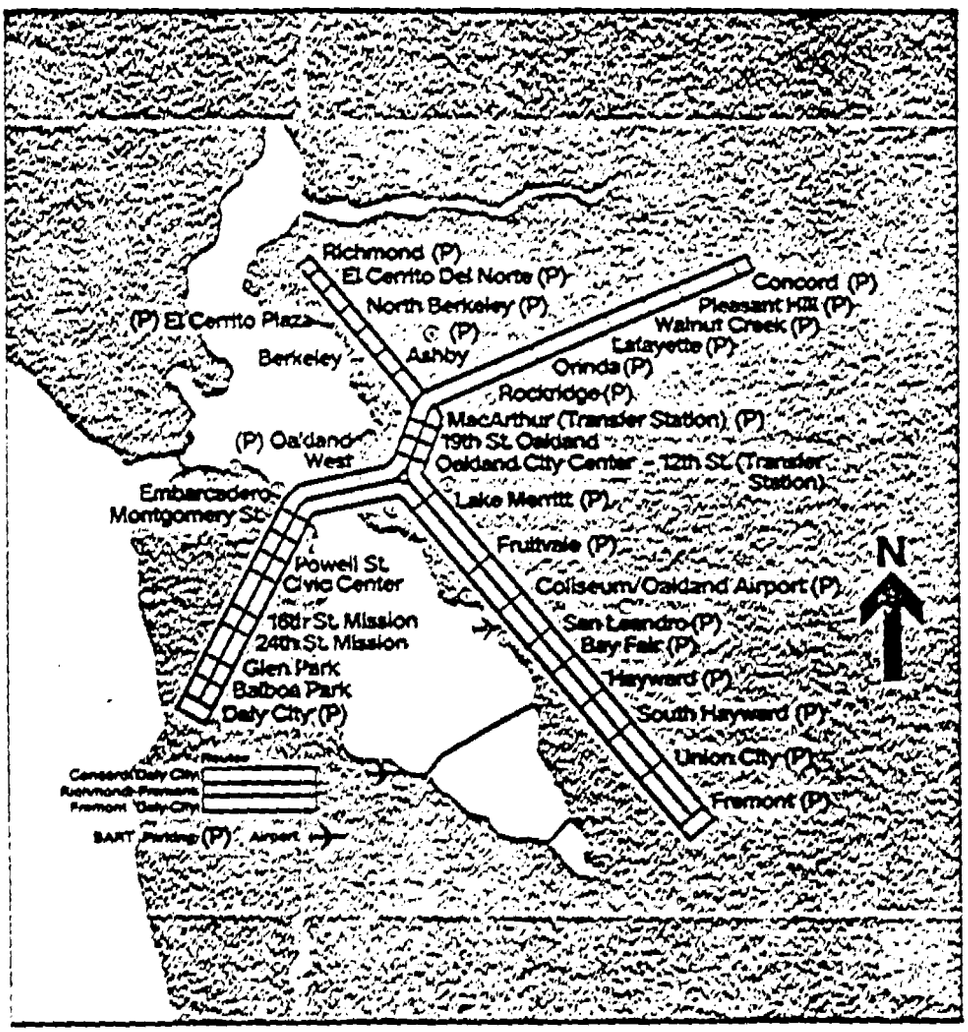
The application was submitted for a second time on October 19, 1979 on a briefing schedule extending to December 4, 1979. At its regularly scheduled meeting on April 15, 1980, the Commission voted to issue a recommended decision by ALJ Porter as a proposed report. This was done on April 16 and provided for the filing of written exceptions by April 30 and oral argument before the Commission en banc on May 7, 1980. Through the written exceptions and oral argument, BART made representations that were not, up to that time, a part of the record. Those representations are that BART can and will be able to limit the number of trains in the transbay tube at one time under SORS operation. This limitation will allow the Commission to grant immediate conditional approval to operate

the system under SORS. The specific representations are discussed under the section of this decision titled "Non-involved Trains". Accordingly, the proposed report of ALJ Porter has been modified herein in that respect. Also, a modification is made concerning the proposed report's recommendation on a monitoring system for SORS. Otherwise we have adopted the proposed report.

The BART System

BART is an electrified third-rail powered train transit system operating in the counties of Alameda, Contra Costa, and San Francisco. There is a total of 71 miles of route track on the system of which 23 miles is underground, including the Berkeley Hills Tunnel and transbay tube which are each about 3.5 miles long. The system is roughly shaped like an "X" (see Page 7) and serves from Richmond on the northwest to Fremont on the southeast and from Daly City on the southwest to Concord on the northeast. There are 34 stations on the system and three main routes, Daly City to Concord, Daly City to Fremont, and Richmond to Fremont. Transfers between routes are primarily made at MacArthur and Oakland City Center Stations. Two types of cars are operated, "A" cars which have control cabs and "B" cars which do not; all cars carry 72 seated passengers. Normal train consists range from two A cars and one B car to two A cars and eight B cars making ten cars the maximum and three the minimum. The approximate length of a ten-car train is 700 feet.

The BART System



Early Operation

Pre-revenue operational testing of BART's primary ATC system during July and August of 1972 indicated that the ATC detection of single unpowered cars, two-car unpowered dead trains, and two-car powered trains was not always reliable. Accordingly, when revenue service was initiated in September 1972, a manual block system was used. This entailed having a supervisor located at each BART station who was in communication with supervisors in stations preceding and succeeding his on the line. Assuming four stations in the system, A, B, C, and D, train separation was guaranteed in the following manner. With trains positioned at only stations A and C and moving in the direction A to D, the train at A was held by the supervisor at A until the train at C had left C and the supervisor at C had so informed the supervisor at A. The train at A could now proceed to B but could not leave B for C until the train that had been at C left D. This two-station separation on the system was necessary because trains had been known to run through a station without stopping even though they had been programmed to stop. The manual system was later replaced by a computer automated block system (CABS). Under this system computer control replaced the human supervisor on duty at each station. The first version of CABS, CABS-2, maintained the original two-station separation that had been implemented under the manual system. The version of CABS in operation today, CABS-1, maintains one-station separation which effectively allows much lower headways than two-station separation. Since September 16, 1974 BART has operated its entire system using CABS for train separation.

Present Operation

The present automatic train control system works in the following way. The 71 miles of BART track are divided into about 1,500 blocks of track each of which is electrically isolated from all others. The blocks range in length from 100 to 1,200 feet.

Electrical currents in the blocks are used to determine whether a train is present within the block. They are also used to transmit speed codes to the trains; these codes tell the train how fast to operate in each block or, in the alternative, whether it should be stopped. Assuming a series of blocks, if there are no trains within those blocks, then the speed of a train in the blocks can be greater than if a second train occupies blocks ahead of the first train. Likewise speed codes transmitted to blocks following a block occupied by a train are reduced accordingly, the closer such blocks become to the occupied block. These speed modifications are called "following move speed profiles."

Assuming four blocks, 1, 2, 3, and 4 in order and a normal maximum speed of 80 miles per hour, if there is a train just ahead of those blocks, speed codes in those blocks might be reduced to something on the order of zero in the fourth block, 18 in the third, 36 in the second, and 50 in the first. Blocks behind that could remain programmed at 80 miles per hour. The flaw in the system is that occasionally the ATC fails to detect a train occupying a block. This inability of the ATC to post an occupancy for a block even though a train is present there is a hazard to the operation and can lead to serious consequences. First, under the ATC system a train must be detected and then it must be protected from trains encroaching from its rear. The presence of a train in a block causes following move speed profiles to be generated for the blocks behind that train. This allows following traffic operating in the automatic mode to either come to a safe stop behind the occupancy or reduce speed prior to entering a block where a stop is required. Should a train suffer a detection failure, sometimes referred to as a "dropout", the speed codes in the block behind the train will revert to the higher speed codes of the through-train speed profiles, the speed codes that would reflect clear track ahead. As a result, the undetected train could be subject to a rear-end collision. This condition was the reason for the installation of the early

manual system and, later, the CABS-2 and CABS-1 systems. Under CABS operation, the central computer identifies each train on the system and remembers its progress. The computer can remember the last known position of a train even if that train should suffer a detection failure. This is the key feature of CABS. Should a train in a block have a dropout, the computer remembers that it was supposed to be there and will retain that information until the train has logically, according to the computer, returned to the block or left the area. The computer uses its information to hold a train at a station platform until it has determined that all of the track to the next station platform is clear of any trains and that any trains that have been on that track have properly exited the section.

Present System Limitations

The basic limitation of CABS is throughput of trains, i.e., headways. Under CABS-1 operating headways between trains can never be any shorter than the run time from one station to the next. As long as trains are kept one station apart on the BART system, then BART will basically be limited to approximately seven minutes between trains even during peak- or rush-hour service. This is the equivalent of operating between 33 and 36 trains on the system for typical rush-hour service.

The second constraint that CABS imposes on the system is reliability, and the key to that constraint is the two central computers at BART's central control facility at Lake Merritt. One operates on-line and one operates in a back-up mode ready to take control of the system should the first computer fail. There are times when both computers fail; such failures are infrequent, but occur in the BART system several times per year. The effect under CABS is that without the central computer tracking and releasing trains station-by-station, the system must stop. When both central computers fail, each

train in the system is stopped when it arrives at the next station. The train is held in that station and cannot proceed again in automatic until the central computers have been restored and all trains have been reidentified for the system. This obviously results in very serious curtailment of BART service and occurs because the central computers are involved in the train separation process.

A third aspect that limits BART under the CABS mode of operation is failure management. Failure management can be defined as the ability to manage equipment failures as they occur. Successful failure management is the ability to maintain consistent reliable service in spite of equipment failures.

For example, certain features which had been built into BART's train protection and train operation system have had to be disabled under the CABS operating system. An example is the capability of having a train run through a station. The advantage of being able to run a train through a station comes when a disabled train has off-loaded its passengers and BART is attempting to get it to the nearest siding and off the system as quickly as possible. Under CABS the crippled train, operating at reduced speed with no passengers, is required to stop at every station platform along its way even though its destination may be the nearest yard or siding. Under that operating procedure the crippled train slows down all trains behind it. Under close headways BART would be able to lift that type of restriction and get the train out of the way of the traffic behind it without causing vast schedule perturbations, to following traffic.

Another aspect of failure management is directly related to the decreased operating headways under SORS as compared to CABS. Under CABS and the one-station spacing, BART can run no less than about a seven-minute headway. That type of headway results in very little slack in the system and schedule disruptions anywhere on the system are immediately felt throughout the system.

The Close Headways Program

Neil A. Brumberger, manager of train control systems in BART's engineering department, testified concerning the reasons for and nature of the close headways project which was initiated in March 1976 and involved five major issues affecting system safety.

First, the detection issue that surfaced during the tests conducted in 1972 required a solution before BART could hope to operate trains at close headways.

The second issue was stopping distances. In order to achieve BART's original design goal of 90-second operating headways, the system was signaled for a 2.7 miles per hour per second brake rate. That rate implies that a train traveling at 27 miles per hour on level track would take approximately ten seconds to stop. Early tests of the system showed that this brake rate was too high and not always achievable; during wet weather conditions, in particular, trains routinely exceeded the stopping distances which had been built into the system.

The third and fourth issues dealt with two design flaws in BART's automatic train protection system. The BART engineering department identified these two flaws in the course of its review of the train protection system as, first, a design error in the speed code transmission equipment which is located along BART's wayside. This flaw could result under certain remote conditions in improper transmission of a speed command to a train. The second item was a design flaw in the speed code receiving and decoding equipment located in each of BART's A-cars. This flaw could cause a train to improperly interpret a speed command.

The fifth main element of the program dealt with the series of steps that had to be taken with respect to the central computer. These steps were not taken specifically as a result of any safety issues which had been raised but, rather, were steps to prepare the central computer for close headways operation and as such became part of the SORS program.

These were the basic issues which needed to be addressed and which necessitated the CABS program. In conjunction with consultants, BART undertook a program to resolve each of the issues and the result is the proposed close headways program.

The first element of BART's close headways program was to solve the detection issue, an issue that BART maintains has come up primarily under unrealistic testing conditions that entailed a two-car train whose revenue operation is precluded by BART's proposed order.[3/] Detection is presumably better with longer trains because there are more axles to create shunting across the tracks. Nevertheless, alternate means of protection were considered to augment the primary ATC system and among these SORS was selected and implemented as a means of solving the detection problem.

On the issue of stopping distances BART's original design, as stated earlier, called for a 2.7 mile per hour per second deceleration rate in order to achieve the original goal of 90-second operating headways. In wet weather trains cannot achieve that high a brake rate and exceed the stopping distances that were built into the system using the optimistic brake rate. CABS has been some protection against the brake problem even through it was for the primary purpose of overcoming the detection issue. The introduction of CABS alleviated the safety aspects of stopping distances by keeping trains sufficiently far apart so that even under slippery track conditions there is no threat of trains colliding. Also, BART introduced an impeded mode operation in wet weather which operated trains at 75 percent of the full normal speed. This feature prevented trains from over-running stations in wet weather. After an extensive program of testing which included

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3/ BART and the Commission's staff offered proposed orders that would authorize their versions of close headways operation. These were directly compared in Exhibit 87 which is attached hereto for reference purposes as Appendix B.

all kinds of conditions, the lowest brake rate observed was 1.73 miles per hour per second. After further testing BART has chosen two brake rates to reprogram the system. The first is 1.2 miles per hour per second for all exposed track, and the second is 1.6 for all covered track. On some covered track sections for certain reasons BART uses the 1.2 rate. (See the section on Underground Wet Track.)

Using those brake rates BART reprogrammed approximately 10,000 individual speed codes that are used on the 1,500 track blocks on the system. The new speed codes take into account the grades on the system as well as certain conditions surrounding stations, cross-overs, and yards.

Braking is the primary reason for the staff's suggestion that no trains with less than three cars be operated. The staff points out that speed profiles are designed with certain margins so that if there is a partial loss of braking on a train there would still be enough braking capability to stop that train safely. Assuming a ten-car train, if one car loses its brakes, there is approximately a 1/10th loss in braking capability. If a three-car train loses one car's brakes, the loss is approximately 1/3, a much more serious situation.

It appears that BART's automatic train control system is now programmed for realistic stopping distances for the conditions that BART has found through experience trains will encounter.

The third and fourth elements of the program basically dealt with redesigning the speed code transmission equipment at the wayside to correct the failure mode which had been identified. BART also redesigned and modified the speed code receiving and decoding equipment on board the A-cars to rectify the design flaw that had been identified there. These activities were implemented under existing Commission orders and have received staff approval for use in revenue service and, therefore, no further authorizations with respect to those two modifications are being requested in this application.

The fifth element of the close headways project has involved a modification to the central train control computer. The purpose of the central computer is to maintain a schedule and to adjust headways to provide uniform service throughout the BART system. The computer also monitors and displays alarms from various pieces of equipment located throughout the system to the central train controllers and supervisory staff. The central computers, in their original design concept, did not have direct train safety responsibilities, although under CABS they maintain train separations. Train protection is built into the local hard-wired ATC equipment which is located in every station and along the wayside of the BART tracks. The issue that has arisen with respect to the central computers is that early tests, which the BART engineering department conducted in conjunction with Lawrence Berkeley Laboratories (LBL), indicated that the central computer would be operating at full capacity with 50 to 60 trains on the system instead of the 105 trains expected within the original design. BART expects that when the central computer reaches its full capacity its responses will become sluggish, and delays on the order of a fraction of a second will be incurred in the posting of alarms or in responding to commands from the central supervisory staff. This is not a very significant amount of time but would be noticeable to the central supervisory staff. It is possible that with the computers operating well above capacity, this sluggishness would worsen and might cause a delay of one or two seconds in the posting of information to the staff. Therefore, BART took a number of steps to increase the capacity of the central computers and it appears now that the computers will operate quite satisfactorily with the expected number of trains (43) that will be on the system under SORS operation.

The SOR System

SORS is made up of 52 mini computers, two computers in each of 26 train control stations. The two computers in each station are fully redundant, operate 24-hours per day, are on-line,

and maintain full train protection at all times. In the case of failure of one computer, the other computer is fully capable of protecting all trains in the area. Under the unlikely possibility that both computers might fail concurrently, local sensors in that station detect that fact and enforce a 27-mile per hour maximum speed restriction in the affected area. That speed restriction is maintained until at least one computer is back on-line and all trains in the area have their SORS protection restored.

Under SORS a train is never lost in the system because SORS always remembers if there was a train in a block and whether that train has logically left the block and the block is clear. SORS maintains 700 feet of protective occupancy behind the most forward position that a train has achieved. As the train moves through the system from block to block, SORS moves along with it; as long as the train progresses block-by-block through the system, SORS advances its protection by adjusting following move speed profiles behind the train, always moving that protection up as the train moves. Should the train encounter a detection failure, SORS would not advance the protection it established behind the train when it was in the block in which it lost detection. This detection failure results in SORS stranding or retaining the occupancy latches behind the block that the train was last in and not advancing them. The effect, of course, is to stop any following trains operating in the automatic mode from encroaching on the lead train which has suffered a detection failure. This is the fundamental feature of SORS, i.e., it requires that the train be detected in every block along its route and as long as it does so, SORS follows it with protective latchings. Should a train drop out SORS remembers the last block it was in and will not let another train into that block or lift any following speed profiles because SORS presumes it is still occupied. Because SORS works on the track circuit level and uses the blocks that are built into the track system, instead

of the station-to-station level as CABS does, it can safely allow for higher throughput because the distances between the shunts that SORS uses, i.e., the A-points between blocks, are much less than the station-to-station distances.

It should be understood that the primary ATC system will still control the operation of the system; the purpose of SORS will be to insure that if the ATC system loses a train through lack of detection and tries to give a following train an improper speed code, SORS is the backup protection to prevent such an occurrence. Under SORS, unless the track ahead is clear and ready for the type of speed code that the ATC would generate, SORS steps in and prevents the ATC from acting improperly.

Advantages of SORS

The general manager testified that in his opinion ridership on BART would increase as a result of the implementation of close headways because the load factors will be reduced and the operation of trains directly from Richmond to Daly City would be inaugurated. In his opinion this would bring an immediate increment in patronage because people now using automobiles or buses will switch to BART. BART believes it can attract new passengers who have not regularly used BART before by providing a service that does not cause passengers to wait on a platform for a long period of time.

The general manager testified that he could project, with some confidence, that the load factors on BART will be less for an initial period after the institution of SORS. That initial period may be only a year or less but certainly the first six months should see a definite drop. That drop should induce additional demand and patronage should continue to grow from there. BART plans for train consist sizes and schedules which limit load factors to a 1.3 average in the peak hour.

Witness Brumberger testified that BART has enough equipment at the present time to support a three-minute minimum headway on the system.

Other advantages of the SORS are discussed under the section on fire safety.

Evaluation and Testing

BART has utilized a set of criteria in its evaluation of the safety of the proposed change and submitted them in the hearings as Exhibit 46. There is no pat mathematical formula that can be used to specify a level of safety. No such overall criteria have been developed for the BART system nor for that matter, any other transit system that participants in this proceeding know of. Ultimately the question of safety rests on judgment and judgment must be exercised on the basic question posed to the Commission of whether BART's proposed mode of operation will provide an adequate level of safety for BART riders. In the judgment of the parties who have worked with this system continuously for extended periods of time, the operation under SORS should be at least as safe as under CABS. Those parties are, in addition to the BART staff, the Commission's staff and independent experts from LBL. They all generally support BART's application, although there are several points of disagreement between BART and the staff which will be discussed herein. In point of fact, no one has opposed BART's basic request. BART is not asking to operate the system under the ATC with no backup. The backup they are proposing is SORS.

In making extensive analyses and reviews of the proposed system, BART relied on many experienced institutions in the Bay Area. These include Westinghouse Corporation who helped design and install SORS, TRW Corporation, SRI International, Hewlett-Packard Corporation, LBL, and the staff.

SORS has gone through a very vigorous installation acceptance phase and frequent preventive maintenance tests have been performed on all of the SORS computers. There have been six full-scale demonstrations under the close headways mode of operation at

three-minute operating headways. These tests were conducted in February, March, and April of 1978. With the exception of one SORS-related incident, which was a design problem revealed during the demonstration on February 12, 1978 and which is discussed below, all of the demonstrations, including high-density demonstrations, were successful with SORS performing properly and maintaining continuous train protection.

The February 12, 1978 problem occurred during a high saturation test which involved operating as many trains as possible on the system to see if SORS would provide appropriate protection. Operators of trains in the vicinity of the incident reported that they were stopping with only one shunt separating their train from the train ahead. This meant that a train occupying a block was approached by a second train in the block immediately behind the first train; under the general rules of SORS protection, that should not have occurred at the particular locations involved. During the incident all trains came to safe stops and no unsafe condition existed. However, the incident violated the rules programmed into SORS for separation and resulted in subsequent investigation and changes to SORS.

SORS was initially installed by Westinghouse Corporation in 1974 and completed its first series of acceptance tests in the first quarter of 1975. For practical purposes it has been on-line and operating ever since. It has been operating subordinate to CABS but, nonetheless, there have been 4½ years of operation of the SORS computers in the parallel mode.

Issues Between BART and Staff

At the close of the first set of hearings in this matter in December 1978, there were six outstanding issues between the staff and BART. The first of these was the so-called B-point issue.

This issue related to certain aspects of the train detection system under SORS operation. The second was the program to monitor performance of the SORS when it goes into operation. The third was the issue of whether SORS constraints should be utilized during revenue service only or whether they should be required during nonrevenue service as well. The fourth was the speed with which close headways operations should be phased in. The fifth was the manner in which additional trains would be added to the system and whether or not the addition of those trains should require Commission staff concurrence. The sixth and last issue was the extra reporting that the Commission staff had requested of BART and the time during which such additional reporting measures would be necessary. In addition to those six, two other issues have surfaced since the close of the initial set of hearings. The first of these is the impact that close headways operation might have on fire safety; the second concerns the resignaling of certain portions of underground track on the San Francisco line (M Line).

Over the year and a half period that this proceeding was litigated, BART and the Commission staff have cooperated extensively in defining the issues involved and attempting to solve them. The points at issue between BART and the staff that remain now are: monitoring the new system, operation during nonrevenue service, the undergroumd vent separation system, certain operating restrictions, additional reporting requirements, fire safety, and resignaling wet underground track. These are discussed in the following portions of the decision, together with the B-point issue because of its importance to the BART operation and safety considerations.

B-Points

Witness Brumberger explained the purpose of B-points as follows. In the original design and construction of the BART system the track structure was separated into the series of 1,500

individual track circuit blocks established by A-point shunts and discussed elsewhere in this decision. BART found that some of these track circuits were too long to properly define, for operating purposes, the position of a train in the system. Therefore, in some of the blocks one or two B-points were established which did nothing more than provide a mechanism to determine the relative position of a train in the block. As an example, a block defined by two A-points at each of its ends can be divided into three sub-blocks by the addition of two B-points within the block. This would allow the ATC system to precisely locate the position of the train in the block relative to the three sub-blocks.

What is the purpose of B-points then from an operational standpoint? An example of their use would be the Daly City end of the transbay line. One of the primary things that BART must make sure of is that a train does not go beyond the end of a platform, particularly at the end of a line such as at Daly City.[4/] Yet, BART wants to be able to berth a train in the station automatically without the train operator assuming the train controls to hostle it in manually because manual operation is more time-consuming. When BART was built, the end-of-the-line block at Daly City was equipped with a single track circuit and one transmitter. That transmitter can transmit only one speed code at a time. BART wants the train given non-zero speed codes at a long enough distance from the end of the track so that the longest train can berth in the station and, yet, have all trains traverse the block at the highest speed possible. To accomplish this, B-points are used. As the train enters the block it is given a speed code of 18 miles per hour. As it crosses the first B-point and is detected, the speed encoding equipment would change the speed code to six miles per hour. As the train progressed further into the block and crossed the second B-point, that detection would result

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4/ At the Fremont Station on October 2, 1972 a train ran through the end of the line and landed partially in the parking lot.

in a speed change from six miles per hour to zero. The net effect is that one track circuit has been used to transmit three different speed commands to the train.

The effect of this system is that the passage of the train into the block and over the B-points may affect the speed of the train in that particular block but not its protection from the rear because the hard-wired ATC system only knows that a train is somewhere within a block. B-points are not shunted points as are A-points, that is, the track is not broken at a B-point. It is the lack of this shunt that precludes SORS from being a back-up to B-points because SORS works only on the primary blocks within the ATC system. With no SORS back-up with its protective measures to come into play, a hazard is created in the system.

The question arises as to why BART did not replace all the B-points with A-points and simply make more blocks within the ATC system. To do so would require replacing one track circuit with three, for example, when two intermediate B-point shunts are installed. Two more sets of transmitters and receivers and the modifications therefor would be required. Such a retrofit for the system would be an enormously expensive undertaking and disrupt service for an extended period of time. A perfect solution, of course, would be to remove all B-points from the BART system. However, this would cause serious degradation of service in terms of extended trip times, longer headways between trains, and frequent manual train operation.

Although the extent of the risk is unknown, loss of detection from moving trains is at least rare if not, as BART claims, nonexistent. The worst consequence of such a loss would be a collision at the speed of the train just prior to the B-point, typically 18 miles per hour, less whatever deceleration is accomplished after crossing the next shunt or by a train operator exercising an emergency stop. For a collision to take place, an obstacle, most

likely a train, would have to be located within that deceleration distance. These factors combine, the staff claims, to create an unquantifiable risk which, in its opinion, does not justify a wholesale removal of B-points.

The culmination of the B-point problem came about in a letter dated October 5, 1979 from R. S. Weule, BART's director of safety, to Alex E. Lutkus, manager of the Commission's BART safety section. This letter outlined agreements which were made at a meeting September 18, 1979 between a representative of BART and the Commission staff. Of a total of 233 B-points in the system, 40 were identified as performing no essential functions and which BART has agreed to totally disable prior to inaugurating close headways operation. Twenty-nine other speed profiles involving B-points were identified as nonessential and will be modified. The list of B-points to be wholly disabled and speed codes to be modified was attached to the letter which is Exhibit 88 in these proceedings and is attached as Appendix C. Witness Brumberger testified that in his opinion there would be no measurable degradation in service as a result of the agreement. This is because none of the 69 modifications to be made occur at critical headway locations or other constraining places in the system.

The order herein authorizing close headways will also provide that the Commission's staff shall be advised of any future changes in the status of B-points because, as witness Wesley Erck, computer control system specialist for the staff, testified, BART's speed profiles may change from time to time and certain functions that are provided by B-points may also change. We will order that any modifications will be reviewed by our staff and brought to the Commission's attention if it is necessary to alter the order herein. This will give BART some flexibility in this matter.

Monitoring Program

One of the main issues remaining between BART and the staff involves monitoring SORS after installation. The monitoring program would be a means of overseeing BART's operation during the initial phase-in of close headways, assessing the safety of the revised operation, and, in the case of the staff's proposal, a continuous monitoring of SORS and its functions. BART opposes such a special monitoring program. For several reasons it believes it is not necessary. BART points out that it already has a very extensive and sophisticated capability for monitoring and investigating safety violations on its system. BART claims the highly trained engineers in its safety and engineering departments with their specialized test equipment for use in review of equipment failures are all the capability needed to determine the cause of any suspected safety violation. BART maintains it is ready to thoroughly investigate any suspected safety violation that might arise and would curtail close headways operation if it had any evidence that a flaw existed in its train protection system which might threaten safe train operation. BART prefers to tailor its investigative steps to the particular problem arising and the specific circumstances surrounding that problem. Nevertheless, at the insistence of ALJ Coffey, BART submitted a 4-part monitoring program (Exhibit 54).

The first part of BART's program monitors for proper SORS operation. This would be accomplished by painting each of the shunts in the system, i.e., each of the copper bonds which define the limits of the some 1,500 track circuits, with a highly visible fluorescent paint. Markers would be added to the trackway 700 feet to the rear of each of these shunts, thus, defining the limit of the length of a ten-car train. This feature would permit train operators to determine whenever their train had come too close to the train ahead and had perhaps violated proper

SORS protection. Train operators would be required to report any incident where they could not see at least two painted shunts or one painted shunt and one 700-foot marker between their train and the one ahead. The second feature of the program would cause the red taillights on a train to flash at about a two cycle per second rate any time the track circuit behind the train did not have a protective zero speed code. This flashing red light would alert the train operator of a following train whenever the train ahead might not have protective following move speed profiles. The third element of the proposed monitoring program deals with the recording of SORS operation. BART proposes to install cameras in each SORS station during the first 48 hours of close headways operation. These cameras would be placed on a display panel which is part of each SORS installation. That panel contains lights which show the status of every occupancy and every SORS protective latch that is being generated by the SORS computer in that station. By recording that information during the first 48 hours of close headways operation at each station, BART, through subsequent analysis, would be able to determine that proper close headways operation was taking place. Further, BART proposes that any time a safety violation or a suspected violation occurs it would install a camera in the station involved, record a minimum of ten hours of SORS operation, and use that data to supplement other investigative measures in resolving suspected safety violations. The fourth element in BART's program deals with preventive maintenance procedures for the SORS computers. BART proposes to increase the frequency of preventive maintenance procedures for SORS computers from every 60 days to every 30 days. The last aspect of the BART program is not a monitoring feature but rather a limit on its use. BART proposes that during the phase-in period of SORS extra measures be employed over and above the monitoring and investigative capabilities that BART already has in place. BART would continue that extra monitoring for 90 days after the entire system has been operating under close headways.

The staff proposal would provide for devices to be permanently in place to collect data on a continuous basis at all SORS computer locations. Under its program, whenever anything is reported as a possible violation BART would be able to go out, collect the already recorded data, analyze them, and determine whether, in fact, an incident or violation had occurred, what had led up to its occurrence, and, quite probably, what mechanisms contributed to its occurrence. The staff claims its proposal would provide a record of incidents as they occur thereby providing a record that could be used to understand the nature of the incident and whether, in fact, it was a violation at all, and what subsystem contributed to the incident. The staff maintains that a record of the SORS inputs and outputs can be used to determine whether the inputs were coming in a normal fashion and whether SORS algorithms were generating outputs as predicted and as understood by people knowledgeable about the SORS operations. The staff claims that if those cases check out, one can isolate the failure to either the speed encoding equipment as failing to respond to the SORS protection or the inability of the train to respond to the speed codes. Under the staff proposal BART would be required to analyze tape data only in the case of a specific violation. These reports of violations would come most likely from train operators following procedures described in BART's proposal.

The staff, in a lengthy critique of BART's proposal, claims that BART's system would largely correspond to the staff's as to the type and volume of information that could be gathered, but the problem the staff sees with the BART proposal is that BART would not install the equipment until after an incident had happened. Under the system proposed by BART, unless these incidents happened during the initial 48 hours of the SORS installation, BART will not have a monitoring device in place. Therefore, the staff believes there will be no way to reconstruct an incident other than what can be done with whatever operator report is available at the time, and BART could only hope that the incident would recur, and

recur within ten hours. The staff points out that as SORS operation is improved with use as time goes by, operational anomalies in the system will become less frequent. As anomalies become rare it may take weeks of collecting data in order to get the incident to recur. During that time, passengers would be exposed to the possibility that it might recur and lead to an accident. Also, it could be something that recurs well after the ten hours of observation that BART plans to make after an incident has occurred. The staff maintains that when an incident occurs, BART does not propose to install monitoring devices systemwide but only at the location of the incident. It is possible with a system as sophisticated as SORS that that same problem may occur but somewhere else on the system where the monitoring devices which have been installed will not pick it up at all. The staff has no problem with what BART has proposed as a means of partially fulfilling the needs of a monitoring program but claims that the recording devices are inadequate from the standpoint of number and continuity. The staff claims that although, initially, it will cost more to install the staff-proposed monitoring system, over a period of years it may reduce the cost of determining what has occurred during an incident on the system. This is because the data will be available quickly and in more complete form than would be the case with the BART proposal.

To summarize the staff position, it claims that what is missing in BART's proposal is the ability to reconstruct a violation so a determination of what happened and what led up to or caused the incident to occur can be made. Setting the monitoring equipment up after the incident and monitoring for an arbitrarily short time, would lead to delays in collecting data. The staff proposal would allow for immediate investigation and a determination of whether an actual incident had occurred. Under the staff plan there would be no reason to restrict BART's operation while an investigation is

being made of a reported incident. The staff claims that having the type of data that would be available from their plan would not put the Commission in the awkward position of having to decide between several alternatives such as shutting BART down, ordering BART to go back to CABS-1 for a while, or letting BART continue to operate under SORS with the possibility that there may be another incident and/or accident.

The overall BART position regarding the Commission staff proposal on monitoring is that such a special program is really not necessary nor appropriate. BART believes it would be more useful to employ available funds to investigate suspected safety violations using the same technical judgment and facilities that have successfully been used in the past by BART. BART cites as an example of that approach the investigation that was made following the February 12, 1978 high-density demonstration where, in a matter of a few days, the problem was identified and solved. BART claims that the Commission staff admits that the kind of continuous monitoring program and recording that the staff has proposed will not permit the resolution of every suspected incident that might occur on the BART system. BART claims that it is not feasible to install a monitoring system that is capable of identifying the cause of every suspected violation that could occur. Therefore, the choice becomes one of maximizing the technical effectiveness of the program at a reasonable cost. The major differences between the staff's proposal and BART's, according to BART, is that the staff program would require BART to record all SORS inputs and outputs in all stations 24 hours a day, 365 days a year, for as long as SORS is used to protect trains on the system. BART believes this to be excessive and unwarranted. It believes that the proposal does not address the specific request of ALJ Coffey nor does it enhance the safety of the system.

In answer to a question on whether or not BART had ever been unable to resolve a reported loss of SORS protection either in tests or in any other monitoring of the SORS computers, witness Erck testified that in discussions with BART personnel there are times when it is difficult to figure out what has happened when incidents occur, but that with varying degrees of probability, the explanations or resolutions are accurate. He stated that the loss of SORS protection is something that probably has been explained in each of the instances so far, although failure of SORS to track a train has not always been explained as completely or as finally as the staff would like. While the February 12, 1978 incident was resolved to the satisfaction of everyone, BART was not at that time running seven-day-a-week service, nor was the system saturated with trains. Mr. Erck said that if a similar incident were to happen during revenue service today, he would question whether BART would stop the service to conduct the experiments that were conducted immediately following the incident.

BART introduced, as Exhibit 79, an estimate of the cost of implementing three different versions of the Commission staff proposal and the proposal of BART (see Appendix D). The staff has no comment on the estimated costs of installing its recommended system. The three versions which are displayed in Appendix D are acceptable to the staff as adequately describing the installation to be made and the estimated cost of that installation.

The proposal of BART would require an additional 3.5 persons, a capital cost of $10,000, and an annual operating cost of $39,000. However, it should be noted that the $39,000 annual operating cost is for only the first 4½ months of close headways operation since the BART proposal will not be one of continuous monitoring but will come to an end after close headways operation has been fully implemented.

The first way that BART would implement the staff proposal, version one, would be to extend the BART proposal for filming SOR display panels in each station utilizing time-lapse cameras. This would cost BART $25,000 in capital cost, $1,116,000 in annual operating cost, and 30 additional personnel. Versions two and three would employ two different methods of computerized data collection. Version two would involve installing a magnetic recording system in each SORS computer in each station to capture the SORS information directly from the computer itself. This proposal would require a capital cost of $360,000, an annual operating cost of $564,000, and 17 additional personnel. Version three would require a new central computer to record and store the required information. This would be a specialized mini-computer operating through leased telephone lines, would be connected to each of the remote SORS locations, and would capture the data from one of the two computers in each location. The cost of that program would be $640,000 in capital expenditures with an ongoing operating cost of $20,000 per month and require five additional personnel. BART claims that the last two options, versions two and three, would require over one year to install and that would be from the time the BART staff has the funding and authorization from the general manager to proceed.

The staff admits that it does not have any specific guidelines as to how much money should be spent for a given amount of safety, particularly when it is very difficult to determine just how much safety is going to be provided by any particular program. The staff readily admits that the cost of its program would be approximately as shown in Appendix D. The staff realizes its program will be expensive but believes that the features it proposes are very desirable and that the costs are small compared with the overall costs of the close headways project.

Of the three BART versions for implementing the staff proposal, the staff favors version three. Although it has a quite high initial capital

cost the ongoing cost is considerably lower than the others. It would provide data available at central and could essentially be called up at any time without the delay of someone going into the field to retrieve the data. The staff suggests that if version three would take BART considerable time to get into place, then it recommends adoption of version one in the interim. BART could proceed with staff version one until the other system was in place and then make the switchover.

Witness Brumberger testified that there would be no degradation in service should the Commission choose the staff's proposed system. The general manager testified that if authorized by the Commission, BART will proceed with the close headways project regardless of which monitoring system is ordered by the Commission.

BART's understanding of the staff monitoring system as being one of perpetuity is incorrect. The record shows that the staff suggests that the monitoring system be in place only as long as the system is operated under SORS. It is possible that in the future the SORS will no longer be needed because the ATC system will be shown to be operable without the possibility that it would lead to accidents on BART.

BART claims the staff's system would entail a large cost for reviewing tapes and analyzing devices and information collected. However, the staff testified that BART would be required to review tapes and analyze them only if an incident occurred. If no report of an incident is made, then the data become expendable. Under the staff and BART proposals the detection of incidents would not differ, but the availability of data with which to analyze the incident would be significantly different. The data available under the staff program will be far more complete and timely.

At the request of the ALJ, BART's counsel filed a letter stating that BART uses 8 percent as the in-house interest rate when assessing the feasibility of proposed projects. Witness Brumberger

testified that the estimated economic life of the equipment BART would install to implement the staff program would be ten years. Using these two figures and the capital and annual costs shown in Appendix D, the uniform annual cost for version one installed for the first year and version three for the next 10 years can be calculated as follows:

Present Worth Factor, 1 Yr., 8% = 0.926
Present Worth Factor, 10 Yrs., 8% = 6.710
Capital Recovery Factor, 11 Yrs., 8% = 0.140

Present Worth of 11-Year Project:

1 x $1,141,000	=	$1,141,000
0.926 x 6.710 X $240,000	=	1,491,000
0.926 x $640,000	=	593,000
Total Present Worth		$3,225,000

Annual Cost of 11-Year Project:

0.140 x $3,225,000 = $452,000

Assuming BART carries about 40,000,000 passengers per year (the record indicates about 150,000 per weekday plus weekends) the cost per passenger trip would be about 1.1 cent. It appears the staff program would be well worth that small investment in safety. However, before committing such a large sum to an 11-year project it would be appropriate to gain some experience with monitoring. Therefore, we will order BART to implement staff version one for one year and report on its effectiveness and costs at the end of nine months' operation so that a more reliable evaluation can be made of what kind of permanent monitoring system should be installed.

SORS Operation During Nonrevenue Service

This is the third of the issues remaining between the staff and BART. BART takes the position that utilizing SORS protection during nonrevenue service is unnecessary and inappropriate. BART claims it wants the ability to operate without SORS during nonrevenue service hours because of the limited daily period available to accomplish needed activities on the system such as track maintenance, SORS maintenance, movement of trains from one yard to another, tests and other activities which must be restricted to nonrevenue service periods. Requiring that SORS be imposed during these periods would limit the effectiveness with which BART can use the two or three hours each night during which all trains are removed from the system and the track is available for nonrevenue activities.

The performance of SORS maintenance at night would require that SORS be turned off (disabled) at particular stations. The disabling of both SORS computers at a station will cause a 27-mile per hour speed limit restriction on all trackage under the control of that station. Frequently BART will have only one train on the system and it would be in the process of transferring from one yard to another for some purpose. If that train had to traverse a station in which the SORS computer had been turned off for preventive maintenance, it would be required to limit its speed to 27 miles per hour even though no other trains were in the vicinity. That limit would cause an extension of the time that BART needed to make such transfers and would limit its ability to perform other functions on that track. BART points out that the CABS order of the Commission applies only to revenue service hours.

The position of the staff on SORS operation during nonrevenue service is simply that the safety of BART employees and BART equipment is just as important as the safety of revenue passengers. The staff proposes that SORS may be turned off and the 27-mile per

hour restriction disabled during nonrevenue service if BART will adopt acceptable and simple manual procedures to be followed under these circumstances. If both SORS and its speed restriction backup are to be disabled, there must be some other means for keeping trains safely separated. The staff claims BART's example of a single train being unnecessarily delayed is irrelevant because as long as no other trains are on the system, the procedures are moot because there would be no other trains to be concerned about. The staff points out that the procedures would only need to assure that, in areas where SORS is disabled, trains are kept reasonably separated.

Another of the ordering paragraphs for this decision as proposed by BART and the staff has to do with certain conditions to be put on performance regulations effective with the removal of the CABS restrictions. The major difference between the two proposals is whether the conditions should be required during nonrevenue service as well as revenue service. It is the staff's position that these performance regulations and SORS operation should be required at all times unless specific procedures are developed to allow exceptions during nonrevenue service only. The issue is much the same as operating SORS during nonrevenue service. Again, the staff's point is that if the protection that the proposed ordering paragraph would provide is required during revenue service, there is no reason for BART to reduce that protection during nonrevenue service because it should provide the same protection to its employees

as it does to its paying passengers. The staff claims that during nonrevenue service traffic densities should not be great and BART should be able to provide the same separation between disabled trains at nonrevenue times that it does during revenue service. One of the main points is that no train with less than three cars may be operated during nonrevenue service under the staff proposal whereas, under BART's proposal, a one- or two-car train could be operated. Because of the braking problems that have been incident to the system in the past, the staff claims that operation of trains of less than three cars could create an unsafe condition.

BART's argument that the ability to move trains expeditiously during nonrevenue hours will be hampered by the operation of SORS does not stand up. In the worst case there will be a slowdown to 27 miles per hour on the span of track controlled by a SOR computer pair that is turned off for maintenance. It is hard to understand how this can be an example of a degradation of service because BART witnesses, when testifying in support of SORS, stated that it is going to speed up the system and that, among other things, there will be the ability of running trains through stations. If a partially disabled train has to be moved from a given point on the system to a maintenance yard, why it would move any slower or any differently during nonrevenue service with SORS turned on or off, except for the case noted above, escapes us. Also, the staff proposal allows for specific procedures to be adopted to provide equivalent protection during nonrevenue service. We will adopt the staff proposals on this issue.

Phasing in SORS

At the end of the previous hearing there was a considerable difference between the BART and staff recommendations regarding the initial area for installation of SORS. During the hiatus in this matter from January to June 1979 and through the summer of 1979 prior to the last set of hearings, the staff considered BART's and its own proposal and developed what it believes adequately meets the need for an initial service area and it is acceptable to BART. The geographical confines of the proposed area for initial close headways operation have never been in dispute nor is the staff interested in how slowly BART phases in close headways. It is

concerned that BART sustain SORS operation at no less than six stations within the initial area on a continuous basis. The staff summarized its position in a proposed ordering paragraph concerning the matter which requires that there will be at least 30 concurrent days of SORS operation at no less than six stations within the initial service area before further expansion. The staff recommends the above so that the effects of close headways operated through contiguous stations can be assessed, not just the marginal effects of a station here and there. Thereafter BART could phase close headways operation into the remainder of the system at any pace desired.

The initial service area for close headways agreed to by BART and the staff is a high-density corridor bounded by the Ashby, Orinda, Coliseum, and Daly City stations.

BART now adopts the language and intent of the staff proposal in regard to the initial service area and the period of service prior to an expansion of SORS beyond that area.

Maximum Trains on the System

Operation under close headways will permit BART to increase the capacity in the transbay corridor from an average of ten trains per hour to 16 or 17 trains per hour during the peak commute period.

In moving from the ten trains per hour to 16 or 17 that BART expects under SORS, the 16 to 17 limitation is not a result of the number of cars available or SORS itself. BART has enough cars to run more trains than it proposes and SORS would not be a limiting factor. The current limitation is the turnback capability at Daly City.

This brings us to another issue between the staff and BART and that is the question of the saturation limit of the central computer from the standpoint of how many trains can be safely operated on the system at one time. BART claims that the limit is

50 to 60 trains. BART had proposed to add trains to the system until it reached roughly 42 or 43 trains when it would perform a measurement on the central computer to verify that it was not exceeding its capacity. BART would use that data to refine its projections of saturation and thereafter extend the number of trains on the system beyond 43, possibly to the 46- to 50-train level. When that next plateau had been reached, BART would again monitor the central computer and use that data to further refine its saturation projections. The original staff proposal on this issue would have required all of the above steps as well as a stipulation from BART that it receive staff concurrence each time it wanted to add trains to the system beyond the 43-train plateau.

BART and the staff now agree on an ordering paragraph that puts the maximum number of trains that may be operated on the system at 43 until the staff is adequately notified. It provides for information which will enable the staff to make an assessment as to whether further information is going to be required and at what point in service that information will be needed. We will adopt the proposal.

Reporting Requirements

BART and the staff each propose an ordering paragraph that refers to monthly reports by BART to the staff containing measures of service reliability and performance indices. There is a difference in the proposals concerning the length of time that the ordering paragraph would be in effect. BART proposes that the period commence with the initiation of close headways operation at the first SOR station and continue until 90 days after the systemwide close headways operation has been implemented. The staff takes the position that it is difficult to predict how long this information is going to be useful to it. It may find that some of it does not meet its needs but that some of it is very useful even in the long term. Therefore, the staff wishes to keep the matter open so there

will be a flexibility available to it. This flexibility would allow for a later decision on how much information is required and how long it should be furnished. A precedent for this was set in the past by the cooperative efforts of the staff and BART. The staff has authorized discontinuance of a number of items that were previously required to be filed with the Commission and has taken actions necessary to alter previous Commission orders so as to discontinue the filing of information found to be of no further use to the Commission. We will adopt the staff's recommendation on this issue.

Overview of Fire Safety and SORS

Following the fire which occurred in the transbay tube on January 17, 1979, a number of questions were raised about fire safety including the possibility that the removal of the CABS constraints and the approval of SORS would affect fire safety particularly in the transbay tube and the Berkeley Hills Tunnel. This was the purpose of the ALJ Ruling issued on June 28, 1979 which reopened hearings and called for BART's analysis. BART's response acknowledged that unconstrained close headways would have an unacceptable effect on fire safety under certain conditions. Under the close headways operation there could be a number of trains at one time in the transbay tube. Without going into fire safety, per se, which is the subject of another proceeding before the Commission, the following issues relating to fire safety arise when considering authorization of close headways operation.

1. Passenger evacuation and train load factors.
2. Passenger evacuation and train traffic.
3. Smoke and ventilation.
4. Fire fighting and the removal of passengers on non-involved trains.

In examining each of these four issues in its report, BART attempted to look at all factors of a future train fire and

determine which might be affected by changing the operating mode from CABS to SORS.

In evaluating the four relevant fire safety issues, vis-a-vis close headways operation, BART maintains that passenger safety will be equal to or improved under the close headways operation and that no specific areas could be found in which passenger safety would be significantly degraded.

Ralph Weule, director of BART's safety department, testified that the problem with fire safety and close headways can be reduced to the possibility of having a non-involved train stop behind a burning train in such a position that smoke is drawn through the ventilation system across the non-involved train. Under the current CABS operation that would be highly unlikely because of the single station separation enforced by CABS-1. Under close headways operations, the probability of such train positioning occurring becomes quite likely. This could occur in the underground areas of the system. BART's solution to the problem is to set up criteria to implement a vent separation system. For instance, in the transbay tube, BART has ventilation dampers located about every 1,000 feet. Under the proposed vent separation system there could be no more than one train between two adjacent vents. In the case of the Berkeley Hills Tunnel there are vents only at the ends of the tunnel, therefore, BART would allow only one train at a time on each of the tunnel tracks. The same constraint would apply in other underground areas; only one train would be allowed between any pair of vents.

Witness Weule testified that system improvements are underway or planned to improve fire safety in underground areas. Although this is the subject of a separate proceeding, he testified as to the following improvements which BART is either in the process of making or has made: a new communications system installed for the fire department; improved markings in underground areas such as renumbering and repainting of doors, exit signs, and arrows; vehicle

modifications such as collector shoe replacement, resistor covers, shoe fuses, and seats; covering the catwalk in the Berkeley Hills Tunnel to give better footing to patrons under evacuation conditions; installing a dedicated fire department communications line within the Berkeley Hills Tunnel; placement of redundant ventilation fans in the Berkeley Hills Tunnel; procurement of portable train radios to enable all train operators to have radio capability; design for future installation of a second radio channel; design for future car modifications to insure uncoupling regardless of train line failure within a consist; installation of redundant power to the San Francisco vent structure; and more consultant resources to analyze and improve the current fire protection system. Mr. Weule testified that the purpose of the second radio channel is to give more flexibility in train radio communications so as to relieve the present congestion in train radio use which is approaching an unacceptable condition. Emergency situations, of course, compound the problem. Mr. Weule testified that the second radio system should be in operation by mid-1981.

Witness Erck testified for the staff on several general fire safety subjects. On the matter of the load factor improving under close headways, the staff is not convinced that it will improve but has no basis to disagree with BART on the matter. Mr. Erck testified that the possibility that there might be a train ahead of a fire train underground preventing the fire train from reaching the next station would entail a coincident failure on the train ahead of the fire train. Mr. Erck wanted to make sure that the Commission recognized that such a problem could exist; however, he did not believe there was a high probability that it would occur. He made the point that under close headways that possibility is increased to some degree but he did not consider it to be a significant problem.

Mr. Erck testified that the fire safety documents at BART central were not completely up-to-date. The most important thing that was not revised was the procedure for handling the vent fans in case of a fire in an underground area. Mr. Erck also criticized the access the controller had to particular documents which detail emergency procedures.

Passenger Evacuation and Load Factors

The issue of passenger evacuation and train load factors turns on the average before and after load factors involved with a change in operation, load factor being the relationship of the number of passengers on board to the number of seats available for passengers. BART concludes that the lower the load factor, the more quickly passengers can be evacuated from a train. Because close headways will increase the system capacity by providing for the operation of more trains, there will be a reduction in load factors with a corresponding reduction in passenger evacuation time per train.

The effect of close headways on evacuations was also investigated by the staff. The staff's position is that if a burning train can be moved to a nearby station, clearing the track ahead may be complicated by the presence of additional trains under close headways. Barring the unlikely coincidence of an immobilized train blocking the path, a possibility even under CABS, the staff concluded that the minimal increase in movement instruction time should have little or no effect on the fire train's transit time. If the burning train cannot be moved, the nonincident bore will have to be cleared of revenue trains and rescue trains dispatched. The number of trains to be cleared from the nonincident bore will be increased under close headways. However, the staff points out that the maximum removal time will still be the transit time between the adjacent stations, the same as at present under CABS. The staff's general conclusion is that evacuations may be complicated by the increased number of trains and people immobilized in an incident,

even though the evacuation of the fire train would proceed as at present. The staff agrees with BART that the assurance of ventilation paths between all trains by the separation procedures proposed, will prevent direct involvement of adjacent trains in the hazard area and will permit evacuation of passengers on those trains to be delayed until evacuation of passengers on the incident train is assured. The staff maintains that trains in the incident tunnel can be kept far enough apart so that effects of the fire will involve only the burning train. More trains and/or passengers may have to be removed from both tunnel bores, but they should not be exposed to any real hazard nor should it interfere significantly with immediate rescue efforts. The staff concludes that BART's proposed ventilation separation of trains is adequate to mitigate the bunching effect of close headways operation on the evacuation of trains and passengers.

Passenger Evacuation and Train Traffic

Passenger evacuation and train traffic is a factor influenced by the number of trains within the vicinity of a burning train. Under the present CABS system, a burning train is generally assured of having clear and unobstructed track to the next station because the CABS separation requirements dictate that a train which is released from a station has clear track to the next station. An exception to this is the transbay tube where it is possible under CABS to have two trains on the same track between Oakland West and Embarcadero stations, the first stations at each end of the tube. This can occur because there is a dummy station in the middle of the transbay tube which, due to the length of the tube, was created for operational purposes. Even under this circumstance, however, BART maintains that it would be necessary to clear only one train ahead of a burning train.

Under SORS operation, clear track to the next station cannot be guaranteed because the whole concept of the close headways operation under SORS implies that more than one train can be

expected between stations. Under the SORS operation, unlike that of CABS, a train can be ushered through a station without stopping. Therefore, under SORS, if there is a train between a burning train and the evacuation station, that train can be ushered through the station without stopping, thus clearing the way for the burning train. BART sees a slight advantage to having more trains in the tube should one train catch fire and that is the possibility of assembling rescue trains in adjacent stations more quickly so that they can be brought into the vicinity of the disabled train with less delay.

Smoke and Ventilation

The issue of smoke and ventilation, under CABS, rests on the impact of other traffic that may be in the vicinity of a burning train in the tube. There would be, of course, under SORS, a greater possibility that a train would be in close proximity to a burning train in the tunnel because there will be so many more trains on the system and the headways can be half those at present. It would be possible for smoke and heat from a burning train to be drawn across a non-involved train before it can be removed from the tube. To eliminate such a possibility, BART proposes to allow no more than one train in the section of underground track bounded by any pair of ventilation outlets. This will insure that smoke and heat from a burning train will be effectively removed without its being drawn past a non-involved train. There is the possibility that ventilation fans might be out of service, thereby effectively extending the distance between ventilation fans and requiring additional separation of trains. BART witnesses testified that repair records indicate that two fans per year fail and require unscheduled maintenance, and the typical restoration time for such repairs is one to two days. Therefore, BART proposed to take no additional measures to enforce additional train separation should

an individual fan be inoperative and under repair. The requirement that trains would be separated by at least one ventilation outlet eliminates any degradation of the ventilation system under the SORS operation. In most underground areas ventilation systems can be operated either as a supply or exhaust; this provides the capability of establishing in any desirable direction the air flow required simply by activating the two adjacent fans, one as a supply and one as an exhaust. The problem does not exist in the Berkeley Hills Tunnel where only one train will be allowed on each track at a time because ventilation to the tunnel is supplied by a single fan at one end of the tunnel for each track. Another location in the system where air flow might be affected, under SORS, is the transbay tube. Here ventilation dampers are located at approximately 1,000-foot intervals and are operated in the exhaust mode only. BART agrees to always maintain one clear exhaust damper between any two trains under SORS operation so as to insure that the damper closest to a possible train fire is always unobstructed and able to remove smoke and heat.

Mr. Erck of the staff stated that the actual design, testing, and implementation of the vent separation system is not yet complete, although there is a conceptual agreement between BART and the staff concerning the system. He urged that the vent separation system should be reviewed by the staff before it goes into effect with the staff having final approval over the operation before close headways is implemented. The staff also investigated whether adequate information was available to central controllers to establish the proper ventilation path under close headways operation. This would involve knowing that relative positions of individual trains and ventilation mechanisms will be remotely sensed with sufficient resolution to determine the appropriate ventilation path, even if the operator of the burning train were unable to report his precise location. Through staff analysis of the possible

hazard conditions and the existing monitoring facilities, the staff has confirmed that appropriate information is available to central controllers for proper response but that documentation is lacking.

The differences between the staff and BART proposals for an ordering paragraph on the vent separation system has to do with the system being approved by the Commission staff. A working design and implementation and testing of the device mechanisms and the procedures that go along with such an installation have not been presented in final detail to the Commission staff. We will adopt the staff recommendation requiring a staff review.

Non-involved Trains

Firefighting and the removal of passengers on non-involved trains is an issue that BART claims is alleviated by the operation of SORS because the increased number of trains that the closer headways would permit enhances the likelihood that a train would be available to serve as transportation for emergency personnel and evacuation of passengers. Complicating factors involve the removal of passengers from non-involved trains on the same track as the burning train and on the need for emergency personnel to approach the burning train on the incident track. Under close headways, it will be possible to have passenger-carrying trains stopped ahead of and/or behind a train on fire in the tube. However, by enforcing the vent separation requirement, such trains would not be in a hazardous position because, in theory, the smoke could not be carried past the nonincident train since it would be beyond the ventilator nearest the fire train. Additionally, there would be more revenue trains on the non-involved track under close headways thereby providing additional means to evacuate passengers from an incident train. BART believes the net effect of close headways on firefighting and the removal of passengers from non-involved trains is inconsequential.

We do not agree with BART on this issue. Under CABS-1 and normal ATC operation, the maximum number of trains in one bore of the tube is limited to two. In the analysis which follows we rely on the following facts which are a matter of record in this proceeding.

a. The transbay tube is about 3.6 miles long.

b. Maximum train length is ten cars or about 700 feet.

c. Vent outlets in the transbay tube are about 1,000 feet apart.

d. Under SORS operation, trains will be separated by two clear blocks, i.e., a train could occupy every third block.

Also, in the record of Case No. 9867, recently heard before ALJ Doran, we take note of Exhibit 91 sponsored by witness Belding which shows the largest load observed in surveys made for a ten-car train was 1,650 passengers. (P. WDB-5, L. 4 & 5.)

Using the above data and assuming the worst case condition, we can make the following calculations to determine the number of passengers under present operation and under SORS operation who might have to be evacuated from the tube in the event of a severe fire or some other catastrophe.

Assuming 700-foot blocks, the length of a ten-car train, under SORS there could be a ten-car train every 2,100 feet (three blocks x 700 feet). The number of trains in one bore of the tube then could be nine (3.6 miles x 5,280 feet/mile divided by 2,100 feet). If the blocks in the bore are not uniform and the vent separation system does not allow for uniform spacing of trains, there could be fewer than nine trains. We will assume eight as the maximum. It follows that under SORS 13,200 (eight x 1,650) passengers might have to be evacuated or accommodated some way in the event of an incident in the tube, as compared to 3,300 (two x 1,650) under CABS-1, almost 10,000 more. However, this is the theoretical maximum and based on representations made by BART management at the oral argument on May 7, 1980, i.e., six would be the maximum number of trains possible under actual operating conditions, the 13,200 is reduced to 9,900 in a worst case condition.

What is the rationale for using a worst case condition instead of the average condition as espoused by BART? It is simply that the worst case is what may have to be contended with in the event of an incident. Murphy's Law should not be dismissed, not even lightly. We note the following exchange between ALJ Porter and witness Weule, BART's director of safety:

"By ALJ Porter:

"Q. Mr. Weule, in considering the improvements in evacuation of a train which SORS would bring about, isn't it reasonable to consider the worst case situation?

"What I mean by that is that if you have some trains out, if you have a strike, if you have a gas shortage, if you have a whole lot of things acting on the system, isn't it possible that at some time you are going to have a train that is going through the Transbay tube with a crush load?

"A. Oh, absolutely. Absolutely.

"Q. All right. Then what is the significance of worrying about, considering average load factors, if that is the worst case condition that you might face in an evacuation procedure?

"A. Because you face that worst case condition much less or many fewer times with more capacity under the close headways mode of operation than you would under the CABS mode of operation.

"Q. In other words, you were looking at probabilities on this rather than the one-time case which might occur, and that is that you would have trains packed like sardines?

"A. That is correct. I don't frame it in terms of probability, understand, but in comparing the two systems, the CABS system and the close headways system, I firmly believe that there will be fewer trains going through in a crush load condition under close headways than under CABS.

"Q. Well, then, you are considering probabilities, aren't you?

"A. To a degree, yes, but not as an answer to anything.

"It simply lowers that probability. It does not change anything we are doing in terms of the fire safety program and approving things, as far as fire performance is concerned.

"Q. In making your plans and in working with fire departments and evacuation people, and so forth, are you working on the basis of the most probable number of passengers that you would have to evacuate or the absolute maximum number that you would have to evacuate?

"A. The worst case for those planning purposes, yes.

"Q. All right. Then for planning purposes, is it relevant in this proceeding to consider what your load factor changes might be in the future, as long as you are now considering the worst case?

"A. No. In that light it does not." (Tr. 4900, 01.)

In its written exceptions to the proposed report and at the oral argument held May 7, 1980 BART made the following representations concerning the number of trains in <u>one bore</u> of the transbay tube at one time:

a. With SORS implemented, and under normal operations, there would be no more than two trains in the tube.

b. In order to gain the maximum benefit from operations under SORS there would be an occasional requirement to have up to four trains in the tube.

c. With no operating restraints placed on the system, and assuming the vent separation system is functioning properly, the maximum number of trains in the tube could be six.

Pending completion of the seat replacement program, which is the subject of Case No. 9867 and a recommendation of BART and the Commission staff on operating procedures to limit the number of trains in the transbay tube, we will authorize operation under SORS on the condition that no more than four trains may occupy one bore of the transbay tube at one time. In addition, we will require BART to report weekly the number of times operating procedures required more than two trains to occupy one bore of the tube and, in the same report, indicate its progress on the seat replacement program. The purpose of such a report will be to determine whether BART's representation that operational requirements exceeding two trains are occasional in nature is accurate so that if it is not, the Commission may reconsider this order and set more stringent limitations.

So that there will be data available on load factors in the transbay tube under SORS operation, we will require the staff in cooperation with BART to make random checks of peak trains between Embarcadero and Oakland West stations.

Underground Wet Track

The staff brought up a problem with speed profiles for blocks of underground track that may occasionally be wet. As discussed previously, the speed profiles of BART are designed with two different brake rates, one for outdoor or exposed track which may occasionally be wet, and one for underground track which presumably does not get wet. The staff testified that, specifically, significant portions of the underground San Francisco line between

Civic Center and Glen Park stations were very wet and continued to be wet for a period of six to eight weeks in January and February of 1979. In a letter dated June 28, 1979 the staff brought this to the attention of BART's director of safety and suggested that BART should either modify the tunnels to prevent water leakage onto the track or resignal the track according to appropriate wet-track brake rates. At the close of hearings in October 1979, BART had not responded to this letter. However, BART and the staff have now reached an agreement on this issue, and the speed profiles have been appropriately changed in the areas affected to reflect the wet-track brake rate of 1.2 miles per hour per second. BART and the staff suggest an order in this proceeding to cover the issue. The staff suggests such an ordering paragraph be interpreted by all parties concerned to apply to new areas which BART or the staff may find to be wet after implementation of this order. We will include an ordering paragraph in this decision to cover the issue and all parties are put on notice that the Commission intends it to apply not only to the Glen Park-Civic Center area, but to all underground areas of BART which may suffer water problems resulting in wet trackage.

Environmental Considerations

Counsel for BART stated that BART had filed a capital grant application (Close Headways Capital Improvement Program) with the U.S. Department of Transportation which was primarily for SORS. The application was filed March 10, 1977 and contained, as required in all Urban Mass Transportation Administration capital grant applications, a statement concerning environmental impact. BART's statement was that close headways did not constitute a project within either the Federal Environmental Quality Act or the California Environmental Quality Act (CEQA). At the time the grant application was filed it was also submitted to the Association of Bay Area Governments (ABAG). ABAG has a process of review whereby it

notifies cities, counties, and agencies who might have an interest in or be affected by the application of the fact that such an application was filed. Those cities and counties and other agencies and interested parties are then given the opportunity to comment on the application including comments on environmental impacts. Through that review process there were no comments from any of the political subdivisions except the City of El Cerrito which basically urged only that the city be given direct BART service to San Francisco. There were no comments concerning adverse environmental impacts. This was verified by a letter that BART received from the State of California, Office of Planning and Research, which has overall coordinating responsibilities for environmental impact projects in the State. Under CEQA, (Public Resources Code Section 21167, Subsection D) the filing of any actions to set aside projects must be done within a six-month period. The time period within which anyone had the right to challenge the project by a court action has long since passed since the application was filed in March of 1977. In addition to the above, BART directs the Commission's attention to Public Resources Code Section 21080, which describes projects to which CEQA is not applicable. This was enacted in 1978 so it would not have applied at the time of the BART close headways capital grant application. Section 21080(b)(11) reads as follows:

> "A project for the institution or increase of passenger or commuter service on rail lines already in use, including the modernization of existing stations and parking facilities."

BART submits that it has complied with the appropriate environmental review requirements, that the time period for challenging BART's decision in this regard is long since passed and, therefore, any legal action to set aside the BART decision would be barred by the limitation contained in CEQA. Further, federal government approval

of the capital grant project demonstrates the federal approval and the federal position on environmental impact. The type of proposal that BART now has before the Commission in this matter would merely be an increase in service on existing rail lines. Therefore, under today's law it would be categorically exempt from CEQA.

Previous Commission Orders and Resolutions

BART and the staff suggest ordering paragraphs for this decision having to do with rescinding certain decisions and resolutions of the Commission 90 calendar days following systemwide implementation of close headways operation. Also, they recommend modifying certain provisions of other decisions. We will adopt the recommmendations.

Staff witness Erck brought up two special matters that the staff wants clarified in any order issued by the Commission. First, staff has no objection to BART's installing any kind of control equipment if it includes a version of the commanded speed indicator which is available for the train operator. Second, even though the orders and resolutions will be rescinded, the staff wants it understood that a trained operator must be at the controls of any train operated by BART. We adopt both of these clarifications.

Findings of Fact

1. The San Francisco Bay Area Rapid Transit District (BART) is subject to regulations of the Public Utilities Commission relating to safety appliances and procedures pursuant to Section 29047 of the Public Utilities Code.

2. By this application BART requests Commission approval for BART to use its primary automatic train control system supplemented by a sequential occupancy release system (SORS) in lieu of the present computer automated block system (CABS).

3. Duly noticed hearings in this application were held at which all interested parties had an opportunity to be heard.

4. Under the present CABS operation BART is limited in the number of trains it may operate on the system because all trains must be separated by at least one station during revenue service.

5. Under the present operation BART is limited to approximately a seven-minute headway.

6. Under the proposed close headways system of operation BART will be able to operate at headways of approximately 3½ minutes.

7. Several problems that BART has had with operating their system such as train detection, stopping distances, speed code transmission and receiving, and central computer capacity will be solved by the institution of the close headways operation.

8. The automatic train control system will be operating the system with SORS as a back-up control for safety purposes.

9. Institution of the close headways, or SORS, will significantly improve the operating characteristics of BART.

10. The resolution of the so-called B-point problem, as outlined in the body of this decision and as agreed to by the Commission staff and BART is reasonable.

11. Version three of the monitoring systems proposed by the staff for keeping track of the reliability of SORS and solving any problems which may arise with the system would be the most effective of the four systems proposed.

12. Because of the cost involved, the staff's monitoring system, version one, should be put in operation on a one-year trial basis to determine its effectiveness and actual costs.

13. BART should be ordered to report nine months after installation of staff's version one monitoring system on the system's effectiveness and costs.

14. The operation of SORS during nonrevenue service is required for the safety of BART employees and the protection of BART equipment.

15. The phase-in procedure, as recommended by the staff, is reasonable and should be adopted.

16. The procedure whereby BART will be allowed to run up to 43 trains on the system prior to further approval by the staff is reasonable and should be adopted.

17. The recommendations of the staff concerning reporting requirements as outlined in this decision are required and should be adopted.

18. Documents at Central Control concerning the safety of operations and the procedures required during an emergency are not up to date.

19. Certain areas of BART's underground operation have been subject to wet track conditions.

20. Where the conditions referred to in Finding 19 occur on BART's system, BART should be ordered to invoke the wet track speed profile procedures available for setting the train speeds in those areas subject to review by the staff.

21. The ventilation system separation procedures proposed by BART in this proceeding are reasonable and should be adopted subject to final staff approval.

22. Under close headways operation it will be possible under a worst case condition to have as many as six trains and 9,900 passengers in one bore of the transbay tube.

23. Under normal operations with SORS in place, there will be no more than two trains in one bore of the transbay tube at one time.

24. To achieve optimal operation under SORS there will be an occasional requirement to have four trains in one bore of the transbay tube.

25. The interests of public safety dictate that pending completion of BART's seat replacement program under Case No. 9867 approval of close headways operation should be conditioned on BART's operating no more than two trains in one bore of the transbay tube at one time with the occasional condition of up to four trains when required for optimal operation.

26. A recommendation on the number of trains that may be in one bore of the transbay tube under SORS operation after completion of BART's seat replacement program should be developed by BART and the Commission staff and presented in further hearings.

27. Maximum load factor data for trains operating in the transbay tube are required for proper consideration of operating restrictions the Commission may impose in a final decision in this application.

28. The close headways operation proposed by BART does not constitute a project within either the Federal Environmental Quality Act or the California Environmental Quality Act.

29. The rescinding of certain decisions and resolutions of the Commission 90 calendar days following the systemwide implementation of the close headways operation as recommended by the staff and BART should be adopted.

Conclusion of Law

Subject to the conditions noted in the findings and embodied in the order following, BART should be authorized to initiate close headways operation under the SOR system.

INTERIM ORDER

IT IS ORDERED that:

1. The San Francisco Bay Area Rapid Transit District (BART) is authorized to utilize the automatic train control system for train separation without the computer automated block system (CABS) subject to the following conditions:

A. In order to lift the CABS restrictions as specified in Paragraph 1.B of this order and implement close headways operation for any sequential occupancy release system (SORS) station area, BART shall:

a. Operate the SORS as a backup for the primary detection system during both revenue and nonrevenue service. SORS may be disabled during nonrevenue service only when adequate train separation is assured by Central Control operating procedures, as authorized by the Commission staff.

b. On an interim basis for a period of one year from the date of initial SORS operation, or until further order of the Commission, install a monitoring system equivalent to version one as described in Exhibit 79 in this proceeding to continuously record SORS input and output signals at SORS installations.

c. Nine months after the installation of the system required by Paragraph 1.A.b. file a report with the Commission describing the effectiveness of the system for use in detecting and investigating violations of proper SORS enforced train separation, the cost of the system for the 9-month period, and recommendations for changes or improvements to the system.

d. Disable all B-point functions whose sole purpose is to alter speed codes within following move speed profiles.

e. Operate the vent separation system, as approved by the Commission staff, during revenue service to prevent drawing smoke from a burning train past a nonburning train on the same track.

f. For underground areas which experience wet conditions, resignal the automatic train protection system so that the speed profiles conform to the appropriate wet track brake rate.

B. In accordance with the requirements of Paragraph 1.A for any SORS station area, BART may remove the CABS restrictions (required by Decision No. 83339 in Case No. 9445) in that area as follows:

a. Modify the train control computer software so that it no longer enforces the CABS station-through-station separation within the areas.

b. Unspike track switches within the MacArthur (K-35) interlocking.

c. Disable the CABS zero speed gates within the areas.

d. Enable station run-through capability within the areas.

e. Enable the station dwell timers after the CABS restrictions have been lifted from the entire BART system.

f. Enable automatic dispatching hardware at yards when yards exist within the areas.

C. The modifications described in Paragraph 1.B. shall be performed and maintained in such a manner that CABS may be restored if necessary. This capability shall be retained until close headways has been implemented and CABS removed from the entire system for a period of at least ninety (90) calendar days.

D. Before the initial removal of CABS restrictions as specified in Paragraph 1.B., BART shall establish procedures such that:

   a. Performance Level 1 (PL 1) commands shall not be issued automatically nor be the default condition for train operations. Manually issued PL 1 commands shall be issued by the Central Control train controller only after assuring dry track conditions within the area affected by the command(s).

   b. Any trains with a loss of friction braking capability on one or more cars shall operate at one-half of commanded speed.

   c. No trains with less than three cars may be operated.

   d. The restrictions of this paragraph may be excepted only during nonrevenue service and only when sufficient train separation is assured by Central Control operating procedures as authorized by the Commission staff.

E. Close headways operation shall not extend beyond the initial service area (the area bounded by Ashby, Orinda, Coliseum, and Daly City SORS station areas) until at least six (6) SORS stations within that area have been operated under close headways concurrently for at least thirty (30) calendar days.

F. Not less than three (3) calendar days prior to implementing the close headways operating mode described in Paragraph 1.A., and removing the CABS restrictions as specified in Paragraph 1.B., for any SORS station areas, BART shall notify the Commission staff of the specific stations involved.

G. No more than thirty-six (36) trains shall be operated during revenue service until thirty (30) calendar days after the initiation of close headways operation. Ten (10) calendar days prior to exceeding forty-three (43) trains in revenue service, BART shall provide the Commission staff with a report of the projected capacity of the central train control computer under the increased number of trains.

H. BART shall file with the Commission staff until the staff notifies BART, in writing, that they are no longer required:

   a. Weekly reports on all reported violations of proper SORS train separation and any other SORS-related problems, the investigation and analysis of each incident, and the corrective action taken.

   b. Weekly reports identifying, on a daily basis, all SORS stations where CABS has been removed and daily tabulations of all SORS alarms, SORS resets, and SORS restricted speed releases for each of those stations.

   c. Monthly reports on the periodic maintenance of SORS equipment.

   d. Monthly reports containing the measures of service reliability and performance indices utilized by BART.

I. BART shall enforce procedures to:

   a. Prevent revenue trains from encroaching on dead trains.

   b. Prevent revenue trains from entering unpowered track areas.

   c. Offload passengers and remove from revenue service any trains which have suffered excessive loss of braking capability, as determined by guidelines authorized by the Commission staff.

J. BART may provide any service route it chooses. No notice of changes in routing of trains is required by the Commission.

K. Commission Resolution No. S-1411 dated April 19, 1976 is rescinded.

L. Ninety (90) calendar days following systemwide implementation of close headways operations, Decisions Nos. 81248, 83339, 83707 shall be rescinded.

M. BART shall retain on each of its trains a visual indication of the speed signals being received by the train's automatic train operation system.

N. The train control system shall be supplemented by the presence of a trained operator at the controls of each train.

O. BART shall not allow more than four trains to occupy one bore of the transbay tube at one time, i.e., between the east portal of the tube and Embarcadero station.

P. BART shall file a weekly report with the Commission on the number of times and length of time more than two trains occupy one bore of the transbay tube and include in that report a statement of progress on the seat replacement program under Case No. 9867.

2. BART shall advise the Commission staff of any proposed change in the status of B-points which BART may make after the B-point modifications ordered by this decision.

3. BART shall work with the Commission staff to develop operating procedures designed to limit the number of trains and passengers that can be in the transbay tube at one time under SORS to a level commensurate with optimal safety and operational requirements.

4. BART shall work with the Commission staff to develop peak-load factor data for trains operating between Embarcadero and Oakland West stations.

The effective date of this order ~~shall be thirty days after the date~~ is the date hereof. KH

Dated JUN 3 1980, at San Francisco, California.

President

Commissioners

Commissioner Claire T. Dedrick, being necessarily absent, did not participate in the disposition of this proceeding.

BART GLOSSARY OF TERMS

A Car - a vehicle with control cab which encloses the operator's position and houses train control equipment.

A Line - the mainline track from the Oakland Wye to Fremont.

"A" Point Receiver - a track speed code receiver which is paired with a transmitter primarily designed for train detection and protection purposes.

Algorithm - a mathematical formula; a rule of procedure for solving a mathematical problem that frequently involves repetition of an operation.

Automatic Train Control (ATC) - the method (and, by extension, the specific system) for automatically controlling train movement, enforcing train safety, and directing train operations.

ATC includes four major functions:

Automatic Train Operation (ATO) - controlling speed, programmed station stopping, door operation, performance level modification, and other functions traditionally assigned to the train operator and conductor.

Automatic Train Protection (ATP) - assuring safe train movement by a combination of train detection, separation of trains running on the same track or over interlocked routes, overspeed prevention, and route interlocking.

Automatic Train Supervision (ATS) - monitoring of system status and directing traffic movement to maintain the schedule or minimize the effect of delays.

Communication (CS) - interchanging information (voice, data, or video) between system elements separated by distance.

Backup Train Protection - any system that protects the train from collisions with other trains that is in addition to the primary control and protection of the trains.

B Car - a vehicle not equipped with a control cab.

"B" Point Receiver - track speed code receiver either a current or voltage type installed in addition to an "A" point receiver for refined speed profile adjustments or train protection.

Block - a length of track of defined limits, on which the movement of trains is governed by automatic train control.

Brake Rates - the rate at which trains decelerate due to braking effect either in miles-per-hr.-per second or feet-per second-per second.

CABS - computer automated block system. A computer system used to maintain station separation of BART trains.

C Line - the mainline track from MacArthur Station to Concord.

Central Control - the main control and monitoring facility for the trains, located at Lake Merritt. This is the location of the central computer and the main control panels.

Circuit, Track - an arrangement of electrical equipment, including the rails of the track, that forms a continuous electrical path used for the purpose of detecting the presence of trains on the rails: the track circuit is also used to communicate commands or other information between wayside equipment and the train.

Close Headways Operation - a system utilizing SORS to allow trains to operate closer than the one station separation control enforced by the CABS system.

Computer Automated Block System - (see CABS above)

Computer Self-Diagnostic Tests - tests that are performed by the computer upon itself to determine if it is operating correctly.

Consist - the number, type, and specific identity of cars that compose a train.

Crossover - two turnouts, arranged to form a continuous passage between two parallel tracks.

Data Transmission System(DTS) - one of several digital communications systems at BART. Specifically, the one used to transmit commands and monitoring information between the central train control computer and remote stations.

Detection Dropouts - the loss of detection of a train by the primary detection system.

Dead Train - a train with no external power energized to any part of its equipment.

Dropouts - the recorded disappearance of a train by lack of detection.

Dwell (or Dwell Time) - the elapsed time from the instant a train stops moving in a station until the instant it resumes moving.

Dynamic Braking - an electrical regenerative feature which converts the dynamic energy stored in the train movement into electrical energy either to return it to the power supply system or to waste it in resistor grids. In the process, the train is subjected to a braking effect.

Fail-Safe - a characteristic of a system which ensures that a fault or malfunction of any element affecting safety will cause the system to revert to a state that is known to be safe: alternatively, a system characteristic which ensures that any fault or malfunction will not result in an unsafe condition.

Failure Management Strategies - strategies used by Central Control to allow the system to operate as close to normal as possible when a system failure has occurred.

False Occupancy - an indication of track occupancy when no train is present.

Friction Brake - the mechanical brake system in the vehicle. When applied, it will use frictional effects generated between the brake disc and pads to slow or stop the car in motion.

Gate - the limit of an interlocked route where entry to that route is governed by a signaling device.

Fixed Gate - the limit of an interlocked route beyond which automatic operation of trains is never permitted.

Gate Stop - a designed zero speed code which is imposed in front of an interlocking gate. The zero speed will not be removed unless the alignment through the interlocking is properly made and locked.

Grade -

1. the ratio of the vertical rise or fall of the track to horizontal distance traveled. Equivalent to the tangent of the angle of the track with the horizontal.
2. ground level, usually in the expression "at grade" meaning at the finished surface of the ground, after any construction modification such as cut or fill.

Half-Speed Restriction - a designed feature in the cars which, when activated, will automatically restrict the train speed to one-half of its command speed.

Hardware/Software - Hardware, -- equipment
Software, -- computer programs

Headway - the time separation between two trains traveling in the same direction on the same track, measured from the instant the head end of the leading train passes a given reference point until the head end of the train immediately following passes the same reference point.

Hi-Density Tests - a series of tests performed in 1979 to test the algorithms of the SOR computer when utilized in the close headways operation.

Hostle - manual operation of a train, usually into a station or yard.

Impeded Mode - an added vehicle speed control device. When actuated, it will place the train in the impeded mode of operation and reduce the train speed to 75% of the commanded speed.

Initialization - the clearing and re-starting of a system.

Interlocking - an arrangement of signals and control apparatus so interconnected that functions must succeed each other in a predetermined sequence, thus permitting train movements along routes only if safe conditions exist.

Interlocking Route - a route between two opposing interlocking signals.

Initial Service Area - the first few stations or sections of track which will be placed in service after the authorization of close headways operation.

Junction - a location where train routes converge or diverge.

K Line - the mainline track from MacArthur to the Oakland Wye.

Latching - an electrical or mechanical operating condition which requires special or particular action to change its status.

Latched Occupancy - a track occupancy condition registered in a computer which requires certain predetermined actions in order to change or remove the existing track occupancy.

Lead Train - the preceding train of two or more trains which move in the same direction.

M Line - the mainline track from Oakland Wye to Daly City.

Mitigating Factors - a measurable quantity which can be used to represent the improvement of operation or reduction of failure rate in equipment.

Murphy's Law - if anything can go wrong, it will. (Author unknown.)

Normal Direction - the prescribed direction of train traffic as specified by the rules, usually the direction in which all regularly scheduled revenue service operations are conducted.

One/Two Station Separation - trains are separated intentionally by one or two stations.

Opposing Train - a train moving in the direction opposite to another train on the same track.

Overspeed Control - that onboard portion of the car borne ATC system that enforces speed limits in a fail-safe manner.

Performance Level - a modifying function applied to speed commands by the onboard train control hardware. Different performance levels are used to change the train's acceleration and speed response to fixed wayside signals.

Primary Detection System - a sub-system which is a part of the basic automatic train control system, functioning in sensing the existence of a train on the track. Information from the system is utilized for enforcing train separation and safe operation.

PL1, PL2, etc. - Performance Levels 1, 2, etc.; or

PM1, PM2, etc. - Performance Modifications 1, 2, etc. are the levels of train speed response to the track speed commands. Level 1 is the maximum level of response in speed and acceleration as commanded from the track speed profile. Levels 2 to 6 are gradually lowered levels of response.

R Line - the mainline track from MacArthur Station to Richmond.

Redundant System - a system that has two or more independent parallel paths that perform the same function.

Revenue/Non-Revenue Passenger Service - operating with paying passengers/operating without paying passengers.

Route - a succession of contiguous blocks between two controlled gates or interlocked signals.

Conflicting Routes - two or more routes (opposing, converging, or intersecting) over which movements cannot be made simultaneously without possibility of collision.

Normal Route - a prescribed route, a route in the normal direction of train travel.

Reverse Route - a route opposite to the normal route.

Route Request - registration at an interlocking of a desired interlocked route.

Running Rail - one of the two rails comprising the track upon which a rail vehicle moves.

Run Through - intentionally passing a station platform without making a scheduled stop.

Shunt - a conductor joining two points in an electrical circuit so as to form a parallel or alternate path through which a portion of the current may pass.

Sequential Occupancy Release (SOR) - a scheme for providing protection against rear-end collisions by latching block occupancy and requiring occupancy of blocks in correct sequence.

Speed Profile - the maximum allowable speed or speeds that a train may travel between stations dependent upon the position of trains ahead.

Speed Code Signals - signals transmitted to the train via the tracks that control the speed of trains.

Stranded Latch Occupancy - an indicated occupancy on the SORS computer that has not been re-set after the train has passed.

Switch - a device that moves rails (switch points) laterally to permit a train to transfer from one track to another.

Facing Point Switch - a track switch with points facing toward approaching traffic.

Trailing Point Switch - a track switch with points facing away from approaching traffic.

Switch point - a movable tapered track rail, with the point designed to fit against the stock rail.

Third Rail - a rail positioned alongside the running rails and maintained at an electrical potential for the purpose of supplying electrical power for the propulsion of trains (also called the "contact rail").

Train - a consist of one or more cars combined into an operating unit (see also Consist).

Train Identification - method of designating trains by means of such information as train number, destination, or length: may be accomplished automatically for functions such as routing or dispatching.

Train Lines - bundles of wire that carry electrical signals throughout the length of the train.

Transfer Track - a section of track in a train yard where the transfer between automatic main line and manual yard mode of operation takes place.

Wayside - that area of the trackway immediately adjacent to the running rails, including the third rail and ballast.

Wye - a track configuration, resembling the letter Y, where three main tracks are joined by switches and connecting track in such a manner that a train entering from any main track can exit via either of the others.

Yard - a network of tracks for making up trains and storing cars.

COMPARISON OF ORDERS AS PROPOSED BY CPUC STAFF AND BART FOR OCTOBER 16, 1979, HEARING ON APPLICATION NO. 57727

STAFF'S PROPOSED ORDERING PARAGRAPH 1

On the effective date of this order, the San Francisco Bay Area Rapid Transit District is authorized to utilize the Automatic Train Control system for train separation without the Computer Automated Block System (CABS) subject to the following conditions:

1. In order to lift the CABS restrictions as specified in Paragraph 2 of this order and implement Close Headways operation for any SORS station area, BART shall:

(A) Operate the Sequential Occupancy Release System (SORS) as a backup for the Primary Detection System during both revenue and non-revenue service. SORS may be disabled during non-revenue service only when adequate train separation is assured by Central operating procedures, as authorized by the Commission staff.

(B) Implement a program to detect and investigate violations of proper SORS enforced train separation. As a part of this program, supplement SORS with a mechanism to continuously record the SORS input and output signals in a manner so that reported incidents of violations of proper train separation can be reconstructed and analyzed. Monitoring and recording shall continue as long as SORS is required by the Commission to backup the Primary Detection System.

(C) Disable all 3 point functions whose sole purpose is to alter speed codes within following move speed profiles.

(D) Operate the Vent Separation System, as approved by the Commission staff, during revenue service to prevent drawing smoke from a burning train past a non-burning train on the same track.

(E) For underground areas which experience wet conditions, resignal the Automatic Train Protection System so that the speed profiles conform to the appropriate wet track brake rate.

BART'S PROPOSED ORDERING PARAGRAPH 1

Differs from staff's proposal in subparagraphs 1(A) 1(B) and 1(D). which read as follows:

(A) Operate the Sequential Occupancy Release System (SORS) as a backup for the Primary Detection System during revenue service.

(B) Conduct a program to monitor SORS protection commencing with the initiation of the first SORS station and continuing for a period of ninety (90) days following implementation of SORS systemwide which contains the following elements:

(1) BART shall provide trackway markings which define the limits of SORS protection. Train

operators shall report any incident in which a train comes to a stop within the SORS protected area of a lead train.

(2) BART shall provide visual indication to train operators when a lead train does not have a proper following move speed profile. Train operators shall report any incident in which they are forced to stop their train behind a train displaying such indication.

(3) BART shall install a monitoring apparatus to record SORS input and output signals during the first forty-eight (48) hours of SORS control in each train control station, and shall record these signals for a period of at least ten (10) hours at SORS installations where possible violations of SORS protection have been reported.

(4) For the duration of the monitoring period, BART shall perform periodic maintenance on each SORS computer at thirty (30) day intervals.

(D) Operate the Vent Separation System during revenue service to prevent drawing smoke from a burning train past a non-burning train on the same track.

STAFF'S PROPOSED ORDERING PARAGRAPH 2

2. In accordance with the requirements of Paragraph 1, for any SORS station area, BART may remove the CABS restrictions (required by Decision No.83339 in case No. 9445) in that area as follows:

(A) Modify the train control computer software so that it no longer enforces the CABS station-through-station separation within the areas.

(B) Unspike track switches within the areas (this applies only to the MacArthur (K-55) interlocking).

(C) Disable the CABS zero speed gates within the areas.

(D) Enable station run-through capability within the areas.

(E) Enable the station dwell timers after the CABS restrictions have been lifted from the entire BART system.

(F) Enable automatic dispatching hardware at yards (when yards exist within the areas).

BART's PROPOSED ORDERING PARAGRAPH 2

Identical to staff's proposal.

STAFF'S PROPOSED ORDERING PARAGRAPH 3

3. The modifications described within paragraph 2 shall be performed and maintained in such a manner that CABS may be restored if necessary. This capability shall be retained until Close Headways has been implemented and CABS removed from the entire system for a period of at least ninety (90) calendar days.

BART'S PROPOSED ORDERING PARAGRAPH 3

Identical to staff's proposal.

STAFF'S PROPOSED ORDERING PARAGRAPH 4

4. Before the initial removal of CABS restrictions as specified in paragraph 2, BART shall establish procedures such that:

(A) Performance Level 1 (PL 1) commands shall not be issued automatically nor be the default condition for train operations. Manually issued PL 1 commands shall be issued by the Central train controller only after assuring dry track conditions within the area affected by the command(s).

(B) Any trains with a loss of friction braking capability on one or more cars shall operate at one half of commanded speed.

(C) No trains with less than three cars may be operated.

(D) The restrictions of this paragraph may be excepted only during non-revenue service and only when sufficient train separation is assured by Central operating procedures as authorized by the Commission staff.

BART'S PROPOSED ORDERING PARAGRAPH 4

4. Before the initial removal of CABS restrictions as specified in paragraph 2, BART shall establish procedures for revenue operation such that:

(A) (Same as staff's proposal)

(B) (Same as staff's proposal)

(C) No trains with less than three cars may be operated during revenue service.

(D) (BART proposes to delete this subparagraph).

STAFF'S PROPOSED ORDERING PARAGRAPH 5

5. Close Headways operation shall not extend beyond the Initial Service Area (bounded by Ashby, Orinda, Coliseum, and Daly City SORS station areas) until at least six (6) SORS stations within the Area have been operated under Close Headways concurrently for at least thirty (30) calendar days.

BART'S PROPOSED ORDERING PARAGRAPH 5

Identical to staff's proposal.

STAFF'S PROPOSED ORDERING PARAGRAPH 6

6. Not less than three (3) calendar days prior to implementing the Close Headways operating mode described in Paragraph 1 and removing the CABS restrictions as specified in Paragraph 2, for any SCRS station areas, BART shall notify the Commission staff of the specific stations involved./

BART'S PROPOSED ORDERING PARAGRAPH 6

Identical to staff's proposal.

STAFF'S PROPOSED ORDERING PARAGRAPH 7

7. No more than 36 trains shall be operated during revenue service until thirty (30) calendar days after the initiation of Close Headways operation. Ten (10) calendar days prior to exceeding 43 trains in revenue service, BART shall provide the Commission staff with a report of the projected capacity of the Central Train Control Computer under the increased number of trains.

BART'S PROPOSED ORDERING PARAGRAPH 7

Identical to staff's proposal.

STAFF'S PROPOSED ORDERING PARAGRAPH 8

8. BART shall file with the Commission staff until the staff notifies BART, in writing, that they are no longer required:

(A) Weekly reports on all reported violations of proper SORS train separation and any other SORS-related problems, the investigation and analysis of each incident, and the corrective action taken.

(B) Weekly reports identifying, on a daily basis, all SORS stations where CABS has been removed and daily tabulations of all SORS alarms, SORS resets and SORS restricted speed releases for each of those stations.

(C) Monthly reports on the periodic maintenance of SORS equipment.

(D) Monthly reports containing the measures of service reliability and performance indices utilized by BART.

BART'S PROPOSED ORDERING PARAGRAPH 8

Identical to staff's proposal except that BART would have the heading read as follows:

8. For a period commencing with the initiation of Close Headways operation at the first SORS station until ninety (90) days after systemwide Close Headways operation has been implemented, BART shall file with the Commission staff the following:

STAFF'S PROPOSED ORDERING PARAGRAPH 9

9. BART shall enforce procedures to:

(A) Prevent revenue trains from encroaching on dead trains.

(B) Prevent revenue trains from entering unpowered areas of track.

(C) Offload passengers and remove from revenue service any trains which have suffered excessive loss of braking capability, as determined by guidelines authorized by the Commission staff.

BART'S PROPOSED ORDERING PARAGRAPH 9

Identical to staff's proposal.

STAFF'S PROPOSED ORDERING PARAGRAPH 10

10. BART may provide any service route it chooses. No notice of changes in routing of trains is required by the Commission. (This rescinds Commission Resolution S-1411, dated April 19, 1976).

BART'S PROPOSED ORDERING PARAGRAPH 10

Identical to staff's proposal.

STAFF'S PROPOSED ORDERING PARAGRAPH 11

11. Ninety (90) calendar days following systemwide implementation of close headways operations, Decisions Nos. 81248, 83339, 83707, and Resolutions S-1358, S-1365, and S-1382 shall be rescinded. Notwithstanding the foregoing, the following order provisions from Decision No. 81248 and from Decision No. 83339 are modified to reflect the need to continue certain requirements specified therein. These provisions, ordered here, are:

(A) BART shall retain on each of its trains a visual indication of the speed signals being received by the train's ATO system (amended from Decision No. 81248, Paragraph 3).

(B) The train control system shall be supplemented by the presence of a trained operator at the controls of each train (amended from Decision No. 83339, Paragraph 1).

BART'S PROPOSED ORDERING PARAGRAPH 11

Identical to staff's proposal.

BART

BAY AREA RAPID TRANSIT DISTRICT
800 Madison Street
Oakland, California 94607
Telephone (415) 465-4100

October 5, 1979

Mr. Alex E. Lutkus, Manager
BART Safety Section
Public Utilities Commission
California State Building
San Francisco, California 94102

Dear Mr. Lutkus:

Subject: B-Points

A meeting was held on September 18, 1979 at the BART Engineering offices, attended by Mr. Neil Brumberger, Close Headways Project Manager, Mr. Wes Erck, CPUC staff, and myself to discuss the issue of B-Points under Close Headways operation. The issue was first raised by the CPUC staff during the Close Headways hearings conducted during 1978.

Under Close Headways operation the primary system will be supplemented by the SOR system to ensure continuous train protection. The CPUC staff position, as raised during the hearings, is that B-Points are a form of primary train detection not supplemented by SOR. As such, they might represent a possible risk and should be removed or modified to protect against possible failure.

The BART position, as presented during the hearings, is that B-Points represent a negligible risk to patrons, and there is a great deal of evidence to demonstrate the safe operation of B-Points over the six years of BART operation. Additionally, the functions performed by B-Points are critical to the system and offset any risk perceived by the CPUC staff, and the total removal of B-Points would have a severe and unacceptable effect on operations.

Over the last several months, Neil Brumberger has worked with Wes Erck on a proposal which might resolve this issue. In the course of this work, each of the 233 B-Points in the system was individually evaluated according to the importance of the functions it performed. On the basis of this evaluation, each B-Point was classified as either essential or non-essential to operations. Essential functions included: berthing in transfer tracks, terminal zones and station platforms; through speed optimization; and approaches

to interlockings. Non-essential functions included following move speed profiles.

Those B-Points which did not perform essential functions would be either removed or modified on the basis that the risk perceived by the CPUC staff is not offset by any significant operational benefit.

Those B-Points which performed functions essential to operations would be retained on the basis that the value of the function offsets whatever risk the CPUC staff might perceive.

Following these criteria, of a total of 233 B-Points systemwide, 40 B-Points were identified which performed no essential functions and which BART will totally disable prior to starting Close Headway operation. Additionally, 29 other speed profiles involving B-Points were identified as non-essential and will be appropriately modified. The lists of B-Points to be wholly disabled and of speed codes to be modified is attached.

In the meeting of September 18, 1979, BART's proposal to make the above modifications and thereby resolve the B-Point issue was reviewed and found acceptable by Wes Erck.

Should you have any further concerns regarding this issue, please contact me.

Sincerely,

R. S. Weule
Director of Safety

Enclosure

RSW:nab

B - P O I N T R E M O V A L S

	TRACK	MULTIPLEX SYSTEM	CIVIL LOCATION
1.	A2 - NOR	A10 - A	971 + 73
2.	M1 - REV	A10 - E	899 + 02
3.	C1 - REV	A10 - H	929 + 75
4.	C1 - NOR	A10 - H	941 + 90
5.	C2 - NOR	A10 - G	929 + 76
6.	A1 - NOR	A20 - B	1060 + 27
7.	A1 - NOR	A40 - B	1327 + 55
8.	A1 - NOR	A60 - B	1691 + 78
9.	A1 - NOR	A70 - B	1816 + 77
10.	A1 - NOR	A70 - B.	1825 + 37
11.	A2 - NOR	A80 - A	2064 + 25
12.	TF 3/4	A77 - B	1954 + 32
13.	A2 - NOR	A70 - A	1873 + 75
14.	A2 - REV	A60 - A	1691 + 81
15.	A2 - NOR	A40 - A	1364 + 48
16.	C1 - NOR	C20 - D	1533 + 72
17.	C1 - NOR	K30 - B	1023 + 10
18.	R4 - NOR	K30 - C	1039 + 50
19.	M2 - NOR	M10 - B	821 + 37
20.	M2 - NOR	M20 - F	430 + 43
21.	M2 - NOR	M20 - F	436 + 25
22.	M2 - NOR	M20 - F	469 + 88
23.	M2 - NOR	M60 - B	351 - 18
24.	M2 - NOR	M80 - B	201 + 27
25.	M2 - NOR	M80 - B	270 + 77

	TRACK	MULTIPLEX SYSTEM	CIVIL LOCATION
26.	M2 - NOR	M80 - D	131 + 90
27.	M2 - NOR	M80 - D	138 + 99
28.	M1 - NOR	M80 - A	166 + 80
29.	M1 - NOR	M80 - A	245 + 17
30.	M1 - NOR	M60 - A	416 + 99
31.	M1 - NOR	M20 - E	461 + 48
32.	M1 - NOR	M20 - E	487 + 90
33.	M1 - NOR	M10 - A	863 + 37
34.	R1 - NOR	R20 - B	1179 + 05
35.	R1 - NOR	R20 - B	1181 + 50
36.	R1 - NOR	R20 - D	1280 + 62
37.	R1 - NOR	R50 - B	1384 + 98
38.	R1 - REV	R50 - D	1499 + 20
39.	R1 - NOR	R65 - B	1610 + 43
40.	R2 - NOR	R20 - A	1172 + 00

SPEED PROFILE CHANGES

	TRACK	MULTIPLEX SYSTEM	BLOCK MODIFIED	BLOCK OCCUPIED	SPEED CODE CHANGE
1.	C2	A10 - G	AL6G	AL1G/AL2G	18/6 -- 6
2.	M2	A10 - F	AR8F	AR13F	18/6 -- 6
3.	A1	A10 - B	AR5B	AR15B	70/50 -- 50
4.	C1	K30 - B	KR8B	KR9B	6/0 ---- 0
5.	C1	K30 - B	KR8B	KR9D	27/18 -- 18
6.	C1	K30 - B	KR8B	KR6D	27/18 -- 18
7.	C3	K30 - B	KR12B	KR14B	36/27 -- 27
8.	C3	K30 - B	KR12B	KR13B	6/0 ---- 0
9.	C3	K30 - B	KR13B	KR9D	36/27 -- 27
10.	C3	K30 - B	KR13B	KR10D/KR11D	36/27 -- 27
11.	C3	K30 - B	KR13B	KR14B	6/0 ---- 0
12.	C4	K30 - E	KL1E	KL13A/KL14A	27/18 -- 18
13.	R2	K30 - C	KL11C	KL8A/KL9A	27/18 -- 18
14.	R2	K30 - C	KL11C	KL13A	27/18 -- 18
15.	C3	K30 - F	KR1F	KR7F	18/6 --- 6
16.	C3	K30 - F	KR1F	KR8F	36/27 -- 27
17.	C3	K30 - F	KR1F	KR9F/KR10F	50/36 -- 36
18.	C1	K30 - F	KR4F	KR7F	18/6 --- 6
19.	M2	M10 - B	MR10B	MR17B	50/36 -- 36
20.	M2	M20 - D	MR3D	MR6D/MR7D	18/6 --- 6
21.	M2	M20 - D	MR6D	MR10D	36/27 -- 27
22.	M2	M20 - F	MR11F	MR12F	6/0 ---- 0
23.	M2	M80 - D	MR3D	MR9D	36/27 -- 27
24.	M1	M80 - C	ML6C	ML1C	50/36 -- 36
25.	M1	M60 - A	ML1A	ML1C	27/18 -- 18

	TRACK	MULTIPLEX SYSTEM	BLOCK MODIFIED	BLOCK OCCUPIED	SPEED CODE CHANGE
26.	M1	M60 - A	ML5A	ML4A	18/0 --- 0
27.	M1	M60 - A	ML11A	ML9A	36/27 -- 27
28.	M1	M60 - A	ML11A	ML10A	18/0 --- 0
29.	M1	M20 - C	ML2C	ML9E	36/27 -- 27

BART AND CPUC STAFF

CLOSE HEADWAYS

MONITORING PROGRAMS

BART's PROPOSAL

1. Paint shunts and 700 ft. shunt markers to show train operators possible violations of SOR protection.

2. Use taillight flashers to warn train operators when a train ahead might not have a protective following move speed profile.

3. Use time lapse cameras to record the SOR inputs and outputs during the first 48 hours of Close Headway operation in each station. Use the same cameras to record SOR inputs and outputs for at least 10 hours following any suspected SOR protection violations.

4. Increase the frequency of SOR preventive maintenance tests from once every 60 days to once every 30 days for each SOR computer.

5. Retain the four above measures during the entire phase-in of Close Headway operation and for 90 calendar days after Close Headways is operating systemwide.

CPUC STAFF PROPOSAL

Monitor and record all SOR inputs and outputs in all 26 SOR stations, 24 hours per day, 365 days per year, for as long as SOR is used to provide train protection.

Version 1: Use time lapse cameras to film the SOR display panels in each station.

Version 2: Use magnetic storage devices in each of the 26 SOR stations to automatically record and store the data directly from one of the two computers there.

Version 3: Use a new central computer connected to each of the 26 SOR stations via a leased communications line to automatically record and store the data directly from one of the two computers there.

**Note: versions 2 and 3 would require one year to implement after funds have been obtained.

MONITOR PROGRAM COST SUMMARY

Program	Additional Personnel	Capital Cost	Annual Operating Cost
CPUC Version 1	30	$25,000	$1,116,000
CPUC Version 2	17	$360,000	$564,000
CPUC Version 3	5	$640,000	$240,000
BART Program	3½	$10,000	$39,000 *

*Note: the cost is for the first 4½ months of Close Headways operation only.