VF Alternate Rail Technology

LOS ANGELES COUNTY
METROPOLITAN TRANSPORTATION AUTHORITY

ALTERNATE RAIL TECHNOLOGY OVERVIEW
FINAL REPORT

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EXECUTIVE SUMMARY

BACKGROUND

During the past several years, Los Angeles County has developed new rail passenger services in response to voters' interest. Propositions C, 108 and 116 provided substantial funding for the purchase of rights-of-way and rail rolling stock, construction of facilities, and (in the case of Proposition C) operation of passenger rail services. In addition, the Los Angeles County Metropolitan Transportation Authority (MTA) participates in a five-county joint powers agency, the Southern California Regional Rail Authority, to develop and provide regional commuter rail service.

In March of 1995, the MTA adopted A Plan for Los Angeles County Transportation for the 21st Century. This 20-year Plan scaled back the number of rail transit lines identified in the Agency's preceding 30-year Integrated Transportation Plan. One element of the March 1995 Plan is the analysis of Alternate Rail Technology (ART) in the form of Diesel Multiple Unit vehicles (DMUs) as a means of continuing to develop rail service at a potentially lower-cost than building light rail lines. The Plan identified five candidate corridors in which the MTA owns railroad rights-of-way.

Funds were identified in the Plan for the possible implementation of ART service if the technology was found to be feasible and cost effective for deployment in Los Angeles County. The Alternate Rail Technology Vehicle (ARTV) Survey, and the related review of technical and institutional issues, represents Phase I of this analysis.

ALTERNATE RAIL TECHNOLOGY VEHICLE OVERVIEW

Primary Characteristics - ARTVs are known by a variety of other names including Railbus, Diesel Multiple Unit (DMU), Diesel Rail Car, or Rail Diesel Car (RDC). They range from vehicles which are virtually a bus on steel wheels, to high speed trains consisting of several units and capable of operating at speeds in excess of 100 miles per hour. Many ARTVs are similar in exterior appearance to the MTA Metro Blue and Red vehicles. ARTVs can be operated as single cars, or as "multiple unit" sets of cars to make longer trains. ARTVs are not powered by electricity; they are driven by one or more internal combustion engines. (The absence of the overhead catenary system and traction power substations represents a substantial capital cost savings for an ARTV system over electrified rail transit.)

ARTVs can be grouped into two categories: vehicles which comply or could comply with Federal Railroad Administration (FRA) regulations and consequently would be suitable for operation on rail lines which are shared with freight trains and other passenger trains; and, vehicles which would not likely be able to comply with FRA regulations, but which are well suited to light rail style operations. Both categories of ARTVs could be suitable for operation on selected rail routes in Los Angeles County.

Current Deployment - ARTVs are manufactured by several suppliers in Europe and Asia. Thousands of ARTVs are operated in numerous countries around the world. Perhaps the largest deployments are in Japan and the United Kingdom where over 2,900 and 2,000 ARTVs, respectively, are in service. Other countries using ARTVs include Australia, Germany, Denmark, Sweden, France, Italy, Spain, Portugal, Israel, Hungary, and Korea. In the United States, there are a small number of 1950s vintage Rail Diesel Cars being operated in local rail passenger services, such as in Syracuse, New York, and being used by railroad museums; a small number of additional RDCs are planned to be rehabilitated for rail service in a few cities around the country, including Dallas.

ISSUES FOR ARTV DEPLOYMENT

There are several issues which must be addressed before deciding whether to deploy ARTVs in the United States generally, and in Los Angeles County specifically. These include environmental, ADA compliance and regulatory compliance issues.

Environmental - ARTVs have different environmental impacts than light rail vehicles, because of their reliance on internal combustion engines on the vehicle itself. However, because some ARTVs use what are essentially bus engines, some ARTVs to be deployed in Southern California would be able to utilize existing bus engine designs which utilize reduced emissions fuels, ranging from "clean diesel" to gaseous fuels (e.g., CNG). In the longer term, fuel cells might also prove feasible for use in ARTVs. Use of such reduced emissions technologies would be consistent with adopted MTA policy regarding buses, and South Coast Air Quality Management District emissions reduction targets.

Accessibility (ADA) - Rail transit systems which use high level platforms require only minor provisions in their vehicle designs, such as sufficient door and aisle widths, to provide accessibility. Rail systems with low platforms must utilize low-floor vehicles with special mini-platforms at stations (as does Metrolink), or some type of lift system. For ARTV services on dedicated rights-of-way, there is the same degree of design latitude as for a light rail system. However, for ARTV operations which would share track with freight trains, compliance with clearance requirements, which affect platform design, will be an essential consideration in vehicle design. Additionally, there are operational impacts associated with ADA compliance, specifically the potential for delay when lifts are used on vehicles operated at close headways.

Regulatory - Those ARTV operations which would share track with freight trains and other passenger trains would be subject to regulation by the Federal Railroad Administration. This would be the case in corridors such as Burbank-Glendale-LA, where ARTVs would operate on the same tracks as Metrolink and Amtrak passenger trains and Southern Pacific freight trains. The majority of existing ARTV designs are considered not to be compliant with FRA regulations. Some manufacturers are modifying their ARTV designs to provide models which will be fully compliant with the strictest interpretation of the regulations. At the same time, there is movement in the interpretation of the applicability of some FRA regulations to ARTVs. The issue of FRA compliance, which has been a major stumbling block to ARTV deployment in the United States, is moving towards resolution.

CONCLUSION

There are numerous ARTV designs, offered by several different suppliers, which might be suitable for deployment on selected rail routes in Los Angeles County. Primary conclusions reached to-date regarding ARTVs include:

- At least six ARTV models are, or will be, FRA-compliant. Two of them may become available in low floor configurations. Some are candidates for immediate application of clean fuels technology.

- At least three light rail-type ARTV models are available. They are not FRA compliant. Some are candidates for immediate application of clean fuels technology. However, application of clean fuels technology would be more difficult on these models than on the generally larger FRA-compliant models.

- Different clean fuels strategies are needed for the short and long term. The short term strategy must take advantage of the best existing technology to minimize emissions impacts while avoiding long delays in implementing service. The long term strategy should consider all technologies including those still in development.

- ARTV operating and maintenance costs are generally comparable to, or slightly higher than, costs for comparable light rail vehicles in comparable service.

- ARTV capital costs are significantly lower than capital costs for a comparable light rail system.

Deployment of ARTVs would be subject to resolution of outstanding issues, among them environmental impact, ADA accessibility and regulatory compliance. Based upon the survey of ARTV products available and proposed for the North American market, it appears that all of these issues can be resolved, and would not prevent ARTV deployment in Los Angeles County.

Other issues, including cost estimates, station design, system connectivity and institutional issues will be addressed in the Phase II analysis, the Alternate Rail Technology Feasibility Study. This Study specifically addresses the Burbank-Glendale-Los Angeles Corridor and will serve as a prototype feasibility study for the other candidate ART Corridors identified in the adopted 20-year Plan. The Phase II Study is underway and scheduled to be completed this Fall. At that time, the MTA Board is expected to decide whether to pursue ART implementation in the Burbank-Glendale-Los Angeles Corridor and whether to perform additional feasibility studies for the remaining candidate ART corridors.

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1.0 INTRODUCTION AND BACKGROUND

1.1 MTA Rail Acquisitions

In the early part of this decade, there was a resurgence of interest in improved transportation services in Los Angeles County, which was mirrored by a similar trend throughout the state and the nation. In Los Angeles County, the voters passed Proposition C and provided the support necessary to also allow passage of California State Propositions 108 and 116, all of which provided substantial funding for the purchase of rail rights-of-way and rolling stock, construction of facilities, and (in the case of Proposition C) operation of passenger rail services.

Using the funds made available, and an increased willingness by the railroads to sell existing rights-of-way, the MTA and its predecessor agency, the Los Angeles County Transportation Commission (LACTC) purchased several hundred miles of right-of-way, much of it with existing tracks, and a significant amount of it with existing rail operations. Working through the Southern California Regional Rail Authority (SCRRA), a Joint Powers Agency, the MTA has participated in the creation of the 5-county Metrolink commuter rail system. Other rights-of-way in the County were reserved for specific, planned rail transit projects, while others were "rail banked" for possible future use as passenger rail corridors.

1.2 The MTA 20 Year Long Range Plan

In March of 1995, the MTA adopted A Plan for Los Angeles County Transportation for the 21st Century. This 20-year long range plan recognized the financial realities of the mid-1990s, and scaled back the number of light rail lines identified in the Agency's preceding 30-Year Integrated Transportation Plan. As a means of addressing the demand for additional passenger rail services within the County, and given existing funding constraints, the 20-Year Plan included a recommendation to analyze the use of Diesel Multiple Units (DMUs) as a potentially less costly alternative to light rail. The Plan also identified five candidate corridors in which the MTA owns railroad rights-of-way, all of which have existing track in varying condition, and one of which is the subject of a certified EIR for light rail operations.

Funds were identified in the Plan for the possible implementation of a DMU system, if a more detailed analysis finds the technology and operations feasible and cost effective. The Alternate Rail Technology Vehicle Survey represents the first phase of this analysis, examining the technical aspects of Alternate Rail Technology Vehicles, which includes both DMUs and other similar vehicles, powered by alternative fuels.

2.0 DEFINITION OF AN ALTERNATE RAIL TECHNOLOGY VEHICLE

Alternate Rail Technology Vehicle (ARTV) is a new term for the type of self-propelled rail vehicle which has previously been called Diesel Rail Car, Railbus, Diesel Multiple Unit (DMU) or Rail Diesel Car (RDC). ARTVs have an outward appearance much like the Metro Blue or Red line vehicles, with one important difference - rather than using electricity from an external source, these cars are powered by an on-board engine, like a bus. These rail vehicles are capable of being linked into trains, each car providing propulsion, and operated by a single train operator. This operation is called "multiple unit" or "MU", and allows considerable flexibility in the operation of these vehicles.

The state-of-the-art for ARTVs is currently a diesel power plant, however, the potential appears great to use gaseous fuels (CNG/LNG/Propane) using existing engines and, possibly in the future, fuel cells. Because of the universal use of diesel power, the most common and internationally accepted designation of this type of vehicle is the Diesel Multiple Unit, or DMU. Some of the DMUs currently manufactured throughout the world today use engines comparable to standard urban bus engines, making the substitution of an off-the-shelf "clean diesel" or gaseous fuel engine possible. In recognition of the importance of the need to minimize emissions from new rail vehicles proposed for use in Los Angeles County, the term Alternate Rail Technology Vehicle (ARTV) has been coined to describe a self propelled, internal combustion engine powered rail vehicle, which utilizes clean diesel or gaseous fuels.

ARTVs are widely used by railroad systems in Europe, Asia, and Australia for service on secondary routes or routes with light traffic. There is also limited use in South and North America. ARTVs are used to operate a variety of different rail services including regional, rural, suburban and urban. Their designs range from basic rail buses with limited capacity and power, to high speed intercity trainsets. ARTVs are generally tailored to the particular type of operation for which they are intended, and industry standardization has not occurred.

3.0 ALTERNATE RAIL TECHNOLOGY VEHICLES IN THE U.S.

3.1 History

A variety of self-propelled rail cars, powered by gasoline, diesel and even steam, were operated in the U.S. from the 1920s through the 1940s. In 1950, the Budd Rail Diesel Car (RDC) was introduced and it quickly became the North American industry standard, with approximately 400 units being built in the following decade. The RDC was a stainless steel, steel-framed, 85 foot long passenger car, with two diesel engines mounted under the floor. The economy of its operation was a significant factor in the continuation of many passenger rail routes, which had become uneconomic to operate using locomotive hauled cars, as ridership declined in the post WWII era.

Budd RDCs were operated throughout the U.S., although primarily in the northeast and north-central regions of the Country, and primarily in rural and commuter rail services. RDCs operated in California included Southern Pacific service between Sacramento and Oakland during the 1950s and Santa Fe's mid-day run of the "San Diegan" during the same era. RDC operation in the U.S. ended in early 1993 when the Maryland MTA retired its Budd RDC fleet.

3.2 Current Efforts

The state-of-the-art in ARTVs is rapidly changing, as the worldwide market matures, and as opportunities develop to use these vehicles in a variety of urban and suburban applications in the U.S.. Rail services are being implemented and planned which will make use of refurbished Budd RDC cars and a variety of newer ARTV models. Interest in ARTVs is growing in many areas in the U.S., including Los Angeles County, as a relatively low-cost means of providing rail passenger service on available and acquired rail rights-of-way. Examples of such projects include:

Syracuse, New York - The first regularly scheduled revenue operation of ARTVs in the United States in recent years is the 3.5-mile "On Track City Shuttle" in Syracuse, New York. Service began on September 26, 1994 and refurbished Budd RDC units, acquired from the Metro North Commuter Railroad, are operated. The shuttle links a station near the Carrier Dome at Syracuse University with Armory Square and the Carousel Center north of the city. Extensions are planned.

Dallas - Fort Worth, Texas - Dallas Area Rapid Transit (DART), together with the City of Fort Worth, is implementing a 42-mile regional rail service which will utilize thirteen RDC units, purchased from VIA Rail Canada and refurbished at a cost of approximately $2 million each. It should be noted that a bid protest is currently delaying the contract to refurbish the cars. The initial 10-mile segment, which will link Dallas Union Station with the South Irving Transit Center is scheduled to open in the Fall of 1996. A planned extension will serve the Dallas-Fort Worth Airport. Double tracking of the existing single track line with passing sidings is planned, and freight and passenger trains will share the same track.

Burlington, Vermont - A new regional rail service has been proposed on a twenty mile route linking Burlington, Shelburne and Charlotte, Vermont, on the state-owned Vermont Railway. Rehabilitated RDCs and other ARTVs are being considered. The State of Vermont Agency of Transportation is developing the project to reduce traffic congestion during a two year reconstruction of one of Vermont's busiest highways, US Route 7. Current proposals call for service to begin as early as the end of 1995.

Oceanside - Escondido, California - The North San Diego County Transit Development Board plans to use ARTV technology for a 26-mile Oceanside-Escondido regional rail line that should begin operation by the year 2000. Daily patronage is forecast to be 14,000, based on existing bus ridership, and assuming a maximum speed of only 45 miles per hour. There is currently some freight service on the line; plans call for freight trains to be operated at night, during non-service hours, in an arrangement similar to that used by the San Diego Trolley.

Folsom - Sacramento, California - The City of Folsom is working to institute an ARTV service demonstration between Folsom and Sacramento. Folsom has worked closely with Siemens Corporation, which has a manufacturing facility in Sacramento, and the "design vehicle" for the service is the Siemens RegioSprinter. Plans are to make maximum use of the existing Southern Pacific Railroad and Sacramento Regional Transit Light Rail tracks in the rail corridor. CNG fuel has been considered, but due to the engineering issues associated with accommodating large CNG fuel tanks on the roof of the car, it was recently decided to use the existing diesel-fueled design.

Ventura County - The Ventura County Transportation Commission is collaborating with the Bronner-Farrar Development Corporation to open a factory to rehabilitate Budd RDC cars, including converting them to compressed natural gas (CNG) operation, and market them for resale. This would serve both transportation improvement and economic development objectives. The initial effort is to produce a prototype vehicle and operate it in Ventura County.

Tampa, Florida - An exploratory meeting recently took place among agencies considering a joint procurement of ARTVs. This group included the Hillsborough Area Regional Transit Authority, the Tampa Bay Commuter Rail Authority, and the Triangle Transit Authority (Research Triangle Park, N.C.). These agencies are inviting other interested agencies to participate with them as a means of sharing and minimizing costs.

Woodland - Davis, California - A study was completed in 1994 which examined the feasibility of ARTV service between Woodland and Davis, providing feeder service to the "Capitol" rail service. While the service appeared technically feasible, the market area, with a total population of less than 100,000, was not projected to generate sufficient ridership to be economically reasonable at this time.

King County, California - A feasibility study is underway for King County, to consider ARTV service between Coalinga, Hanford, Visalia, Exeter, and Porterville. This study, led by King County Association of Governments, includes participation by three San Joaquin Valley counties.

Others Projects - There are several other cities and agencies which have expressed an interest in considering rail service using ARTVs. These include:

- METRA (Chicago): Elgin, Joliet & Eastern
- Central Puget Sound Regional Transit Authority (RTA): Seattle - Tacoma
- Maine DOT: Boston - Portland
- Delaware DOT: Wilmington - Newark
- Georgia DOT: Various corridors throughout the State

- Cleveland RTA: Various corridors around Cleveland
- METRA: Aurora - Barrington
- Bi-State Development Authority: St. Louis - Pacific; St. Louis - Crystal City
- Michigan DOT - Various corridors around Detroit

Other cities which have expressed an interest include Memphis, Nashville, Denver, and Phoenix.

4.0 WORLDWIDE SURVEY OF ARTVs

4.1 Current ARTV Operators

ARTVs have been used extensively in Europe and Asia as a lower cost alternative to building light rail lines, or to operating locomotive-hauled passenger trains. The two largest deployments of ARTVs are in Japan and the United Kingdom, where some 2,900 and 2,000 ARTVs are in service, respectively. The following other countries use ARTVs; the approximate number of ARTVs in service in each country are shown in parentheses. Note that ARTVs range from single cars to three car multi-unit trainsets.

- Italy (1200)
- France (900)
- Czech Republic (750)
- Germany (600)
- Hungary (250)
- Australia (220)
- Spain (220)
- Denmark (185)
- Austria (150)
- Portugal (130)
- Netherlands (115)
- Sweden (100)
- Korea (50)
- Israel (25)

4.2 ARTV Manufacturers

ARTV manufacturers include ABB (U.K.), Siemens (Germany), GEC Alsthom Transport (France), Nippon-Sharyo (Japan), Bombardier (Canada), Goninan (Australia), Fiat Ferroviaria (Italy), Faur (Romania), Hyundai Precision and Industry Company, Ltd. (South Korea), Toshiba Corp. (Japan), Fuji Heavy Industries Ltd. (Japan), Niigata Engineering Company, Ltd. (Japan), Hunslet-Barclay, Ltd. (UK), Linke-Hofmann-Busch GmbH (Germany), and Hunslet Transportation Projects, Ltd. (UK). Some international collaboration and consolidation has also occurred, and as a result, some firms actually offer several different designs developed separately by their predecessors.

4.3 Available Products and Their Characteristics

The range of ARTVs on the market, either available off-the-shelf, or designed and ready to go into production, meet a variety of different missions. Most of the ARTVs are used for regional rail services, typically what are considered intercity, rural or commuter rail operations. The considerations which have driven most of the decisions to use ARTV technology have been the economics of operation and the ability to provide economic service for relatively low passenger volumes. A number of ARTVs have been configured and used for urban services, including relatively frequent service with short distances between stops.

While there are numerous ARTV designs, in use, production, or on the drawing board, this study focuses on thirteen vehicles which are representative of the range of ARTVs currently available and which might be considered for use in Los Angeles County. Inclusion does not represent a recommendation or endorsement of the vehicle model or its manufacturer. Models considered include:

- ABB IC2
- ABB IC3
- ABB Xplorer
- ABB 3000/3100
- ABB 158
- ABB 166
- Siemens VT 628
- Siemens VT 610
- Siemens RegioSprinter
- Nippon-Sharyo New Generation Diesel Rail Car
- Bombardier Diesel Rail Car
- Goninan Sprinter
- Budd RDC (rebuilt).

The analysis of ARTVs includes a comparison with the Metro Blue Line car, which provides a reference point. The Metro Blue Line car was built by Nippon Sharyo. It is an 89 foot long, high-floor, electric-powered, articulated light rail vehicle. It has a regulated maximum operating speed of 55 miles per hour and can accelerate at 3 miles per hour per second (mphps). Each car has 76 seats and space for approximately 154 standees.

The following paragraphs provide a brief discussion of each of the thirteen listed ARTVs. Characteristics discussed include dimensional and performance data, compliance with FRA regulations, capital cost and high or low floor design. Floor height has significant impact on ADA compliance - a vehicle which has a high floor, requires either a high platform or a lift for ADA accessibility, while a low floor vehicle can achieve accessibility with a bridgeplate and low platform. This issue is discussed further in Section 7.2.

ABB IC2 - The ABB IC2 is a two-car trainset (married-pair) manufactured by ABB Scandia. It has a top speed of approximately 100 mph. It is 134 feet long and has a high floor configuration. The IC2 carries 116 seated passengers and 60 standees in the two-car trainset. It does not comply with FRA regulations.

ABB IC3 - The ABB IC3 is designed to operate as a 193-foot-long, three-car articulated trainset, with an un-powered car between two powered vehicles, although it can be operated as a two-car trainset using just the powered units in a configuration similar to the IC2. Each three-car trainset seats between 140 and 180 seated passengers, and 96 standees, depending on the seating arrangement. The middle car in an IC3 three-car trainset is available in a low floor design. The IC3 has a sustainable top speed of over 110 mph and can accelerate at 2.24 mphps. The IC3 carries 608 gallons of fuel and has an operating range of 1,414 miles. IC3s are used in Denmark for intercity service, in Sweden for both regional and interregional service, and in Israel for both intercity and suburban services. The IC3's quick coupling capability enhances its flexibility by permitting trainsets to be rapidly combined into longer trains or separated back into individual three-car trainsets. ABB has announced its intention to offer a fully FRA-compliant version of the IC3 for the North American market.

ABB Xplorer - Sixteen of these high-speed trainsets were recently built by ABB in Australia for the State Rail Authority of New South Wales. The Xplorer is an 85 foot long single unit, designed to operate in trains of between two and eight units in length. It has a maximum speed of approximately 100 miles per hour, and seats between 50 and 66 persons per unit. 28 Endeavour cars were recently delivered to CityRail for commuter rail operations in the Sydney area; these are virtually identical to the Xplorer cars, except for the interiors. Neither the Xplorer or Endeavour cars meet FRA requirements.

ABB 3000/3100 - The Class 3000/3100 by ABB is another Australian ARTV designed for suburban or interurban service. The cars seat between 105 and 113 passengers, and has a maximum speed of 55 miles per hour. The 3000/3100 ARTVs are diesel-electrics and use AC traction motors. They are not FRA-compliant.

ABB 158 - The ABB "Express" intercity ARTVs are used for regional travel, typically on journeys of between two and three hours. The 158 class cars are equipped with public phones, accessible toilets and luggage storage space. These cars maintain an availability of better than 90% and average utilization of 225,000 miles per vehicle annually, with some cars averaging over 900 miles daily. British Rail has achieved an average fuel efficiency of 3.8 miles per gallon with the Class 158 vehicles, and reportedly a three-car train consumes only about a third as much fuel as an equivalent locomotive-hauled train. The Class 158 can operate at speeds of up to 90 mph, and has an operating range of 1,500 miles. The Class 158 cars are not FRA compliant.

ABB 166 - The class 166 "Network Turbo" is British Rail's latest ARTV. It provides commuter services in and out of London at speeds up to 75 mph. It has been designed to optimize fuel efficiency and reduce weight, including the use of aluminum carbodies. It does not meet FRA requirements. The cars are air conditioned, and include passenger features such as interior destination signs.

Siemens VT 628 - The VT 628 is a two-car trainset, with a seating capacity of 144. The unit is a high floor design, with a top speed of approximately 75 miles per hour. The Siemens Duewag Type 628.4/928.4 ARTV is used by the Deutsche Bahn AG (German Railways) for short distance passenger services. Siemens is modifying its VT 628 for operation in the North American market. It is anticipated that the U.S. version of the VT 628 will comply with all FRA standards. Both a diesel-hydraulic and diesel-electric drives are planned to be offered, both sharing a common carbody designed for modular component installation. A low floor configuration for the middle car of a three-car set is under discussion.

Siemens VT 610 - A consortium of Siemens Duewag, ABB Henschel, and AEG has developed the VT 610, a tilt-bodied, diesel-electric ARTV which achieves speeds of up to 100 mph in fast regional passenger services. The equipment is operated in two-car trainsets (married pairs), typically seating 120 second class and 16 first class passengers, and costing approximately $3.8 million. The trucks and active hydraulic tilt system are supplied by Fiat Ferroviaria. The equipment can operate in trains of up to four two-car trainsets. Recently the Deutsche Bahn AG (German Railways) purchased ten VT 610 trainsets for service in Bavaria and is acquiring 48 more trainsets for other regional rail lines. Siemens has no plans to adapt the VT 610 for North American service.

Siemens RegioSprinter - The RegioSprinter is a double articulated, low floor ARTV. The RegioSprinter has a top speed of almost 65 miles per hour and can accelerate at a rate of 2.4 mphps. This car was designed for relatively short haul operations, and is more like a light rail vehicle than a commuter rail car, although it is used for both purposes in Germany.

Nippon-Sharyo New Generation Diesel Rail Car - Nippon-Sharyo's New Generation Diesel Rail Car is based on a design currently in use in the U.S., configured as both an electric MU car and an un-powered push-pull commuter rail coach. No working prototype of the vehicle exists, although the components are in use. The vehicles are designed to have a top speed of 80 miles per hour, with an acceleration rate of 0.78 mphps. Each car has an 87 person seating capacity.

Bombardier Diesel Rail Car - Bombardier is developing a "North American Car" which could be configured as an electric MU car, an unpowered coach, or an ARTV. The design will be based on one of their existing products, and will meet all FRA requirements. It will have a high floor configuration, and a wheelchair lift will be offered for ADA accessible operation with low platforms. Completion of the design is expected during 1996.

Goninan Sprinter - Goninan's Newcastle Works (Australia) recently began to supply a fleet of 22 "Sprinter" diesel-hydraulic cars for the Victoria Public Transport Commission. The Goninan Sprinter is a lightweight ARTV and has a top speed of over 80 miles per hour. Each car can carry up to 90 seated and 15 standing passengers. The Goninan Sprinter is being evaluated to determine whether the existing design complies with FRA requirements.

Budd RDC (rebuilt) - Several retired Budd RDCs have recently been bought to be reconditioned and returned to service. Reconditioning ranges from minimal repairs and cosmetic improvements made by some operators, to complete overhaul as is being performed by DART. The DART Budd RDC will seat 96 passengers. The design speed is 85 miles per hour. The RDC is powered by two turbo-charged Cummins NTA-855R diesel engines. It is a high floor car, and meets FRA standards.

5.0 OPERATIONAL CONSIDERATIONS

5.1 Staffing

ARTVs can be combined to operate as trains consisting of several units. Both rail transit and railroad environments allow operation of ARTVs by a single operator. The quantity of other on-board personnel will significantly affect the economics of ARTV operation, and is largely dependent on fare system policy and ADA compliance strategy. With regard to fare policy, the decision to use fare inspectors in a barrier-free system, as is current Metro Rail practice, would likely be lower in cost than using a conductor and other staff on every train to collect tickets. Regarding ADA compliance strategy, depending on the type of apparatus used to meet ADA requirements, additional on-board personnel may be required to minimize the potential schedule impact of disabled passenger boardings and alightings, particularly if very short headways are scheduled.

Maintenance of ARTVs requires more person-hours per vehicle than light rail vehicles, because of the internal combustion engines on board the ARTV. This staffing requirement would be approximately offset by lack of any need to maintain an electric traction power system for ARTVs. Overall, for the same level of service, staffing requirements for ARTV operations may be considered to be comparable to, or slightly higher than, staffing costs for light rail operations.

Analysis of the staffing needs to produce reliable estimates must necessarily address corridor specific factors including character and level of service, and the organization structure and cost reporting methodologies of the agencies under consideration, to ensure that such comparisons have a consistent basis. The cost estimates to be prepared during the Phase II study will take these factors into account.

5.2 Maintainability

ARTVs, in the context of this study, are candidate vehicles for both light rail transit and mixed-traffic railroad operations. Perceptions about maintainability diverge significantly among professionals in the rail transit environment and their counterparts in the railroad industry. This is largely a result of the almost universal familiarity of North American rail transit agencies, such as the MTA, with European and Asian rail vehicles and their associated maintenance philosophies, and a corresponding absence of overseas rail products on North American railroads.

European railroads and rail transit systems generally utilize a maintenance philosophy which combines more frequent replacement of lower cost components and more highly trained maintenance staff, than are typical for American railroads. This difference in philosophy, combined with the effect on design of widely divergent operating requirements (i.e., a preponderance of heavy freight trains operating over long distances compared with mostly lighter European passenger trains operating over shorter distances) has created a perception that European rail equipment designs are overly complex and less robust than American designs. Failed attempts to deploy European freight locomotives on American freight railroads have reinforced this perception.

Contrary to this perception, however, some European designs have proven themselves to be entirely suitable for American operating conditions. There are two notable examples. The French RTG Turbotrains (and subsequently Rohr duplicates, built in the U.S. under license) have been operated by Amtrak on the Empire Corridor in New York State for over two decades. The ABB model AEM7 and ALP44 electric locomotives, essentially a Swedish design built in the U.S. under license, have been operated in the Northeast Corridor for several years, first by Amtrak and later by New Jersey Transit, Southeast Pennsylvania Transportation Authority and Maryland MTA.

The recent experience of the Victoria Public Transport Commission in Australia suggests that the most important factor affecting maintainability is the specification development process. The abbreviated specification development which preceded the procurement of the Goninan Sprinter cars has resulted in several maintainability problems, including component accessibility and removability. These matters are being addressed in the more rigorous development of a new performance-based specification, which will be used for the procurement of additional cars.

5.3 Wheel/Rail Interface

There are two issues related to wheel/rail interface which have been associated with modern ARTV designs overseas and with the RDC in the U.S.. These are slide under braking and uncertainty of track circuit actuation. These problems have generally been related to the use of disc brakes rather than tread brakes. For example, all modern ARTVs in the U.K. use disc brakes (with the exception of the railbus fleet) while the 1950's vintage heritage units are equipped with tread brakes. It should be noted that these problems are being addressed, and overall there are few major technical problems with ARTV operation in overseas locations such as the U.K., largely as a result of the evolution of their designs over many years.

Slide Under Braking - A combination of a lower level of wheel tread conditioning and higher braking rates has caused some problems with slide on modern ARTVs in the U.K., and there have been a few buffer stop collisions allegedly resulting from this issue. Although slide control systems are fitted, these are bypassed during emergency brake applications. Consideration is currently being given to retrofitting one shot sanding equipment to cope with emergency stops in low adhesion conditions.

Track Circuit Actuation - All modern ARTVs in the U.K. have been affected by this problem, which is associated with low voltage track circuit operation. The lighter axle loads and improved riding qualities of the new trucks combined with the absence of tread brakes, has led to increased electrical resistance between wheel and rail due to build up of contaminants on the tread surface. These are no longer cleared by braking or the wiping action between wheel and rail due to wheelset oscillations. The result has been occasional "disappearance" of trains from the signaling system due to non-operation of track circuits. The solution to this has been to install an active device which induces a voltage in the local circuit formed by the axle and the rail, thus overcoming the increased resistance and operating the track circuit reliably.

5.4 Fueling Station Infrastructure and ARTV Operating Range

Depending upon the operating range of a candidate ARTV and the duty cycle associated with a specific candidate corridor, there could be significant impacts upon the type and location of fueling station facilities required. Diesel fueling facilities currently exist in some corridors, while they would need to be added in others. The Phase II study will address both the corridor-specific operating implications of this issue, and its environmental aspects.

6.0 ARTV COSTS

6.1 Capital Costs

Actual costs for recently produced ARTVs and forecasts made by ARTV manufacturers are both useful in estimating ranges of likely capital costs for ARTVs. The following examples of vehicle types and capital costs are provided as representative data points. Costs are in current U.S. Dollars.

- ABB Class 158 and 166 Turbo - single units, produced in the U.K. for British Rail at a cost ranging between $1.25 and $1.44 million.

- ABB IC3 - three-car articulated vehicle, produced in Denmark for the State Railways of Israel at a cost of $2.8 million.

- Siemens Duewag VT628 - two-car vehicle, produced in Germany for the German Rail at a cost of $2.2 million. Siemens forecasts the cost of an FRA-compliant version of the VT628 to be between approximately $2.5 and $2.7 million for a two-car vehicle, and between approximately $3.3 and $3.5 million for a three-car vehicle.

- Siemens RegioSprinter - three-car "light rail type" articulated vehicle, produced in Germany for German Rail at a cost of $1.2 million. Siemens forecasts that a North American version, which includes coupler modifications and the addition of air conditioning, but which does not meet FRA requirements, will cost approximately $1.5 million.

- Goninan Sprinter - single units, produced in Australia for Victoria Rail at a cost of $1.75 million. An FRA compliant version is estimated to cost approximately $2 million.

Actual capital costs for ARTVs to be deployed in Los Angeles County would be largely dependent on order size, and the degree of deviation from existing "off-the-shelf" designs. For preliminary comparison purposes, the following capital costs estimates may be used:

- FRA Compliant, single unit ARTV: approximately $2.0 million

- FRA Compliant, two-car or three-car ARTV: between approximately $2.5 and $3.5 million.

- Non-FRA Compliant, "light rail type" articulated ARTV: between approximately $1.5 and $1.8 million.

Delivery, which is substantially influenced by the amount of design customization, would reportedly be between 14 and 20 months after contract award for most of the active manufacturers.

The capital cost of light rail vehicles generally ranges between approximately $1.4 and $2.5 million per car, and averages approximately $1.8 million per car. These data are based on a sample of nine light rail vehicle orders, delivered in the U.S. within the last five years.

6.2 Operational Costs

Comparisons between ARTV and light rail operating costs should be centered on three cost factors: vehicle maintenance; electrification infrastructure maintenance; and, energy. For a comparable level of service, and assuming vehicles of approximately the same weight and auxiliary power requirements (e.g., both have air conditioning), the difference in overall operating costs between ARTV and light rail is determined entirely by the differences in these three cost factors.

Analysis of these cost factors to produce reliable estimates must necessarily address corridor specific factors, character and level of service, and the organization structure and cost reporting methodologies of the agencies under consideration to ensure that such comparisons have a consistent basis. The cost estimates to be prepared during the Phase II study will take these factors into account.

To facilitate conceptual-level comparisons of ARTV and light rail operating costs, selected ARTV and light rail data have been combined to establish the following ranges of cost ratios:

vehicle maintenance - Light rail vehicles are estimated to cost between 55% and 75% as much to maintain as ARTVs. This includes maintenance staff and materials, and contract repairs.

electrification infrastructure maintenance - This cost category does not apply to ARTV operation. An approximate, representative light rail cost per route mile per year for a double track system is $25,000.

energy - Light rail vehicle energy requirements are estimated to cost between 50% and 60% of those for ARTVs.

6.3 Life Cycle Costs

The most important issue in considering life cycle costs, aside from capital and operating costs, is the service life or book life of the asset. Assumptions vary among current ARTV operators regarding their service life. British Rail figures are representative of most European practice. Specifically, the book life of BR ARTVs is assumed to be 35 years; and for rail buses it is 25 years. The BR Heritage DMUs, built in the late 1950s, are theoretically life expired at almost 40 years of age. However, 223 are still in service. For purposes of conceptual level analyses, life cycle costs of candidate ARTVs should be assumed to be 35 years.

Overall operating and maintenance costs for an ARTV system would typically be comparable to, or somewhat higher than, operating and maintenance costs for an equivalent light rail system. Conversely, the capital cost of an ARTV system would typically be substantially lower than the capital cost of an equivalent light rail system. The net effect on life cycle costs depends on several factors, including some which are corridor-specific.

7.0 REGULATORY ISSUES

Some of the candidate ARTV corridors identified in the MTA 20-Year Long Range Plan could be operated separately from the general railroad network, as are most light rail lines. In this case, the ARTV operation would be exempt from FRA regulation, but still subject to California Public Utilities Commission (CPUC) regulation. However, operation in a mixed traffic corridor would be subject to both FRA and CPUC regulation. Further, other regulations including the Americans with Disabilities Act (ADA) and the Federal Flammability and Smoke Emissions regulations would be applicable regardless of whether the ARTV operation was in an FRA-regulated environment or not. The Phase II ARTV Feasibility Study currently underway for the Burbank-Glendale-Los Angeles Corridor will provide a more in-depth analysis of these issues.

7.1 Applicability of Federal Railroad Administration Regulations

The Federal Railroad Administration (FRA) establishes standards for self-propelled rail passenger vehicles, generally under its regulations for locomotives. These regulations apply to railroads operated as part of the general, national railroad network. The standards do not apply to a railroad or rail transit system which only operates on track inside an installation which is not part of the general railway system.

7.2 Compliance with Federal Railroad Administration Regulations

If an ARTV is intended to be operated on trackage which is not under FRA jurisdiction, existing overseas off-the-shelf ARTV designs may be acceptable. MTA must then determine whether it will operate two different ARTVs, one for FRA regulated trackage and one for other trackage, or elect to meet FRA standards with all of its ARTVs. There may also be implications if ARTVs which meet FRA standards are operated with Light Rail Vehicles (LRVs), such as the Metro Blue Line vehicles, which do not meet, and are not required to meet, FRA structural standards.

At this time, Nippon Sharyo, Bombardier, Siemens Duewag and ABB have all indicated an interest in the U.S. market, and their intent to offer ARTV products which meet all FRA requirements, including the 800,000 lbs. buff strength requirement. Nippon Sharyo, Ltd. intends to do so by applying diesel engines to a carbody design, essentially the same as those it delivered to the Northern Indiana Commuter Transportation District and Maryland DOT. Bombardier appears to be pursuing a similar approach with one of its existing carbody designs. Siemens Duewag has indicated its intent to modify the 628.4/928.4 ARTV to meet all FRA requirements including the 800,000 lbs, and ABB is similarly modifying its IC3 ARTV.

In anticipation of its FRA-compliant IC3, ABB hopes to demonstrate an IC3 train in the U.S. during 1995. A 3-car trainset has been borrowed from the Danish Rail Service (DSB), and is scheduled to be demonstrated in revenue service in several U.S.

locations, including Atlanta during the Olympics and other locations yet to be determined. The trains will be operated by Amtrak personnel, under contract with ABB, with the operating costs paid by the local agency sponsoring the demonstration.

7.3 FRA Structural Requirements (49CFR-Part 229.141)

The two Federal Regulations which will have the greatest affect on rail vehicle design and construction are the *Body Structure - MU Locomotives* requirements (49CFR-Part 229.141) and the *Americans with Disabilities Act* (49CFR-Part 38). These two requirements will have a major affect on the car structure and arrangement and may preclude use of some or most existing designs.

The Body Structure requirements (49CFR-Part 229.141) were in the past split into two sets of requirements. One set covered cars used in trains where total train weight was under 600,000 lbs., and the other set covered requirements for cars used in trains with total train weight over 600,000 lbs.. The requirements include design and test requirements for compression at the draft sills, vertical load on the anti-climber, vertical load on the coupler carrier, collision post shear, and truck locking to the carbody.

The structural requirements (49CFR - Part 229.141) for cars used in trains over 600,000 lbs. can be summarized as follows: 1) 800,000 lbs. compression at draft stops without permanent deformation; 2) 100,000 lbs. vertical load on anti-climber without exceeding yield point; 3) vertical downward load on coupler carrier of 100,000 lbs. without exceeding yield; 4) collision posts each side of diaphragm opening, with ultimate shear of 300,000 lbs. at top of the underframe; 5) Truck locking to body at minimum ultimate shear value of 250,000 lbs..

Although there appears to be some ambiguity in the FRA Regulations, it is unlikely that an ARTV which is intended to be operated under the jurisdiction of the FRA would be certified unless it were able to meet all FRA requirements, including the 800,000 lbs. buff strength requirement. While acknowledging the precedent of the Amtrak Turbotrains, which do not meet the 800,000 lbs. buff strength requirement and which have been operating on a permanent waiver for over two decades, the FRA's position with regard to Amtrak's High Speed Trainset specification suggests an intent to apply the 800,000 lbs. requirement universally. Further, the FRA has completed a draft revision to its carbody structural requirements. The revision eliminates the lower structural requirements for cars used in trains less than 600,000 lbs. total train weight. All cars must meet the higher crush requirement and other associated structural requirements. The FRA has also included some new "roll over" requirements. Although the new requirements are in draft form only, the FRA has expressed their intention to apply these requirements in the certification process.

With the possible exception of the Goninan Sprinter, none of the existing overseas ARTV designs comply with the previously referred to FRA strength requirements, based on the 800,000 lbs. buff criteria. This situation appears to be changing. For many of the manufacturers, it will be necessary to redesign the car body structure to meet these requirements. This would add some weight, but more importantly would require the time for redesign of the car shell, testing of the car shell, and it would add the uncertainty into the schedule, which is inherent with a new car shell design.

7.4 Americans With Disabilities Act (ADA) Regulations (CFR49 - Part 38)

Providing accessibility in terms of compliance with the Americans with Disabilities Act (ADA) involves three main issues: floor height for access and egress, door and passageway widths, and restroom design.

Floor height - Most of the ARTVs currently available and proposed are high floor designs. Access and egress must be accomplished by either the use of stairs in the vestibules, high level platforms or a motorized lift device. As use of stairs is not ADA compliant, high level platforms or motorized lifts must be used. With the use of high-level platforms, another issue becomes apparent, the difference of several inches in floor heights between current overseas ARTVs and standard North American practice. Without correction, this would precipitate a platform-height compatibility problem for combined operation with other rolling stock, either light rail vehicles such as are used on the Blue Line, or commuter rail equipment, such as are used on Metrolink. Also, some of the overseas ARTVs are narrower than the typical U.S. passenger rail vehicle width, so a suitable high platform would not clear freight or passenger trains. The use of lifts, as are presently deployed on MTA buses, could achieve ADA compliance with a high floor ARTV serving a low platform station, however there are operational drawbacks associated with mechanized lifts, ranging from maintenance requirements to potential delays to scheduled service.

If a low floor design ARTV is used, bridge plates and mini platforms, such as those in use by Metrolink, would be a solution. Such a configuration would minimize the likelihood of having problems if platforms were shared with Metrolink and AMTRAK passenger trains.

Door and passageway widths - Many ARTV entrance doorways must be widened to provide ADA clearance. This includes sufficient width to allow the wheel chair lift arm to pass through and have adequate remaining clearance for ADA passage. On vehicle types with vestibules, the vestibules will most likely have to be widened to meet the ADA 40 inch requirement and allow for maneuvering of the wheelchair. Both doorway widening and vestibule widening would require a loss of passenger carrying space. Such design changes substantially affect the car structure and, as mentioned previously, this can have a major effect on ARTV delivery.

Restroom designs - Restrooms provided in some ARTVs are not ADA accessible, and would require redesign, while others already comply. Disabled restrooms are comparatively very large and remove considerable space from the seating area. Toilet systems are a high maintenance item. They represent a health hazard to repair shop personnel. Retention toilets require additional cost to routinely empty them and dispose of the waste. When not working properly they negatively affect the image of the service far more than if they did not exist. Generally if they don't exist, they are simply not noticed. Depending on the type of service expected of the ARTV, the restroom could be eliminated entirely, consistent with the other Metro Rail vehicles.

7.5 Flammability and Smoke Emissions (CFR 89-1058)

Whether under FRA jurisdiction or not, compliance with the current guidelines on flammability and smoke emission requirement will be necessary. In the past, it could be assumed that European vehicles would not be compliant, but in the last few years, fire resistance standards have begun to be introduced in European practice. The problem would be confirming that the materials used meet the U.S. (NFPA 130) requirements. These are defined in terms of laboratory tests, which are different from the tests used in Europe, and which the materials must pass.

To test all the materials used to U.S. standards may involve some unknown but relatively small cost. The car builder may not have too much difficulty in finding materials that meet these requirements since materials have been developed and tested for other U.S. rail car projects. The materials are available in the industry today, and test reports are in existence on most. The major task for the car builder will be to identify the materials, find U.S. based suppliers that have tested these materials, and change design specifications. The time consumed in this task will probably out weigh the cost of testing. This is an issue that can be dealt with in the normal course of the procurement contract. It does not represent an impediment to the schedule.

7.6 Other Federal Standards

There are other FRA standards, such as Radio Standards, Rear End Marking Devices, Window Safety Glazing, Railroad Safety Appliances, Power Brakes, Automatic Train Stop, Train Control, and Cab Signal Systems. Window glazing in ARTVs may not meet FRA requirements, and safety appliances such as exterior steps and handholds will also need to be reviewed and possibly modified to insure compliance. These are specification issues, and should present no significant implementation barrier.

7.7 Federal Railroad Certification Process

If the MTA proposes any ARTV service which is not under the jurisdiction of the FRA (49 CFR 229), it does not have to meet any FRA standards. The FRA has indicated a willingness to consider alternatives to sheer buff strength, such as crumple zones and energy attenuation devices, etc. Assuming that the decision is made to meet the FRA standards, this will be done through the FRA Office of Safety. This process has, in the past, taken between six and nine months.

ARTVs require a higher level of inspection than un-powered passenger cars. Like locomotives, such as those used by Metrolink, ARTVs must be inspected daily. This, and other standards for both passenger cars and ARTVs, may change in the near future. Based on the Federal Railroad Safety Authorization Act of 1994 (P.L 103-400), the FRA issued a discussion paper on May 12, 1995, to begin work toward major expansion and revision of the Federal regulations. This paper also proposed deleting the 400,000 buff strength requirement for MUs with a train weight of less than 600,000 lbs..

It is important to note that the FRA does not have a process through which it certifies ARTVs or other rail rolling stock and locomotives. Rather, manufacturers and operators are expected to self-certify equipment as meeting the standards. FRA does inspect the equipment which is being operated, and if the equipment does not meet the FRA standards, as published in 49 CFR, then they levy fines against the operator. FRA staff will review vehicle plans and specifications and prepare comments for operators or manufacturers.

In addition, any operator, manufacturer, or individual can request the FRA to waive its standards. This can be based on any number of factors, such as the type of operation, the safety environment of the rail corridor, or the mix of traffic. FRA would review the proposed waiver based on the intended level of passenger protection, and publish a recommendation in the Federal Register. After a reasonable review period, FRA could approve the waiver from some or all of the standards.

7.8 Compatibility Issues and AAR Recommendations

Association of American Railroads (AAR) recommendations are intended to provide compatibility and interchangeability for rail equipment in interchange service. They are recommendations only, and are not binding. While these cars are not operated in interchange service, there are some areas of compatibility that will be required, especially if the cars are operating on tracks that are part of the general railroad system.

Couplers and Air Brakes - In case of failure of an ARTV on a railroad with mixed traffic, it may become necessary for the freight railroad to tow the ARTV to clear the track. To provide for this situation, coupler types and coupler heights will need to match. Existing European designs do not match AAR standards for couplers. Also, in order for the freight railroad to tow the ARTV, the freight locomotive must connect with the ARTV's air brake system and recharge it. This will require compatibility of the air brake systems' operation and brake pipe pressure. This compatibility may or may not exist in current European designs.

While the Air Brake compatibility may require different brake equipment, it is not a serious impediment to schedule. Air brake details are a contractual issue that can be worked out in the normal course of a procurement.

The coupler type is also not of serious consequence, however, the coupler height will require structural modifications on some ARTVs. As mentioned previously, structural modifications can eliminate the advantage of using an off-the-shelf design, unless a carbuilder has an existing design already adapted to the U.S. market.

Communications and Train Control - Operation on a railroad with mixed traffic will require certain communication and train control compatibility. Automatic Train Stop/cab signal equipment and radio communication equipment will have to be made compatible. These are typical issues to be dealt with in the normal course of a rolling stock procurement.

7.9 Air Quality Regulations

While the concept of shifting people from single occupant vehicles to mass transit is generally lauded, ARTVs must demonstrate quantifiable emission benefits in order to gain the support of state and local air quality regulators and policymakers. Emission benefits would be measured in terms of the amount of pollutants that implementing ARTVs would displace from automobiles and other competing forms of personal transportation.

As noted previously in this report, some ARTVs use diesel engines comparable in size to urban bus engines. Other ARTVs use larger engines, comparable to heavy-duty truck engines. Of the regulated pollutants, oxides of nitrogen (NOx) and particulate matter (PM) are the pollutants of most concern from the heavy-duty sector. Heavy-duty engines also emit hydrocarbons (HC) and carbon monoxide (CO), but their contribution to the emission inventory for HC and CO is minor relative to the contribution of light-duty vehicles and other sources. Accordingly, regulatory efforts to curtail the emissions impact of heavy-duty vehicles have focused on NOx and PM.

In California, urban bus engines must meet a standard of 4.0 grams per brake-horsepower-hour (g/bhp·hr) NOx and 0.05 g/bhp·hr PM in 1996. The 4.0 g/bhp·hr NOx standard is delayed to 1998 in other states; otherwise, the same standards apply nationwide. Both diesel and alternative fuel engines are able to meet these standards and will be offered for sale in 1996. Exhibit 1 summarizes the state and federal certification emission standards now adopted for urban bus engines.

Exhibit 1. California and Federal Emission Standards for Urban Bus Engines (g/bhp·hr)

Model	California (CARB)					49-State (US EPA)				
Year	THC[1]	NMHC[2]	CO	NOx	PM	THC	NMHC	CO	NOx	PM
1991-1992	1.3	1.2	15.5	5.0	0.10	1.3	1.2	15.5	5.0	0.25
1993	1.3	1.2	15.5	5.0	0.10	1.3	1.2	15.5	5.0	0.10
1994-1995	1.3	1.2	15.5	5.0	0.07	1.3	1.2	15.5	5.0	0.07
1996	1.3	1.2	15.5	4.0	0.05	1.3	1.2	15.5	5.0	0.05[3]
1997	1.3	1.2	15.5	4.0	0.05	1.3	1.2	15.5	5.0	0.05[3]
1998 & later	1.3	1.2	15.5	4.0	0.05	1.3	1.2	15.5	4.0	0.05[3]

Notes: 1) *Total hydrocarbons, does not apply to natural gas-fueled engines*
2) *Non-methane hydrocarbons*
3) *In-use standard is 0.07 g/bhp·hr*
4) *Both the ARB and EPA allow limited averaging of PM emissions*

The U.S. Environmental Protection Agency recently announced that it will adopt a 2.5 g/bhp·hr HC+NOx standard nationwide in 2004. The California Air Resources Board (CARB) has indicated in the past its intent to adopt a more stringent standard of 2.0 g/bhp·hr in 2002. In mid-July 1995, CARB modified its plans; CARB now intends to adopt the same standard adopted nationally by the EPA. Natural gas engines have already demonstrated the ability to have very low NOx emissions, below 2.0 g/bhp·hr. Significant development will be needed for diesel-fueled engines, but engine manufacturers are confident that 2.5 g/bhp·hr HC+NOx will be achievable with diesel technology.

In considering the specific needs of the South Coast Air Basin, the MTA adopted a policy to procure only alternative fuel buses. While both diesel and alternative fuel engines are expected to meet all emission requirements through at least the next ten years, alternative fuel engines offer near-term benefits for NOx and PM compared to current diesel engines. Exhibit 2 summarizes emission certification data from currently available diesel and alternative fuel engines. After an initial run with methanol, MTA has begun the process of converting its transit fleet to compressed natural gas (CNG) operation.

Exhibit 2. Certification Emission Rates of 1995 Urban Bus Engines (g/bhp·hr)

Engine	Fuel	Description	HP Rating	HC	CO	NOx	PM
1995 Cummins M11-280	diesel	4-stroke, electronic unit injectors w/ catalytic converter	280	0.2	0.8	4.6	0.07
1995 Cummins L10-260G	natural gas	4-stroke, electronic fuel injection, lean calibration, electronic governor & wastegate w/catalytic converter	260	0.2	0.4	1.8	0.02
1995 DDC Series 50 DDEC III	diesel	4-stroke, electronic fuel injection, ceramic turborotor, air-to-air aftercooler, catalytic converter	315	0.1	1.3	4.9	0.06
1995 DDC Series 50G DDEC III	natural gas	4-stroke, lean calibration, GFI electronic central gas injection integrated w/DDEC control & diagnostics, catalytic converter	275	0.6	2.4	2.7	0.03

Sources: California Air Resources Board certification orders; personal communication with engine manufacturers

Detailed information about the route characteristics, fuel consumption and emission performance of ARTVs are needed to assess their emission benefits compared to passenger cars. Without this information, only a very preliminary assessment can be made. The following assumptions were used to roughly approximate the emission benefits of ARTVs:

- the brake-specific emission rates (BSER) of an ARTV is equivalent to those of two urban bus engines
- the brake-specific fuel consumption (BSFC) for each bus engine is 0.50 lb/bhp·hr, which is approximately the same as an urban bus engine over the federal transient cycle
- the route specific fuel consumption (RSFC) of the ARTV is 2.0 miles per gallon per car (a value typical of most ARTVs now in service)

Under these assumptions, the BSER can be converted to an emission factor in grams per mile (g/mi) by multiplying it by the BSFC, the RSFC and the density of diesel fuel (7.1 lbs/gal). For a 1996 ARTV, the resulting NOx emission factor is approximately 114 g/mi. Correspondingly, an average passenger car in 1996 would emit roughly 1 g/mi NOx. These results suggest that ARTVs can result in NOx emission reductions provided that ridership for each ARTV car is sufficient to displace on the order of 114 passenger cars. It is important to emphasize that this is a "back of the envelope"-type analysis that is based on extremely simplified assumptions. However, the results indicate that MTA will have to demonstrate high ridership levels to justify the air quality benefits of ARTVs if "standard" diesel urban bus engines are used.

While ARTVs would be powered by heavy-duty bus or truck engines, they would actually be regulated as locomotives. Federal law preempts California from setting standards for new locomotives and new engines used in locomotives. At present, locomotive engines are unregulated for emissions; however, the Federal Clean Air Act specifically requires the U.S. EPA to adopt emission standards by November 15, 1995. In its draft proposal, the EPA stated that it intends to require new locomotive engines built after January 1, 2000 to reduce NOx by 50 percent from uncontrolled levels, with no required reductions in HC, CO or PM emissions. Effective January 1, 2005, new locomotive engines would have to have 67 percent lower NOx emissions and 50 percent lower PM emissions compared to uncontrolled levels. Both the US EPA and CARB expect these standards to be achievable with diesel technology.

Neither the urban bus nor federal locomotive emission standards would limit the availability of powerplants for ARTVs. At the same time, however, if the introduction of ARTVs into the air basin causes an increase in emissions, the use of transportation funds may cause the Regional Transportation Plan and Regional Transportation Improvement Program (RTIP) to be found in non-conformance. A failure to show conformity could impact the use of federal funds in the SCAG region. Because of this reason, regardless of what the emission standards may allow, ARTVs must result in emission reductions in the South Coast Air Basin, if they are to be successfully implemented. This is best assured by attaining high ridership levels and by using the cleanest available powerplants.

7.10 Potential for Alternative Fuel ARTVs

As discussed in the previous section, alternative fuel engines offer the potential for greater emission reductions than diesel engines in ARTVs, especially in the near term. To the extent that some ARTVs use off-the-shelf heavy-duty urban bus engines, alternative fuel engines are available today. For those ARTVs which use heavy duty truck engines, development and certification of one or more gaseous fuel engines would be necessary.

Much of the initial effort in alternative fuel heavy-duty engines has focused on natural gas. Heavy-duty natural gas engines are generally certified to operate on either of two forms of the fuel: compressed natural gas (CNG) and liquefied natural gas (LNG). The only difference between the two is in how the fuel is stored on-board the vehicle and delivered to the engine. Transit properties have generally opted for CNG due to lower fuel cost and greater familiarity compared to LNG. However, as a liquid fuel LNG is easier to store on-board a vehicle and easier to refuel, making it more practical for some commercial fleets. Natural gas transit engines currently sell for $10,000 to $15,000 more than their diesel counterparts.

The main issue with implementing natural gas ARTVs is integration of the fuel system. With the current state-of-the-art in all-composite cylinders, the required fuel storage volume for CNG is 5.4 times more than diesel to achieve equivalent range. If the additional space needed for CNG fuel cylinders is not available, then vehicle range between refuelings would be reduced. LNG offers an advantage over CNG in this regard; the volume requirement for LNG fuel storage is 2.1 times that of diesel.

Liquefied petroleum gas (LPG) or propane is another alternative fuel vying for the heavy-duty alternative fuels market. Although LPG is clearly suitable for heavy-duty applications, it has received little support in the industry due to perceived supply availability problems. Emissions-certified LPG urban bus engines are not currently available in California, but a few companies are planning to develop LPG engines for the transit market. Detroit Diesel Corporation is expected to come out with an LPG version of its Series 50 engine in late 1995. Costs and emission rates of the LPG engine are expected to be similar to the natural gas Series 50.

No alternative fuel engines are commercially available for high performance ARTVs, such as the Siemens VT 610 which uses 750 HP engines. Use of a non-transit bus alternative fuel engine would likely require MTA to participate in a development program. Prototype engines have demonstrated the feasibility of natural gas in power plants above 300 HP. For example, Walmart has begun operating a Navistar Class 8 truck equipped with a 370 HP DDC Series 60 engine modified to run on LNG. The truck operates 500 miles a day between Porterville and Los Angeles. Also, Union Pacific Railroad expects to receive four LNG-powered locomotives in late summer 1995. GE and EMD will each build two of the locomotives. The GE engines are rated at 4000 HP, while the EMDs are 3800 HP.

While gaseous fuel engines are available now, an advanced technology that shows promise for providing nearly emissions-free, high efficiency propulsion in the future is the fuel cell. A fuel cell is a device which converts hydrogen (from added fuel) into electricity. In their present stage of development, fuel cells suffer from high cost, low power density, and the inability to meet rapid transients in power demand. However, the technology has improved sufficiently to the point where at least one company is considering commercializing fuel cell-powered transit buses. Ballard Power Systems has teamed with New Flyer Industries to develop a 275 HP fuel cell-powered transit bus for possible commercial sale in 1998. The first prototype of this bus will be built in mid-1995. This development followed the successful unveiling of Ballard's smaller, original concept bus in 1993. H-Power Corporation has also developed a prototype bus.

ARTV operations are normally less transient than on-highway vehicles, and engine design is less constrained by the need to minimize volume and weight. These considerations suggest that ARTVs may be a good early application for fuel cells. However, fuel cells are still a speculative enough technology that privately funded development for ARTVs is unlikely to occur in the near to mid-term.

7.11 California Public Utilities Commission Regulation

The CPUC would have limited regulatory authority over any ARTVs which operate over mainline railroad tracks. CPUC authority in such situations primarily applies to at-grade railroad crossings, as specified in CPUC General Orders 72-B, 75-C, and 88-A.

If ARTVs were operated over an exclusive right-of-way, the CPUC would likely have jurisdiction over such operations, as a logical extension of its electrified light rail system jurisdiction. As there are no current ARTV operations in California, confirmation would be required that the ARTV system met the safety requirements applied to light rail.

8.0 OTHER CONSIDERATIONS

8.1 Passenger Acceptance

The primary consideration in the design and operation of most diesel railcars has been cost reduction. Overseas ARTV operators have accepted compromises in passenger comfort in order to reach the cost reduction goal. As a result, some ARTVs have historically exhibited characteristics which might jeopardize passenger acceptance in the United States, particularly with regard to a lack of air conditioning, high noise and vibration levels and exposure to exhaust fumes. During the past decade, overseas standards have become significantly higher, and are comparable to rail rapid transit standards in the U.S.. Passenger comfort must be considered carefully in both specification of new ARTVs, and selection of a manufacturer in the procurement process.

8.2 Local Economic Development Potential

The economic development potential for Los Angeles County of an ARTV program will depend primarily upon the overall North American demand, and the Southern California regional demand, for vehicles of this type. The timing of development of ARTV manufacturing capacity in other regions of North America will also affect the potential for such development in the County. Phase II of this study will address the economic development potential of an ARTV program.

9.0 CONCLUSIONS

There are numerous ARTV designs, offered by several different suppliers, which might be suitable for deployment on selected rail routes in Los Angeles County. Primary conclusions reached to-date regarding ARTVs include:

- At least six ARTV models are, or will be, FRA-compliant. Two of them may become available in low floor configurations. Some are candidates for immediate application of clean fuels technology.

- At least three light rail-type ARTV models are available. They are not FRA compliant. Some are candidates for immediate application of clean fuels technology. However, application of clean fuels technology would be more difficult on these models than on the generally larger FRA-compliant models.

- Different clean fuels strategies are needed for the short and long term. The short term strategy must take advantage of the best existing technology to minimize emissions impacts while avoiding long delays in implementing service. The long term strategy should consider all technologies including those still in development.

- ARTV operating and maintenance costs are generally comparable to, or slightly higher than, costs for comparable light rail vehicles in comparable service.

- ARTV capital costs are significantly lower than capital costs for a comparable light rail system.

Deployment of ARTVs would be subject to resolution of outstanding issues, among them environmental impact, ADA accessibility and regulatory compliance. Based upon the survey of ARTV products available and proposed for the North American market, it appears that all of these issues can be resolved, and would not prevent ARTV deployment in Los Angeles County.

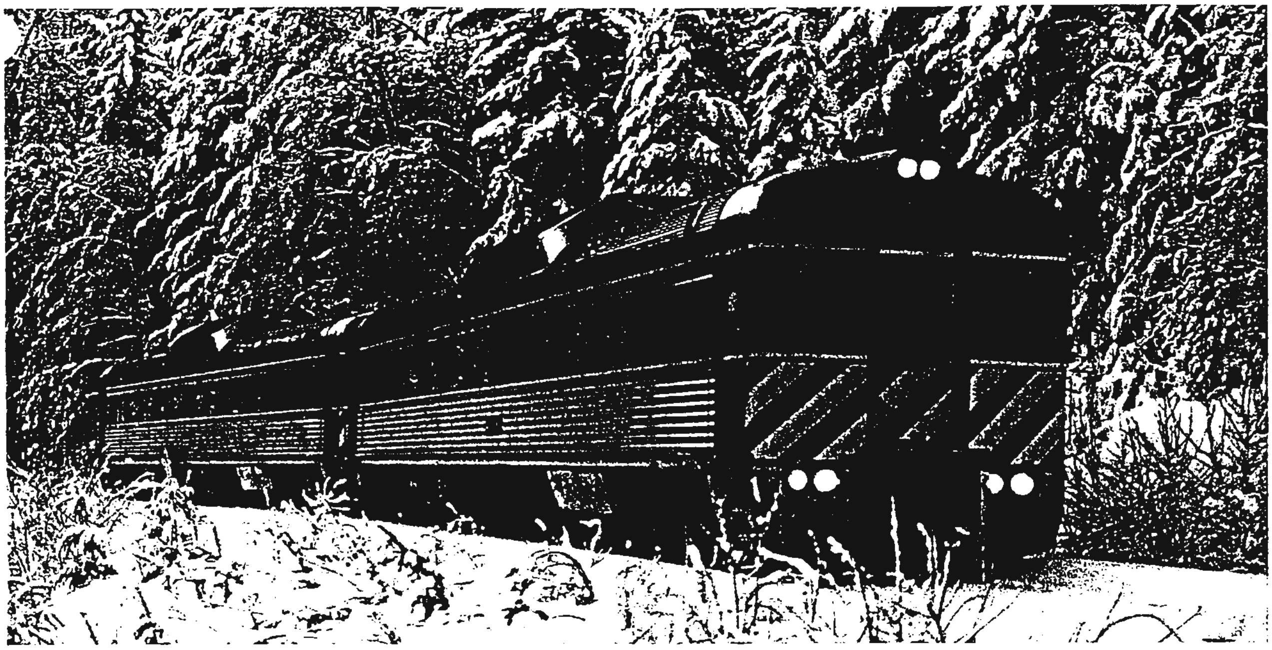
Other issues, including cost estimates, station design, system connectivity and institutional issues will be addressed in the Phase II analysis, the Alternate Rail Technology Feasibility Study. This Study specifically addresses the Burbank-Glendale-Los Angeles Corridor and will serve as a prototype feasibility study for the other candidate ART Corridors identified in the adopted 20-year Plan. The Phase II Study is underway and scheduled to be completed this Fall. At that time, the MTA Board is expected to decide whether to pursue ART implementation in the Burbank-Glendale-Los Angeles Corridor and whether to perform additional feasibility studies for the remaining candidate ART corridors.

ALTERNATE RAIL TECHNOLOGY VEHICLE COMPARISON

MODEL / MANUFACTURER	LENGTH (FT.)	NUMBER OF SEATS	FLOOR HEIGHT	FRA COMPATIBILITY	COMMENTS
LRT: MTA BLUE LINE Nippon-Sharyo	89	76	High	No	**LRT vehicle include for comparison.**
VT 610 AEG/Siemens	170	136	High	No	
VT 628 Siemens	152	144	High	Possible	
REGIOSPRINTER Siemens	81	84	Low	No	Designed for short-haul operations.
NEW GENERATION Nippon-Sharyo	85	87	High	Possible	Under development - no prototypes exist.
DIESEL RAIL CAR Bombardier	Not Determined	Not Determined	High	Possible	Under development - no prototypes exist.
SPRINTER Goninan	85	90	High	Possible	
IC3 ABB	193	154	High / Low	Possible	Proposed for demonstration project.
IC2 ABB	134	116	High	No	
XPLORER ABB	85	66	High	No	
3000 / 3100 ABB	85	113	High	No	
158 / 159 ABB	74	145	High	No	
165 / 166 ABB	76	176	High	No	
RAIL DIESEL CAR Budd	85	95	High	Yes	Forty years old; future viable life questionable.

APPENDIX

COMMUTER RAIL

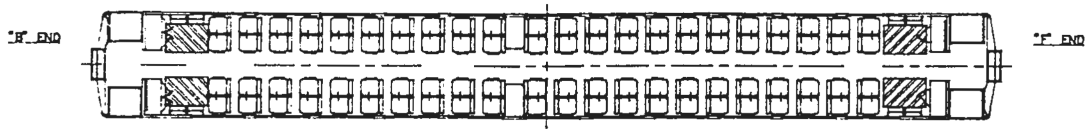


DART's Rail Diesel Car (RDC)

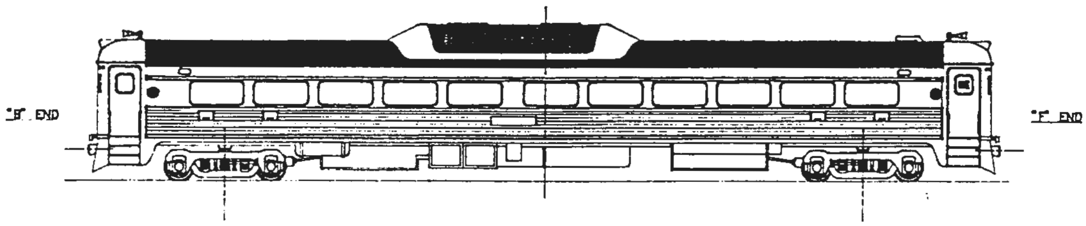
Model Designation	RDC-1
Number of Passengers	96 per car
Wheelchair Positions	4 per car
Design Speed	85 mph
Propulsion	Diesel powered
Electrical Power Generation	Auxiliary Power Unit
In Compliance With	ADA of 1990
Propulsion Diesel Engine:	
Engines Per Car	2
Manufacturer	Cummins
Model	NTA-855R
Type	Turbocharged
Horsepower	300
Number of Cylinders	6
Fire Suppression Agent	CO_2
Starting	Pneumatic
Transmission:	
Transmissions Per Car	2
Manufacturer	Twin Disc
Model	TAC-22-1304
Car Characteristics:	
Length	85'-0"
Width	10'-3/8"
Height	14'-8 1/8"
Weight (Empty)	135,000 pounds
Weight (Full Seated)	150,040 pounds

Passenger Interior:	
Seating Type	2 pass, highback, with armrests
Luggage Racks	Continuous open construction
Linings	Melamine and plymetal
Floor Covering	RCA Rubber
Windows	Single glazed, fixed type
HVAC:	
Capacity	14 ton
Refrigerant	R-22
Passenger Heat	Water floor heat, electric overhead
Air Diffusers	Overhead, continuous and flush mounted
Fresh Air	1200 cfm per car
Cab:	
Cabs Per Car	2
Seating	Fold-away seat
Windows	Windshield and side drop sash
Heat	Separate forced air

COMMUTER RAIL



FLOOR PLAN



ELEVATION

Interior Lighting:

Type	Fluorescent
Mounting	Continuous, above seats, integral with air diffusers

Exterior Lighting:

Types	Headlights, marker lights, ditch lights, and strobe lights

Auxiliary Power Unit (APU):

APU's Per Car	1
Type	Self-contained diesel engine driving an alternator
Output	480 volt, 3-phase 60 Hz
Starting	Pneumatic

Trucks:

Wheel Diameter	34"
Wheelbase	8'6"
Journal Size	5½" x 10"
Gearbox Type	Dana Spicer Model 8
Gearbox Location	Inboard axle
Frame Type	Cast steel
Brake Type	Inboard discs

Brakes:

Type	Schedule 26
Control	Double end control using 26B1 auto brake and 26CV-8 control valves
Air Compressors	Main supply taken from compressors driven by both propulsion engines
Discs	Inboard mounted

Communication:

Train Radio	Two-way
Intercommunication	Two-way private
PA System	One-way; operator to inside and/or outside of car
Passenger Emergency Communication System	Two-way; operator to wheelchair areas

Wheelchair Access:

Loading/Unloading	By use of bridgeplate through vestibule side doors

IC2 Diesel Multiple Unit

For Regional and Local Services

ABB Transportation

IC2 Diesel Multiple Unit

For Regional and Local Services

The IC2 is a 2-car diesel version of an IC-concept which also includes the IC3 and the IR4 products.

The IC-concept is characterised by:

- A high standard of passenger comfort
- Modularization
- Flexibility in daily operations
- Diesel and electric trainsets run coupled together
- Light weight
- Fast acceleration

The IC2 is designed to offer optimal passenger comfort and flexibility at a very economical price. These parameters are of the greatest importance in competition with alternative means of transport. To create optimum passenger comfort, the IC2 has a very low internal as well as external noise level. Flexibility is also a key element in the development of the IC-concept and makes it possible to sub-divide a large portion of the train interior to provide space for wheelchairs, bicycles, prams and play areas for children.

The IC2 is built up from modules to reduce workshop overhaul time and ensure low maintenance costs, high mileage per year and high availability. The use of standard components from other industries is considerable and greatly assists spares procurement.

Fast coupling of up to 3 units ensures flexibility in operation. In this way, three trainsets can operate as a single train over part of the route before being divided into separate units at an intermediate station and then driven on to different destinations. A train coupled in multiple is operated from one driver's cab. A unique feature is a driver's desk which can swing to the side to provide free passage for passengers from train to train via a full width gangway.

Low weight is achieved by using light materials. The car bodies are made of aluminium extrusions and all fittings are of lightweight sandwich construction. Likewise, low weight means reduced fuel consumption and results in lower operating costs and environmentally friendly operation. Low weight also makes rapid acceleration possible, and the train is designed for fast acceleration and deceleration from its maximum speed (up to 160 km/h) to ensure short stops at stations.

Development of the IC2 is not yet complete, and it will be produced for both regional and local service. The IC2 is offered in an economical, basic, version for use on lines in sparsely populated areas. Upgrades are available as optional extras and include: retention toilet systems; combined operation with the IC3/IR4, information system, music system, telephones, air conditioning in entrance areas, and variations in seat numbers and pitch.

Main Data

TECHNICAL	
Track gauge:	1435mm
Train consist:	driving trailer + driving motor
Train length:	41000mm
Max. width:	3100mm
Max. height:	3850mm
Floor height:	1300mm
Weight (tare):	60t
Payload:	16t
Bodyshell:	extruded aluminium
Engines:	2 x 265kW air-cooled diesels
Transmission:	mechanical
Brakes:	electro pneumatic disc brakes, magnetic track brakes
Parking brake:	spring activated (3.0%)
Bogies: front bogies:	2
articulated bogies:	1
Speed (cruise):	up to 160km/h
Acceleration (0-50 km/h):	0.8 m/s 2
Braking (Service):	1.0 m/s 2
ENVIRONMENTAL	
Fuel consumption, approx:	0.7 l/km
Toilet system:	closed, vacuum
Noise levels:	
Passenger compartment, operating:	67 dB
External, operating:	78 dB
PASSENGER FACILITIES	
Number of seats:	116
Min. seat pitch:	1710mm
Tip-up seats:	19
Number of standees:	60
Flexible areas:	2
Flexible area, size:	$7m^2$
Entrance door type:	single leaf swing/slide
Entrance door width:	920mm
Toilet, closed system:	one, optional
TRAIN CREW FACILITIES	
Air conditioners in driver's cab:	optional, 2
Diagnostic systems:	1
Automatic control systems:	1
TRAIN OPERATION	
Automatic coupling/uncoupling of trainsets:	
Multiple unit operation:	1-3 IC2 trainsets
Multiple unit compatibility:	IC3 & IR4 optional
Redundancy: (if one system fails another takes over)	
traction:	2 diesel engines
SERVICE/MAINTENANCE	
Service intervals:	50,000 km
Service/repair:	module exchange
On-board error logging:	1
On board diagnostic system:	1

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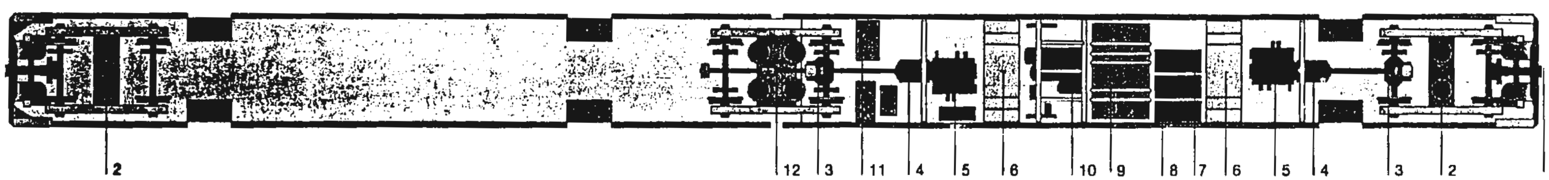

IC2

Et selvkørende 2-vogns dieseltog, som er specielt udviklet til lokal og regional trafik.
Der er lav gulvhøjde i den ene vogn for at sikre let adgang til toget.
Toget har flexarealer til bl.a. stående passagerer, barnevogne og cykler.
Kupéområderne er opdelt med glasvægge, hvilket giver et lyst og venligt indtryk.

Passagerer:

Sofapladser	110
Klapsæder	19
Ståpladser	60

Interiørets modulopbygning giver fleksible indretningsmuligheder.
De tekniske komponenter er samlet i moduler. Det gør vedligeholdelsen let og sikrer høj tilgængelighed.

Flexliner

Moduler

1. Automatkobling
2. Frontbogie
3. Akselvendegear
4. ZF-gear
5. Dieselmotor
6. Vandkølemodul
7. Brændstoftanke
8. El-udrustning
9. Elmodul
10. Trykluftmodul
11. Power pack
12. Fællesbogie

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Bergsøe 4/Buchs's Bogtrykkeri, Randers. 11.94

IC3 Diesel Multiple Unit

For Danish State Railways (DSB)
and Various Export Customers

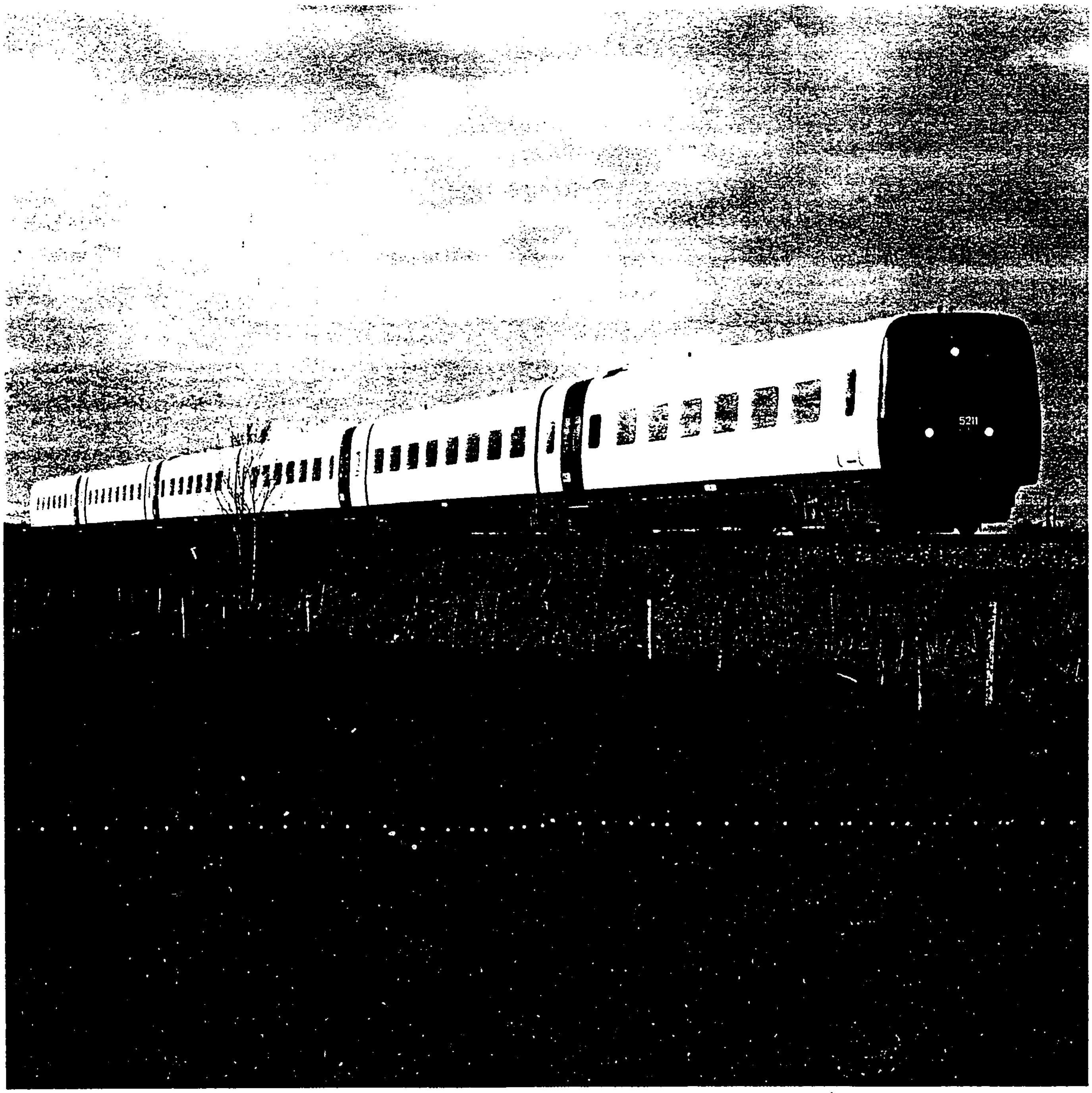

ABB Transportation

IC3 Diesel Multiple Unit

For Danish State Railways (DSB) and Various Export Customers

The IC3 was the very first trainset to be based on an IC-concept which has since been developed into a range which includes the IR4 and the IC2 products.

The IC-concept is characterised by:
- A high standard of passenger comfort
- Modularization
- Flexibility in daily operations
- Diesel and electrical trainsets run coupled together
- Light weight
- Fast acceleration
- An environmentally desirable product

The IC3 is designed to optimise passenger comfort and flexibility, as these parameters are of the greatest importance in competition with alternative means of transport. To create optimum passenger comfort, the IC3 has an efficient air conditioning system and can boast very low internal as well as external noise levels. Flexibility is also a key element in the development of the IC-concept and makes it possible to sub-divide a large portion of the train interior to provide space for wheelchairs, bicycles, prams and play areas for children. Dependant on application, the train can be further equipped with facilities for a passenger information system, music, telefax and modems for personal computers.

The IC3 is built up from modules to reduce workshop overhaul time and ensure low maintenance costs, high mileage per year and high availability. The use of standard components from other industries is considerable and greatly assists spares procurement.

Fast coupling of up to five units - both electrical as well as diesel trainsets - allows the greatest flexibility in service. In this way, five units can operate as one train and later be split to form separate trainsets which can continue on their individual ways to different destinations. A train coupled in multiple can be operated from one driver's cab. A unique feature is a driver's desk which can swing to one side to provide free passage from train to train via a full width gangway.

Low weight is achieved by using light materials. The car bodies are made of aluminium extrusions and all fittings are of lightweight sandwich construction. Low weight means reduced fuel consumption, lower operating cost and is better for the environment. The train is designed for fast acceleration and deceleration from speeds up to a maximum of 180 km/h.

The IC3 is a multi-purpose train which can be modified to fit different service needs. Variants of the same IC3 are used for the following applications:
- In Denmark, the IC3 operates in Intercity service.
- In Sweden, the IC3 is operating in both regional and interregional service.
- In Israel, the IC3 is used for both Intercity and suburban services.

By the spring of 1993, more than 100 trainsets were in operation.

Main Data (DSB/IC3)

TECHNICAL	
Track gauge:	1435mm
Train consist:	driving motor + trailer + driving motor
Train length:	58800mm
Max. width:	3100mm
Max. height:	3850mm
Weight (tare):	96t
Payload:	24t
Bodyshell:	extruded aluminium
Engines:	4 x 265 kW air-cooled diesel
Transmission:	mechanical
Brakes:	electro pneumatic disc brakes, magnetic track brakes
Parking brakes:	spring activated (3.0%)
Braking distance from 160 km/h:	<1200 m
Bogies:	
front bogies:	2 (13.5 t/axle)
articulated bogies:	2 (17.5 t/axle)
Speed (cruise):	180km/h
Balancing speed:	>220km/h
Acceleration (0-40 km/h):	1.0m/s^2
Braking (service):	1.0m/s^2
Braking (emergency):	1.2m/s^2
ENVIRONMENTAL	
Pollution:	EWG 91/542
Fuel consumption DK:	1 l/km
Closed toilet system:	vacuum
Noise levels:	
Passenger compartment:	66dB
External (160 km/h):	85dB
PASSENGER FACILITIES	
Number of seats:	140-180
Min. seat pitch:	2020mm
1st class adjustable seats:	16
2nd class adjustable bench seats:	62
Tip-up seats:	26
Entrance door width:	1400mm
Gangway train to train:	1300mm
Wide entrance doors for disabled access:	4
Toilets for the disabled:	one
Toilets:	three
Air conditioning:	6 systems to UIC553
Catering room:	1
Information system (dot matrix displays):	
door number (2 char):	4
entrance (2 lines):	4
passenger (2 lines):	12
seat reservation	
audio information channel:	1 per seat
Entertainment:	
music/video channels	5/4
Communications:	
telephone at seats:	1 per 4 seats
payphone:	1
telefax:	1
modem for computer:	1
220 V AC connectors:	1 per 4 seats
loudspeaker systems:	3
TRAIN CREW FACILITIES	
Air conditioning/drivers cab:	2
Conductor's compartment:	1
Intercom system:	4
Diagnostic systems:	2
Automatic control systems:	2
TRAIN OPERATION	
Automatic coupling of trainsets	
Multiple unit operation:	1-5 IC3 trainsets
Multiple unit compatibility:	IR4, IC2
Redundancy: (if one system fails another takes over)	
traction:	4 engines
braking:	2 computers
control:	2 systems
electric supply:	2 generators
compressed air:	2 systems
SERVICE/MAINTENANCE	
Service intervals:	50,000 km
Overhaul intervals:	500,000 km
Service/repair:	module exchange
Diagnostic systems:	2
On-board error logging:	2

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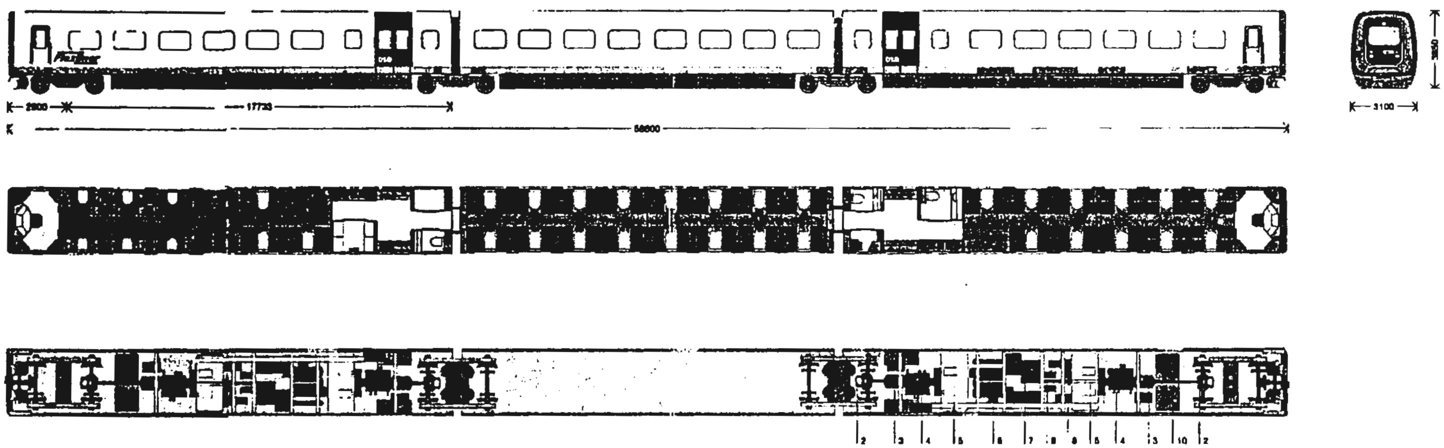
IC3D



Modules

1. Air-conditioning system (on roof)
2. Reversing shaft gear
3. ZF-gear
4. Diesel engine
5. Air intake
6. Pneumatic System
7. E-module
8. Generator
9. Compressor
10. Fuel tank

Flexliner

IC3D

A three-car diesel version. Especially developed for intercity services for use on lines with many junctions and stops.

Seats	
1 st Class	16
2 nd Class	128

The modular design provides for flexible interior solutions.

The consequent modularization of the technical components facilitates maintenance and ensures high availability.

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Diesel Multiple Unit Xplorer High-Speed Railcars

For New South Wales
- State Rail Authority, Australia

ABB Transportation

Diesel Multiple Unit
Xplorer High-Speed Railcars

For New South Wales
- State Rail Authority, Australia

High-speed luxury diesel railcars for long-distance services in New South Wales.

The cars are constructed in spot-welded stainless steel, and have aerodynamically shaped glass reinforced plastic front ends.

There are three car types: A driving car with first class seating as well as a buffet and standard toilet. A driving car with all economy seating and booked luggage, together with wheelchair space and handicapped persons' toilet. An intermediate car with all economy seating and two standard toilets. Trainsets may be assembled with from two to eight cars in the consist.

Seating is two-plus-two across and every seat rotates and reclines. Fold-down tables are fitted to the backs of all seats and on the partitions and end walls of the passenger saloons.

The cars are fitted out for maximum comfort with full carpeting, individual reading lights, magazine pockets at each seat, overhead luggage racks, large tinted windows and individual curtains.

Side entrance doors are power-operated outside sliding plug units, closed and released by the guard, and opened by the passengers by means of local push buttons.

One self-contained packaged air conditioning unit is mounted in the roof of each car above the main vestibule, providing climate control to all saloons as well as to the driving cab.

All cars are powered by a single underfloor diesel engine of 352kW driving through a hydraulic transmission to tandem final drive gearboxes on both axles of one bogie.

A single 118kW auxiliary diesel-alternator set on each car provides power for lighting, air compressor, air conditioning, radiator cooling fans, battery charging and the buffet equipment in a two-car set.

The fabricated bolsterless bogies have trailing-arm coil primary suspension and air spring secondary suspension. Anti-roll bars are fitted and levelling valves maintain a constant car floor height.

Braking is by means of a hydrodynamic retarder in the transmission and through wheel-mounted brake discs.

The cars are semi-permanently coupled together in sets by drawbars, and a Scharfenberg multifunction coupler is fitted at each outer end of a set.

Main Data

Gauge:	1435mm
Length over couplers -	
Driving car:	25250mm
Intermediate car:	24700mm
Width:	2918mm
Roof height:	4110mm
Maximum speed:	160km/h
Traction engine:	Cummins KTA 19R rated 352kW @ 1800rpm
Transmission:	Voith T311 r + KB260/2
Final drive:	Voith V19
Auxiliary engine:	Cummins LT 10R (G) rated 118kW @ 1500rpm
Alternator:	Stamford UCI 271F (two bearings)
Electrical systems:	415V 3-phase 50Hz 24 DC battery
Tare mass -	
luggage car:	54t
buffet car:	55t
intermediate car:	54t
Passenger capacity:	
Economy seating -	
luggage car:	50
intermediate car:	66
First class seating -	
buffet car:	42

ABB

MUT/608/10.94/2K

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Diesel Multiple Unit, Class 3000/3100

For South Australia State Transport Authority

ABB Transportation

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Diesel Multiple Unit, Class 3000/3100

For South Australia State Transport Authority

Suburban or interurban commuter diesel multiple unit railcars featuring three-phase AC drive. Construction is in spot-welded stainless steel with glass-reinforced polyester front ends. One car type has a cab at both ends and may be operated as a single unit. The second car type has a cab at one end only and operates back to back with a similar vehicle to form a two-car set. Multifunction couplers are provided for multiple unit operation. All cars are powered by a single V12 Mercedes twin turbo-charged diesel engine coupled to an alternator running at a fixed 1500rpm. The alternating current produced, is passed through a Stromberg rectifier/inverter to provide a variable voltage, variable frequency power supply for the bogie-mounted AC squirrel cage induction traction motors. By shifting the frequency of the power supply to the traction motors, a retarding torque is produced, capable of braking the vehicle to a standstill. Normal pneumatic braking is provided by means of wheel mounted cheek discs. Engine cooling radiators and the engine induction air cooler are mounted on the roof.

All cars have two sets of double sliding automatic power operated side doors, and the saloons are fully air-conditioned.

Bodyside windows are solar control double-pane units, and the saloon interiors are finished with glass reinforced plastic side panels, polyurethane-finished aluminium panel ceilings and heavy duty wool carpet on the floors and up to the window sills.

Transverse fluorescent lights are provided in the ceiling modules. The five-abreast seating is individually contoured and upholstered in heavy duty wool fabric.

Bogies are of the fabricated bolsterless design with rolling rubber primary suspension and air bag secondary suspension directly connecting the bogie frame and car body.

Provision is made in some cars for wheelchairs, baby-pushers and cycles. UHF two-way radio as well as public address systems are fitted to all cars. The vehicles are equipped with the British Rail Automatic Warning System (AWS).

Main Data

Gauge:	1600mm
Length over couplers:	25774mm
Width:	3050mm
Roof height:	3875mm
Height over radiators:	4270mm
Tare weight:	46.5t
Passenger capacity -	
double-cab car:	105 seated
single-cab car:	113 seated
Maximum speed:	90km/h
Traction engines:	Mercedes OM444 LA V12 turbo charged 354kW @ 1500rpm
Alternator:	Reliance SDGB 3107-4 400kVA 660V
Auxiliary transformer:	T & D Transformers 70kVA 660V-415V AC
Auxiliary load (maximum):	55kW
Transmission-Rectifier/Inverter:	Stromberg 5775974-7
Traction motors:	Stromberg 3 phase, 4 pole squirrel cage induction motors
Brake resistor:	Cutler Hammer 625kW maximum
Air conditioning:	Sigma RPR 25-MR 14.5kW Cooling 11.8kW Heating
Pneumatic brakes:	Knorr
Bogies:	Linke-Hoffman-Busch
Fuel tank capacity:	1474 litres

MUT/607/03.93/2K

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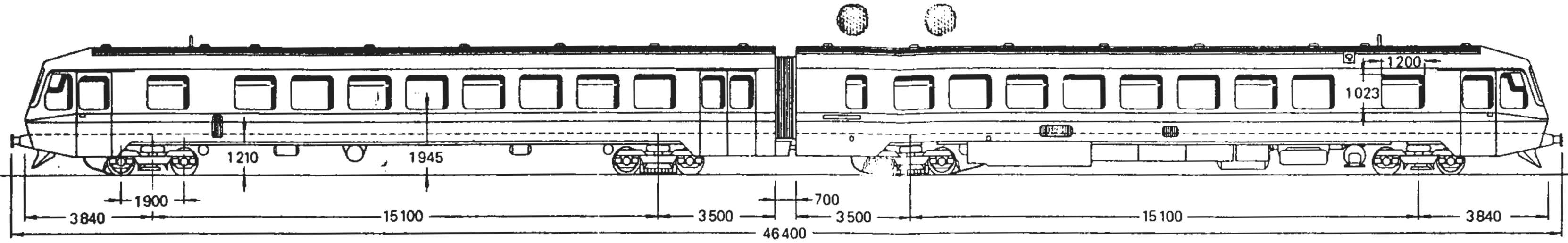
DUEWAG

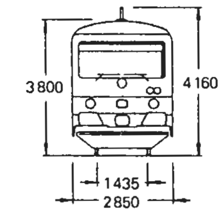
Type 628.4/928.4 DATA

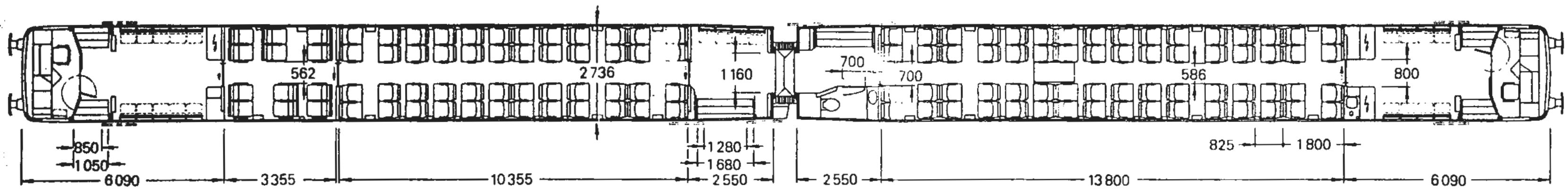
Light-weight Diesel Multiple Unit of the German Federal Railway (DB) for Short Distance Passenger Traffic

Type 628.4/928.4 DATA

DUEWAG







Car body

Self-supporting welded light construction car body manufactured of steel St 37 and St 52 with recessed sides at the close-couple ends. Side and front wall sheet-metal, corrugated sheet floor beneath the WC as well as entrance step housings of alloyed steel 1.4512. Corrugated roof sheets and roof arches of alloyed steel 1.4301. Exterior coated with water-soluble paint. Pilot bar.

Interior layout

Side wall panelling of large FRP hot pressed parts with grained surface and integrated window frames. Internal ceilings of self-supporting moulded laminated plastic boards in sandwich construction.

1st class compartment in driving trailer with comfortable double seating with adjustable backrests and seats. Lighting integrated in the longitudinal luggage rack.

Vandalism-resistant two-place system seats in row and face-to-face arrangement in the 2nd class passenger saloons. Double seats in the passenger saloons adjacent to the intermediate ends can be folded up to enable wheelchairs to pass. Louver lighting as central lightband in the middle of the ceiling, longitudinal luggage racks.

Equipment of the multipurpose areas with handrails in the entrance

area, additional handrails with armstraps, large-volume waste containers, folding seats, bicycle stand, longitudinal luggage racks.

Entrance areas at the intermediate ends with large-volume waste containers, in the driving trailer folding seats, handles at the gangway and in the entrance area, a WC in the motor car. Electropneumatically driven and electrically heatable external mirrors.

A destination indicator per car in the windscreen area and in the side wall at the intermediate end. Closed bellows-type gangway which is fastened to the faces by quick clamping devices.

Insulation

Roof, side and front walls sprayed with sound-absorbing paint. Corrugated sheet floor sound insulated with high-quality two-component agent up into the side walls. Sheeting in the area of the driver's cab drop windows additionally coated with polystyrene fillers bonded into the sound absorbing compound. Side walls, roof sheeting, internal ceilings and floor covered with moisture-resistant, perforated corrugated foil packages.

Acoustic insulation in the floor area by using mineral-fiber mats under the floating-mounted plywood sandwich floor. The particularly noisy sections are insulated additionally by means of heavy mats.

Heating and ventilation

Hot water convection heating in the passenger and auxiliary areas with utilization of the cooling water heat of the Diesel engine. Oil-fired supplementary heating for preheating and in the case of delivering inadequate heat by the cooling water.

Separate heating circuits and temperature sensors in the passenger saloons. Central control of the heating and ventilation system including heat retention and preheating operation by a microcomputer. Pressure ventilation of the passenger saloons with air entry from both sides of the central light band. Air withdrawal through static roof ventilators. Air exchange rate 1.600 m^3/h. Separate heating and ventilation of the driver's cab.

Doors

Convenient, wide three-step entrance for low platforms with electro-pneumatically operated swinging aluminium plug doors. Extra wide double sliding flush doors at the close-couple ends in order to allow rapid passenger flow. Door blocking governed by travelling speed. Manually operated internal doors, the WC door and the ones adjacent to the intermediate vehicle ends suitable for wheelchairs.

Windows

Frameless, auresin vapour-deposited side and access door windows of laminated insulating glass in rubber clamping profiles, every second side window with hinged upper section. Windscreen of 12 mm thick, 3-layer safety laminated glass with particularly penetration-resistant intermediate layers. Laminated insulating glass in the driver's cab drop windows.

Running gear

Bogies with torsionally flexible frame and level-controlled pneumatic suspension. Transmission of the propulsive and braking forces to the coupler carriers of the underframe by a connecting rod. Equipped with compressed air disc brakes and microprocessor-controlled anti-skid controllers. Spring-loaded parking brake in the bogie on the driver's cab side. Flexible emergency support of the car body in the case of deaerated pneumatic suspension. Lifting the car body together with bogies possible.

Drive unit

Use of a supercharged 12-cylinder Diesel engine as drive unit. Diesel engine and gearbox suspended from the underframe in vibration insulators and connected with one another by flexible coupling and cardan shaft. Drive power transmission from the hydraulic gear by further cardan shafts to the two wheelset gears in the driving bogie. Connection of the generator-starter motor with the auxiliary power take-off side of the engine by flexible coupling and cardan shaft.

Setting of 7 engine power stages by electrical controller. Combustion air is drawn in through side wall grilles underneath the windows and cleaned by dry air filters arranged in the underframe. Conduction of exhaust gases through several silencers, discharge above the roof.

Re-cooling the engine cooling water in an underfloor cooling unit with hydrostatic fan drive. Incorporation of the lubricating oil and gear oil heat exchanger in the cooling water circuit. Sound-absorbing aprons.

Electrical equipment

Supply of the 110 V direct current train supply system by a 14 kW generator-starter, power supply at engine standstill by lead battery (165 Ah). External supply from the local power supply system through rectifier unit (110 V, 16 A) possible. Control and automatic surveillance of the drive unit as well as door control by the MICAS® microcomputer system with a diagnostic unit. Operation of a maximum of 3 two-car units from one driver's control desk. Equipment of the vehicles with anti-slip and anti-skid systems, passenger information system, dead man's handle, inductive safety device as well as track radio and loudspeaker system.

Type 628.4/928.4 DATA

Vehicle type	628.4	928.4
Vehicle limitation	EBO § 22, UIC 505-1	
Permissible maximum speed	120 km/h	
Minimum negotiable track radius	125 m	
Track gauge	1435 mm	
Wheelset arrangement	2'B'	2'2'
Total length over buffers	46400 mm	
Car body length	22440 mm	
Maximum width	2850 mm	
Maximum height above top of rail	4160 mm	
Floor height above top of rail	1210 mm	
Pivot distance	15100 mm	
Number of seats 1st class Number of seats 2nd class Number of folding seats	– 64 8	12 48 14
Size of multipurpose area	approx. 7.0 m^2	approx. 8.0 m^2
Empty weight (according to DIN 25008)	41.4 t	29.0 t
Maximum weight (according to DIN 25008)	56.8 t	44.0 t
Fuel capacity engine	1000 l	
Fuel capacity heating	250 l	
Service water reserve	200 l	
Sand reserve	100 kg	50 kg
Bogie	bogies with torsion-elastic frames and level-controlled pneumatic suspension, Wegmann resp. Talbot make	
Bogie wheel base	1900 mm	
Wheel diameter new/worn	770 / 710 mm	
Braking system	KE compressed air disc brake with microprocessor-controlled anti-skid system, two brake discs per wheelset magnetic rail brake in the driving bogie	in the bogie at the close-couple end
Diesel engine	12-cylinder Diesel engine, type 12 V 183 TD 12 turbo-supercharging, 485 kW at 2100 min^{-1}, Daimler-Benz resp. MTU make	
Gear	hydraulic 2-converter gear with quick-mesh gear (centrifugal protection gear) type T 311 r, Voith make	
Power transmission engine - gear gear - wheelset gear	flexible coupling cardan shaft cardan shafts	
Coupler driver's cab ends intermediate ends	side buffers (RINGFEDER® sleeve buffers), light coupling gear tight coupling	
Heating	oil-fired hot water heating, pressurization system	
Electrical equipment	multiple control 110 V DC, batteries 110 V / 165 Ah	
First delivery	1992	

Siemens Transportation Systems
700 South Ewing Street
St. Louis, MO 63103
Phone: (314)533-6710
Fax: (314)533-4739

DUEWAG

U. 611.021.3-16.4.93

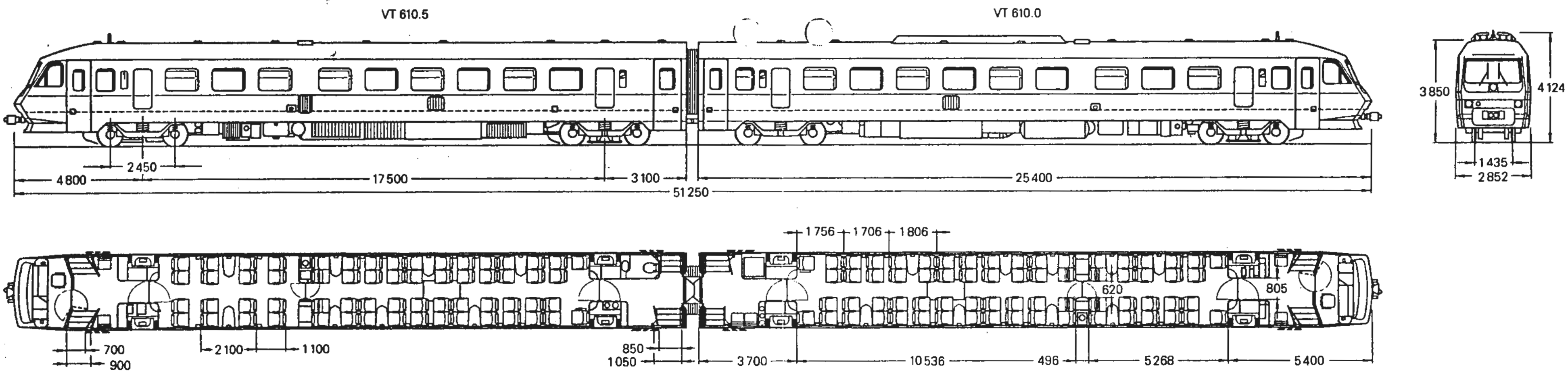
DUEWAG

Type VT 610 DATA

Diesel trainset
with body tilting system and three-phase drive technology
for regional traffic of the Deutsche Bundesbahn

Type VT 610 DATA

DUEWAG

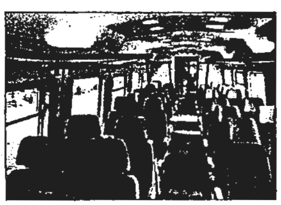


Car body

Lightweight construction thanks to self-supporting welded aluminium structure made of Al Mg Si 0.7 and Al Zn 4.5 Mg1. Predominantly integral structure using large-scale extruded sections. Underframe designed as orthotropic floor panels made of cavity sections and moulded supporting rails for the underfloor equipment. Sidewalls made of open extruded sections. Longitudinal bearers and roof arch made of cavity sections. Roof cover made of a combination of profiles, arches and aluminium sheeting. End walls made of profiles, side sections and aluminium sheeting.

Insulation

Roof, flooring, sidewalls and end walls with sound-absorbing sprayed layer. In the flooring areas and the lower areas of the sidewalls also used as an anti-corrosive agent. Sidewalls and roof covered with corrugated PVC sheeting, mineral-wool mats and aluminium/corrugated PVC sheeting under the floating flooring made of plywood panels with a noise-absorbing intermediate layer.



Interior design

High-quality interior design with cloth-covered vandalism-resistant seats conforming to German InterRegio standards. Two passenger saloons per coach, separated by a glass swinging door. Continuous

longitudinal luggage racks aligned diagonally and jutting forwards alternatively – in the larger passenger saloons with grabrails. Storage surfaces easily accessible. Coat hooks also available for aisle seats.

Large sidewall paneling made of hot-pressed fiber-reinforced plastic. Perforated ceilings made of self-supporting moulded laminated plastic panels. Flooring made of synthetic rubber wrapped up the sidewalls. Impressive illumination system with indirect ceiling lighting and reading spots which can be switched on individually by the passengers.

Spacious entrance vestibules with 6 fold-down seats, space for wheelchairs. Toilet with closed waste-water drainage system at the intermediate sections of the VT 610.5. Intercommunicating gangways with fully-enclosed bellows.

Heating, ventilation

Hot-water convection heating in the passenger and secondary areas using the cooling-water waste heat from the diesel engines. Supplementary electrical heating if insufficient output of the primary heating unit and to preheat the diesel engines and the passenger areas.

Optimum room climate due to continuous monitoring by means of thermostats and central control of the heating and ventilation system with a microcomputer. Separate heating circuits for the individual passenger areas and vestibules. Ribbed radiators in the passenger areas, heater blowers in the vestibules.

Forced ventilation of the passenger areas connected to the hot-water circuit. Waste air removed through static roof ventilators. Air exchange rate 1,800 m^3/h. Additional ventilation through tilting windows. Separate heating units for heating and ventilating both driver's cabs.

Doors and windows

Electro-pneumatically operated swinging-sliding single doors. Central monitoring and control of the doors from the driver's cab. Door blocking depending on the train speed.

Entrance-door and side windows made of vapor tinted double-pane insulated glass. Side windows with aluminium frame, every second window with hinged upper section. Windscreen made of 16-mm thick laminated safety glass with an enclosed heating foil.

Bogies, tilting system

Two-piece torsionally flexible H-frame bogies. Primary and secondary suspension by means of coil springs. One non-driving bogie and three driving bogies per trainset. Non-driving wheelsets equipped with two axle-mounted brake disks, driving wheelsets with an axle-mounted brake disk and a wheelset gear. Automatically operating graduated air brakes. In addition electrodynamic brakes and one pair of electromagnetic rail brakes per trainset. Spring-operated parking brake. Equipped with wheel flange lubrication, sanding equipment and microprocessor-controlled anti-skid and anti-slip devices.

Active body tilting system for tilting the car body towards the curve center in curves by means of hydraulic cylinders positioned on both sides of the coach. Hydraulic energy provided from a high-pressure reservoir with a pressure level of 16,000 kPa. Coach body suspended freely from pendulum bars. Maximum tilting degree of 8°. Center of gyration in seat height. Pneumatic device returning the coach body to its central position on straight rail sections. Transverse-force peaks dampened by means of pneumatic cylinders positioned between the bogie and the coach body.

Superelevation of the curve, lateral acceleration and velocity measured by means of gyroscopes, accelerometers and velocimeters. Signals processed by the electronic control system. Hydraulic system controlled by means of synchronized electromagnetic valves in order to avoid torsional strains of the car body at different angles. Interfering influences resulting from transverse and rolling motions of the vehicle filtered out.

Driving plant

Both motor coaches equipped with a water-cooled supercharged 12-cylinder diesel engine each, suspended elastically in a common supporting frame with the directly-coupled brushless single-bearing three-phase synchronous alternators. Energy flow from the generators through the uncontrolled rectifiers, the direct-current intermediate circuit and oil-cooled GTO-impulse DC-AC-converter with integrated braking controller to the three 3-phase traction motors. The traction motors drive the wheelsets lying on the inside of each bogie through a cardan shaft and a wheelset transmission. Hydrostatically-driven ventilators for the cooling water and the charge air cooler.

Electrical equipment

Electrical auxiliaries supplied during driving operation by the voltage intermediate circuit. In stationary operation vehicle supplied from the train preheating units with single-phase a.c. voltage, 1,000 V $16^2/_3$ Hz or 50 Hz, rectified by means of a rectifier with a subsequent smoothing reactor. On-board vehicle system supplied through inverters and transformers with 3 x 400 V, 50 Hz and 3 x 230 V, 50 Hz. Supply of all the engine auxiliaries with the exception of the tilting device and the cooler ventilators by the on-board 3-phase system. Supply of the 24-V on-board and starter batteries by means of stabilized chargers.

Vehicle control system realized in microcomputer technology of the SIBAS® 16 system. In addition to the dead man's circuit, inductive train control with train stop and train radio control, equipment of the trainset with a point data transmission system (PDS) of type ZUB 121 to monitor the maximum train speed in accordance with the requirements of the tilting device. Up to four coupled trainsets to be controlled centrally from one driver's cab.

Type VT 610

DATA

Type	610.0	610.5
Track gauge	1,435 mm	
Wheelset arrangement	2' (A1)'	(1A)'(A1)'
Maximum permissible speed	160 km/h	
Minimum negotiable track radius	125 m	
Total length over couplings	51,750 mm	
Car body length	25,400 mm	
Bogie center distance	17,500 mm	
Clearance	to UIC 505	
Maximum width	2,852 mm	
Maximum height above top of rail	4,208 mm	
Floor height above top of rail	1,290 mm	
Seating capacity 1st class	–	16
Seating capacity 2nd class (+ fold-down seats)	68 (+ 4)	46 (+ 2)
Total weight (DIN 25 008)	51.1 t	52.1 t
Maximum weight (DIN 25 008)	58.0 t	57.7 t
Fuel reservoir for diesel engines	1,000 l	1,000 l
Water reservoir	–	200 l
Sand reservoir	70 kg	
Draw and buffer equipment — Driver's-cab ends Close-coupled ends	automatic central buffer coupling close coupling	
Bogies	two-piece open H-frame with coil springs for primary and secondary level, FIAT type	
Wheelset distance	2,450 mm	
Wheelset diameter new/worn	890/840 mm	
Braking system	KE pneumatic disk brake with microprocessor-controlled anti-skidding device, electrical rheostatic brake electromagnetic rail brake in one bogie at the driver's-cab end	at the short-coupled end
Diesel engines	2 diesel engines MTU 12 V 183 TD 485 kW at 2100 min^{-1} each	
3-phase driving equipment	2 three-phase alternators Siemens 1 FC6 352-6, 2 rectifiers ABB 13NW07aR2, 1 GTO traction d.c.-a.c converter with integrated brake actuator ABB 13SG17a, one drive control unit Siemens SIBAS® 16, three 3-phase asynchronous traction motors AEG BAZu 5369/4	
Engine/wheelset-gearing power transmission	cardan shaft	
Electrical vehicle equipment — On-board networks Batteries	3 x 400 V, 50 Hz, 76 kVA/54 kW 3 x 230 V, 50 Hz, 3 x 3 kVA/2 kW 3 x 8 V, 165 Ah, for 24-V on-board network 2 x 12 V, 165 Ah, for starter unit	
Heating, ventilation	hot-water convection heating under utilization of the engine exhaust heat and electrical additional heating, pressure ventilation	
Tilting system	hydraulic drive, ± 8° angle of inclination, FIAT type	
First delivery	1991	

Siemens Transportation Systems
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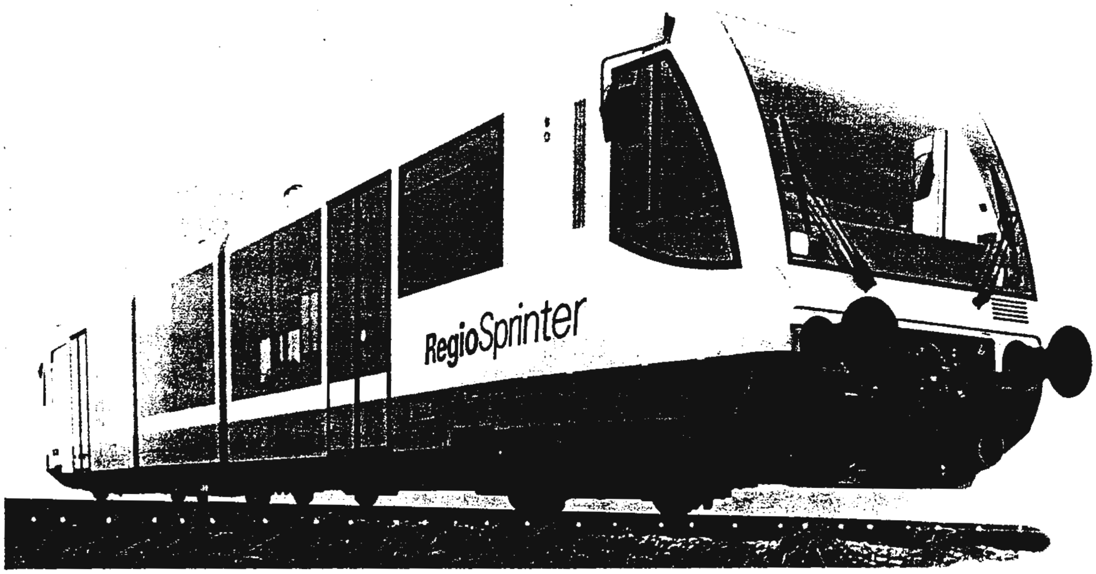
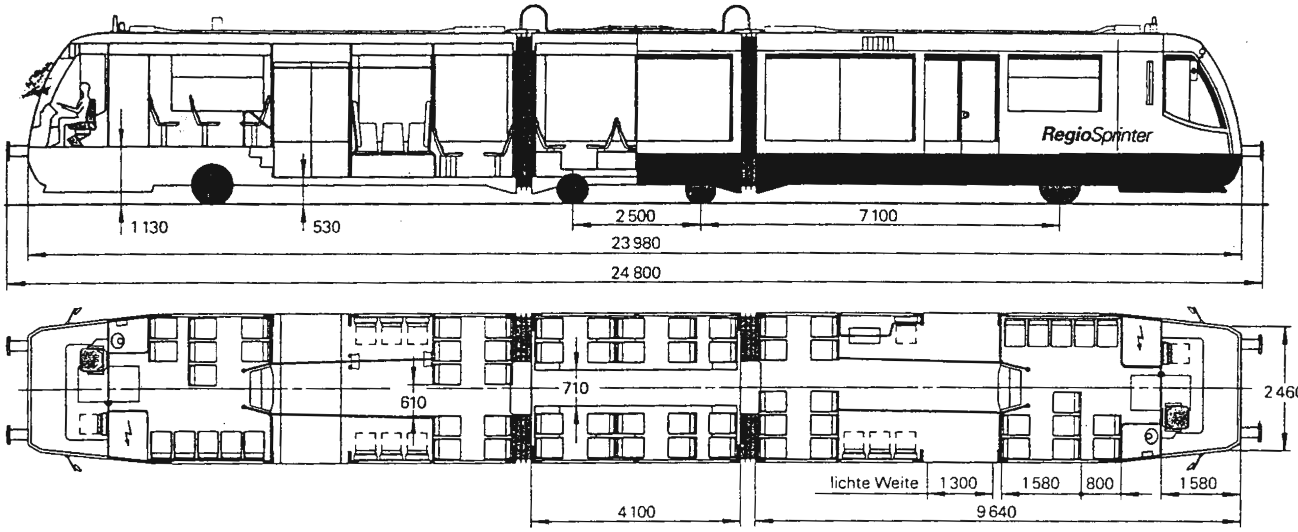
DUEWAG
Member of the
Siemens Rolling Stock Group

SIEMENS DUEWAG

RegioSprinter
The New Lightweight Diesel Railcar for Regional Passenger Service





The interior

The large vehicle width permits facing and row seating in 2+2 and 2+3 arrangements. The main doorways are each provided with a multipurpose area which is equipped with folding-type seats, safety features for securing bicycles and wheelchairs, as well as stanchions, handrails and safety straps. A ticket vending machine is also located in one of the entry areas. The interior is illuminated by a continuous strip of fluorescent lights arranged in the middle of the ceiling. A destination indicator is installed in the windshield section as well as behind a side window in the center section of the railcar.

Technical data

Vehicle series		VT 4 N
Dynamic envelope		UIC 505-1
Maximum permissible speed		100 km/h
Minimum negotiable track radius		80 m
Track gauge		1435 mm
Wheel arrangement (DIN 30 052)		A + 2 + A
Maximum width (without outside mirrors)		2970 mm
Maximum height above TOR		3450 mm
Floor height above TOR	Low-floor area Raised-floor area	530 mm 1130 mm
Number of seats (folding-type seats)		74 (10)
Number of passengers, standing (4 persons/m^2)		100
Size of multipurpose areas		approx. 8 m^2 each
Tare weight (DIN 25 008)		approx. 30 t
Maximum weight (DIN 25 008)		approx. 50 t
Fuel tank capacity		2 x 350 litres
Maximum starting acceleration		1.1 m/s^2
Maximum braking rate	Service brake Emergency brake	1.15 m/s^2 2.73 m/s^2
Power trucks		Single-axle trucks with primary rubber springs and secondary coil springs
Trailer truck		Two-axle truck with primary rubber springs and secondary coil springs
Diameter of driven wheel Diameter of nondriven wheel	new/worn new/worn	760 mm / 700 mm 520 mm / 480 mm
Type of brake		Hydrodynamic retarders, self-actuating electrically controlled air brake system, electromagnetic track brake at the center truck
Engines		5-cylinder turbocharged and intercooled diesel engines with a rating of 198-kW at 2000 rpm
Transmission		5-speed transmission with integral torque converter and retarder.
Draw and buffer gear		Side buffers (RINGFEDER® spring-loaded buffers), lightweight draw gear
Heating and ventilation		Warm-water heaters with multi-speed ventilators, diesel-fuel-fired additional heater, forced ventilation
Onboard electrical equipment		Multiple-unit control, 24-V DC onboard power supply, 24-V batteries / 2 x 200-Ah
First delivery		1995

Introducing **NIPPON SHARYO'S NEW GENERATION**

DIESEL RAIL CAR For North America

- **D**esigned specifically for North American railroad Applications.
- **F**RA/AAR Compliant
- **S**tainless Steel Carbody.
- **C**arbody designed evolved from Maryland DOT and N.I.C.T.D. commuter cars.
- **N**orth American Supply Sources for Operational equipment.
- **P**rovides Operational Flexibility and Versatility.
- **E**conomical Ownership and Operation for low density commuter applications.
- **A**cceleration & Deceleration equivalent to EMU equipment, resulting in potentially lower equipment requirements and fleet cost.

NIPPON SHARYO, LTD.

PRINCIPAL SPECIFICATIONS

ITEM	SPECIFICATION
Type of Car	Diesel Rail Car - Driving Cab each end
Tare Weight	Approx. 128,970 Lb (58.5 Metric Tons)
Dimension	Length: 85' 0" (25,908mm) Width: 10' 6" (3,200mm) Height: 13' 1" (3,989mm)
Seating Capacity	87 Passengers
Type of Service	Inter-City, Commuter (Suburban), Branch Line
Material (Superstructure)	Stainless Steel
Truck	Four Wheel Bolsterless Wheel Diameter 33" (838mm)
Maximum Operating Speed	80 mph (129 kph)
Diesel Engine	Cummins NTA 855-R1 345 hp / 2,000 rpm X 2 / Car
Hydraulic Transmission	Voith or Twin Disc X 2 / Car
Diesel Generator	Driven by Auxiliary Diesel Engine, 50 KVA, 480VAC, 3 PHASE
Low Voltage Power Supply	120 VAC 24VDC
Propulsion Control	Electric Fuel Injection
Brake System	Automatic Air Brake with Main Reservoir through Pipe
Air Compressor	Incorporated with Diesel Engine
Control Voltage	24 VDC
Air Conditioning Cooling Capacity	12.3 Tons
Heating Equipment	Hot Water Heater
Battery	175 AH
Fuel Tank Capacity	158 Gallons X 2 (600 Litres X 2)
Door Operator	Electric
Toilet	Optional
Wheelchair Space	Two per Car

PERFORMANCE CHARACTERISTICS

Powered by two 345-hp Cummins NTA855-R1 diesel engines equipped with electric fuel injection. The engines are installed under the car. Radiators are installed under the car.

Each engine drives the inner axle of one truck through a Twin Disc or Voith hydraulic transmission.

PERFORMANCE

Performance of the Diesel Rail Car is shown below.

Acceleration:

Maximum Acceleration - Full seated load, 2 Car Unit.
0.780 mph/sec. (0 -50 mph)
0.438 mph/sec. (0 -80 mph)

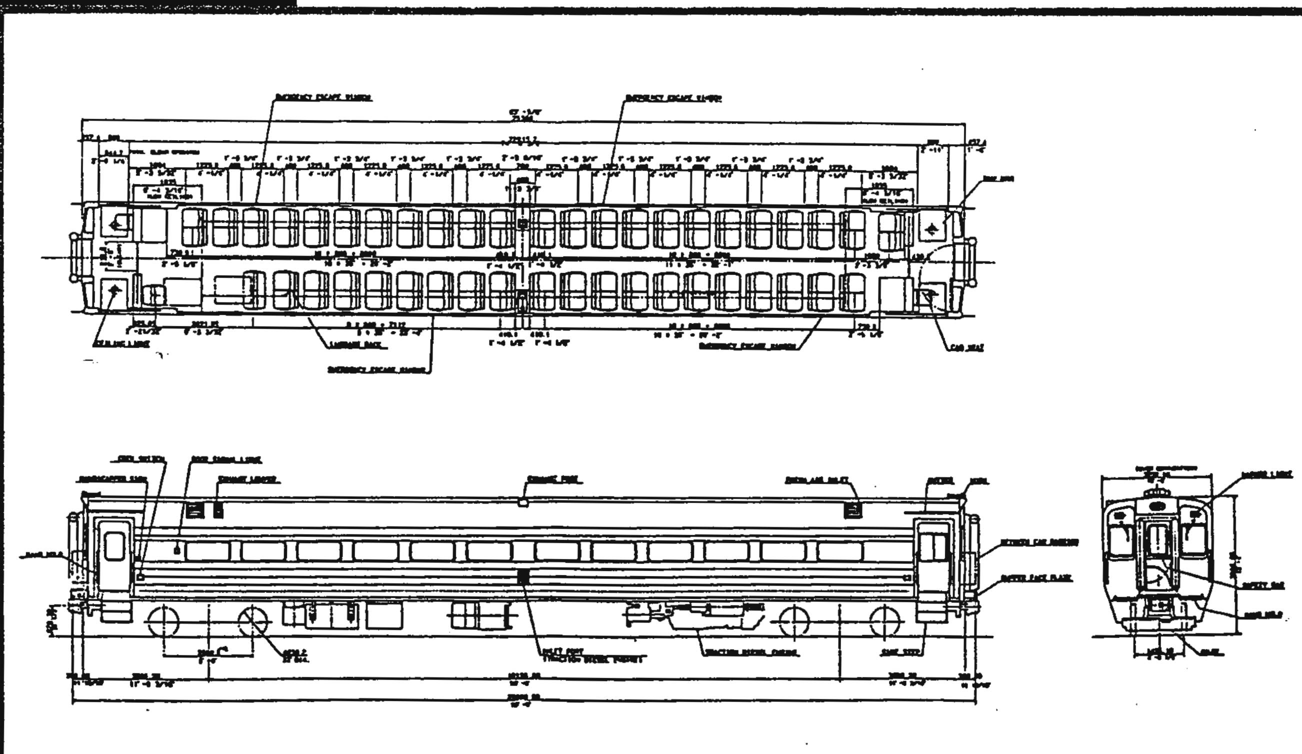
Distance from 0 to 80 mph - 2.8 miles.

Note

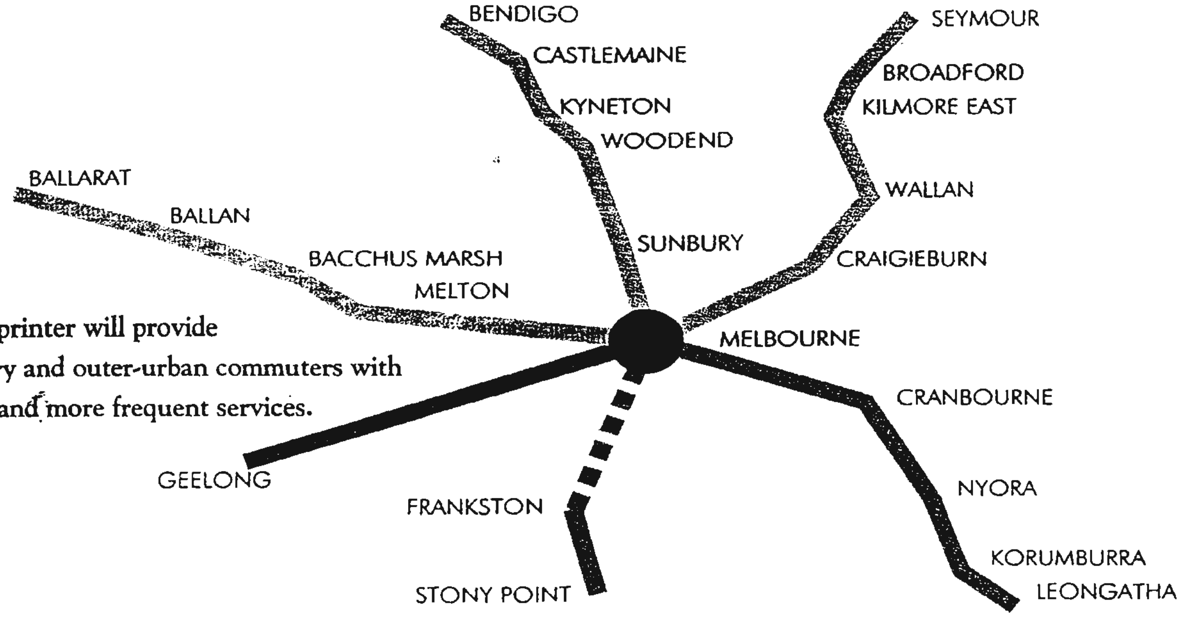
These acceleration rates are comparable with electrically propelled equipment, and are generally more favorable than Locomotive Hauled Coaches.

Deceleration

Full Service Brake Application - 2.1 mph/sec.
Emergency Brake Application - 2.8 mph/sec.



The Sprinter will provide country and outer-urban commuters with faster and more frequent services.



Sprinter

The Sprinter is powered by two Deutz air-cooled, turbo charged diesel engines. This is the first air-cooled diesel rail car in Australia.

The drive line equipment is duplicated to give total system redundancy protection providing high performance and superior reliability.

The Sprinter is manufactured by A. Goninan & Co.

TECHNICAL DATA

FULLY SELF-CONTAINED OPERATING UNIT

Passenger capacity ....90 Seated
....15 Standing

SINGLE OR MULTIPLE UNIT OPERATION

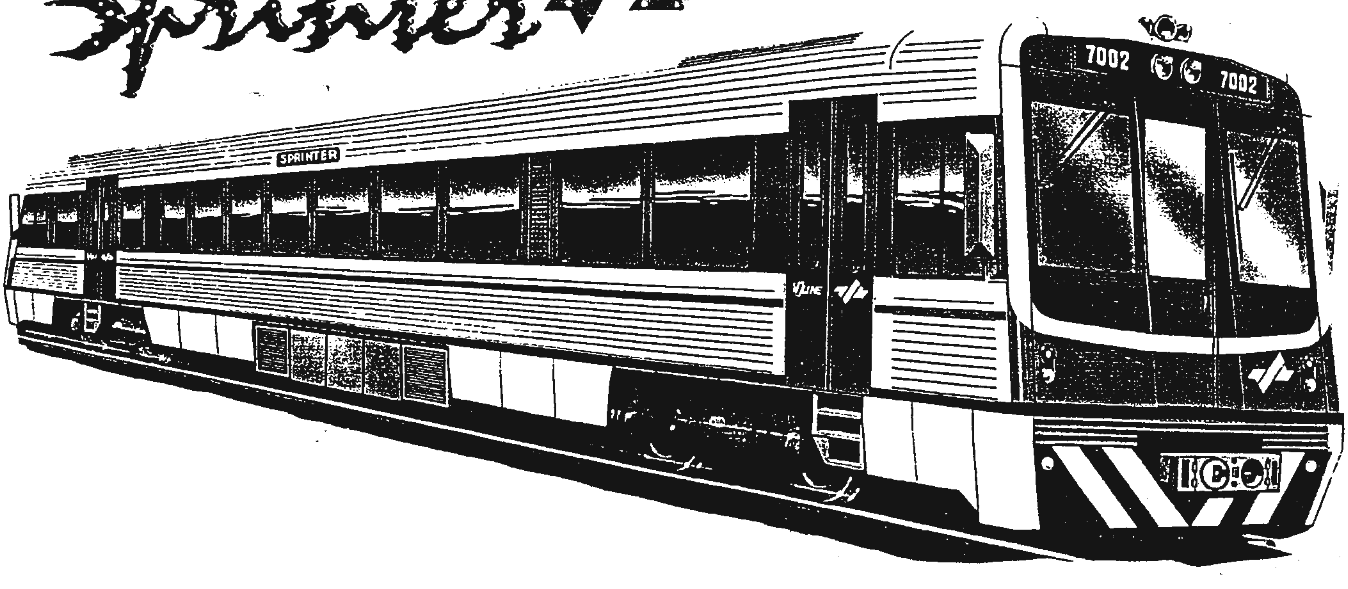
Traction ....Dual Diesel/Hydraulic Drive
Electrical ...Dual Alternator/Electronic Inverter Units

Range ....1000km (min)

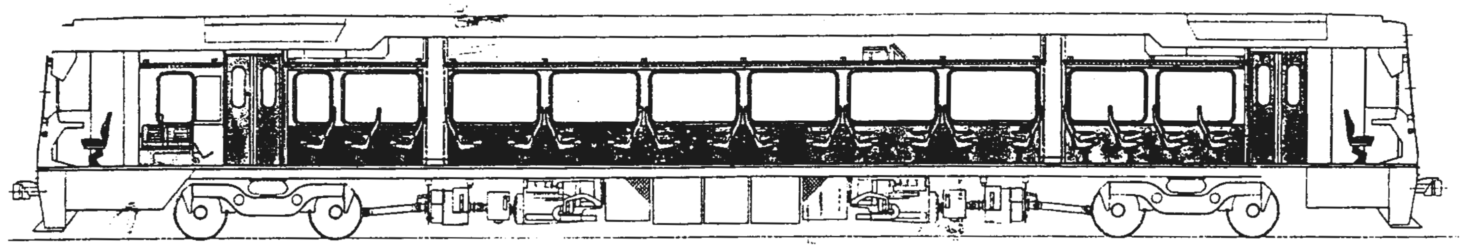
Speed..130km/h

Easily maintained and energy efficient.

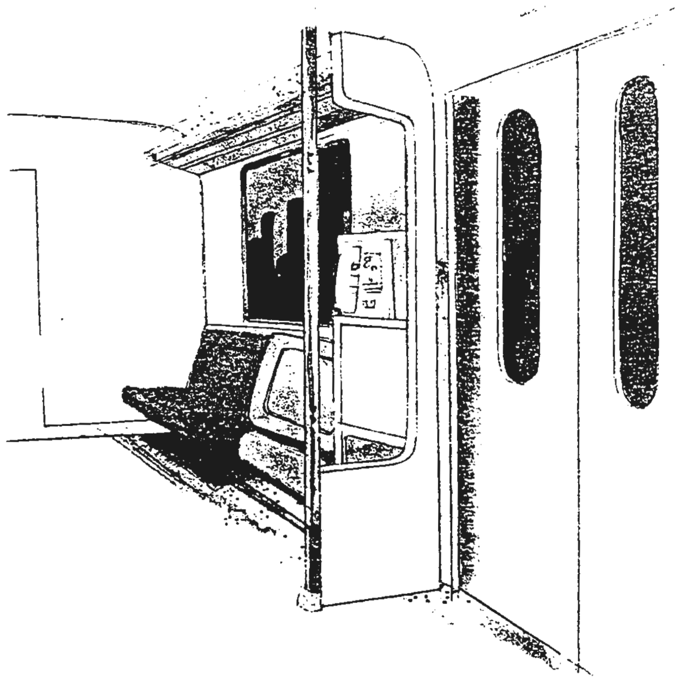
Sprinter



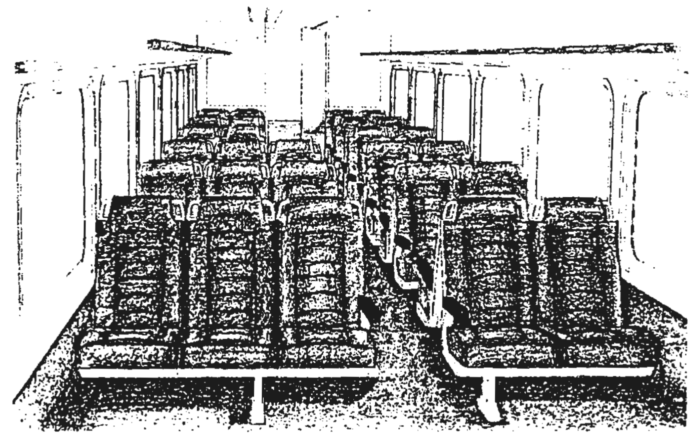
Sprinter



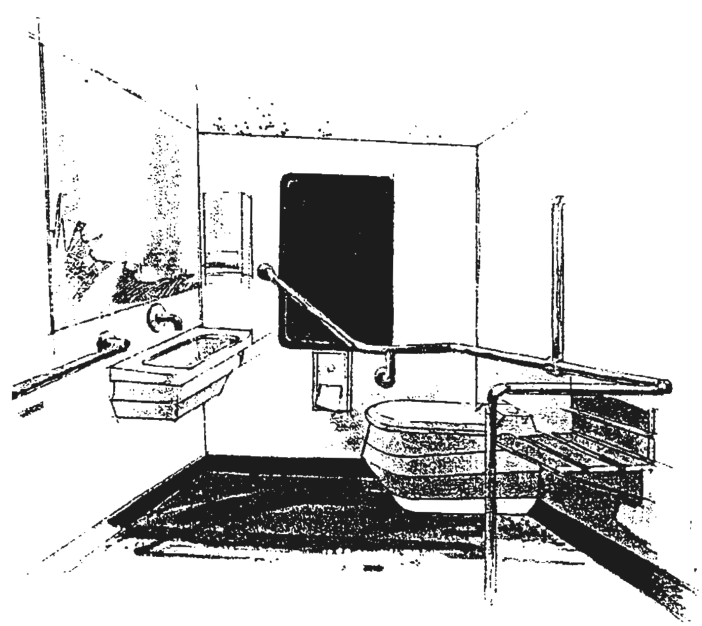
Sprinter is a Lightweight Diesel Rail Passenger Vehicle (LDRPV) designed specifically for the Public Transport Corporation. Sprinter is a high speed, energy efficient vehicle and will provide a quiet ride in air conditioned comfort – modern transport for country and outer-urban commuters.



The air conditioned saloon area is fully carpeted, featuring panoramic windows and a mixture of club style and private seating. Seats are cloth covered. Luggage space is provided in overhead racks or lockable areas at either end of the vehicle.



Special facilities are incorporated for passengers travelling in wheelchairs, they are able to use an area adjacent to the vestibule which has fold-up seats fitted. The design allows for the fitting of a public telephone facility in the vestibule area. *Power operated doors* (swing plug) for passenger access are provided.



Washroom and toilet facilities are designed to cater for wheelchair access, with a fold-down table provided for baby nappy-changing.

Sprinter Facts and Figures

GONINAN
QUALITY

A. Goninan & Co. Limited
A.C.N. 000 003 136
Broadmeadow Rd
Broadmeadow, Newcastle

CHANGED PHONE AND FAX No.s
Phone: (049) 23-5000 Fax: (049) 23-5001
UNCHANGED FAX Nos.
Railway Products Div (049) 69-5391
Heavy Engineering Div (049) 61-3674
Tangara/Supply Office (049) 61-6919
PTC Project Office (049) 62-1174

DIMENSIONS

Coupled Length	25900mm
Over Headstocks	25000mm
Overall Width	2940mm
Bogie Pivot Centres	16600mm
Floor Height Above Rail	1300mm
Max Height Above Rail	3905mm
Wheel Dia. - New/worn	920/870 m

MASS

Tare Mass	50.0 Tonne
Crush Mass	58.0 Tonne
Bogie Mass	6.2 Tonne
Unsprung Mass/Axle	1975 kg

PASSENGERS

Fixed Seats	88
Foldup Seats	2
Wheelchair Positions	1
Standees	15
Lockable Luggage Area	2.1 square Metres

TRACK PARAMETERS

Track Gauge	1600 mm
Max Speed	130 km/h
Minimum Curve Radius	100 Metres
Max gradient	1:33 (3%)
Design Ambient Temperature-	-5 to 40 Deg C

ENGINE (2/CAR)

Make	Deutz-KHD
Model	BF8L513C
Cycle	Four Stroke
Exhaust turbo charging	Yes
Charge air cooling	Yes
No of cylinders	8 @ 90 Deg Vee
Capacity	12.7 Litres
Rating	235 kw @ 2300 rpm

TRANSMISSION (2/CAR)

Make	Voith
Model	T211rz
Type	Hydrodynamic
Engine/wheel ratio	1:2.723

ENGINE CONTROL (2/CAR)

Make	Heinzman
Model	Electronic
No of power notches	8
Idle / Hi-Idle	750/1200 rpm
Max Speed	2300 rpm
Max Tractive Effort/engine	27.0 kN
Wheel Spin Protection	Yes

FUEL CONSUMPTION PER ENGINE

Idle	0.25 Lit/Min
Full Power	1.1 Lit/Min
Nominal (1 engine/car)	0.8 Lit/km
Nominal (2 engine/car)	1.0 Lit/km

BALANCE SPEED LEVEL TRACK

1 engine Operating Per Car	100 km/h
2 engines Operating Per Car	>140 km/h
Max Speed, New/Worn Wheels	145/135km/h

BALANCE SPEED 1:50 GRADE

1 engine Operating Per Car	45 km/h
2 engines Operating Per Car	85 km/h

AUXILIARY POWER

Battery	24V 252Ah @ 5 hours
Battery Charger	Zener, I/O 415V, 24V

AUXILIARY ALTERNATOR (2/car)

Make	Hitzinger
Type	Synchronous
Drive	Shaft, Variable Speed
Rating	34 kW

AUXILIARY INVERTER/RECTIFIER (2/CAR)

Make	Elin
Input	415V Variable Freq.
Output	43Kva, 415V @ 50Hz

AIR CONDITIONING (2/CAR)

Make	Thermair
Model	RE1-2304
Cooling Capacity	28 kW

AUTOMATIC COUPLING

Make	Scharfenberg
Model	Multi-Function

TRAIN OPERATION

P.A. System	Stone McColl
Data Logger	Fischer

DOORS

Make	I.F.E
Model	Biparting Swing Plug
Clear Doorway Opening	800 mm

TOILET (1/CAR)

Make	Monogram
Model	Recirculating

DISABLED FACILITIES

Entrance Ramp	1
Wheel Chair Locations	1
Toilet	
Audio Information	Yes

BODYSHELL

Construction	Semi Monocoque
Material	Stainless, Grade301L
Design End Load	1000 kN @ 1/2 Yield

CRASHWORTHINESS

AntiRide Bars	Yes
Cow Catcher	Yes
Design Collision Load	540 kN
Windscreen	22 mm Thick Laminated
Collision Posts/End	4

BRAKES

Make	Davies and Metcalfe
Model	EBC/5 E.P
Type	E.P Full Shadow, Auto
Service Brake	0.73 m/s/s Minimum
Emergency Brake	0.83 m/s/s Minimum
Wheel Slide Protection	Yes

BOGIES

Design	Goninan
Type	Fabricated
Secondary Suspension	Air Bag, Bolsterless
Primary Suspension	Swing Arm, Coil Spring
Brakes	Inboard Discs

SUPPLIES

Fuel Tank	1100 Litres
Water Tank	150 Litres

SERVICE/MAINTENANCE

Service Interval	50,000 km
Major Overhaul Interval	500,000 km

PEACH 3/93 – 5K

9

ALTERNATE RAIL TECHNOLOGY (ART)

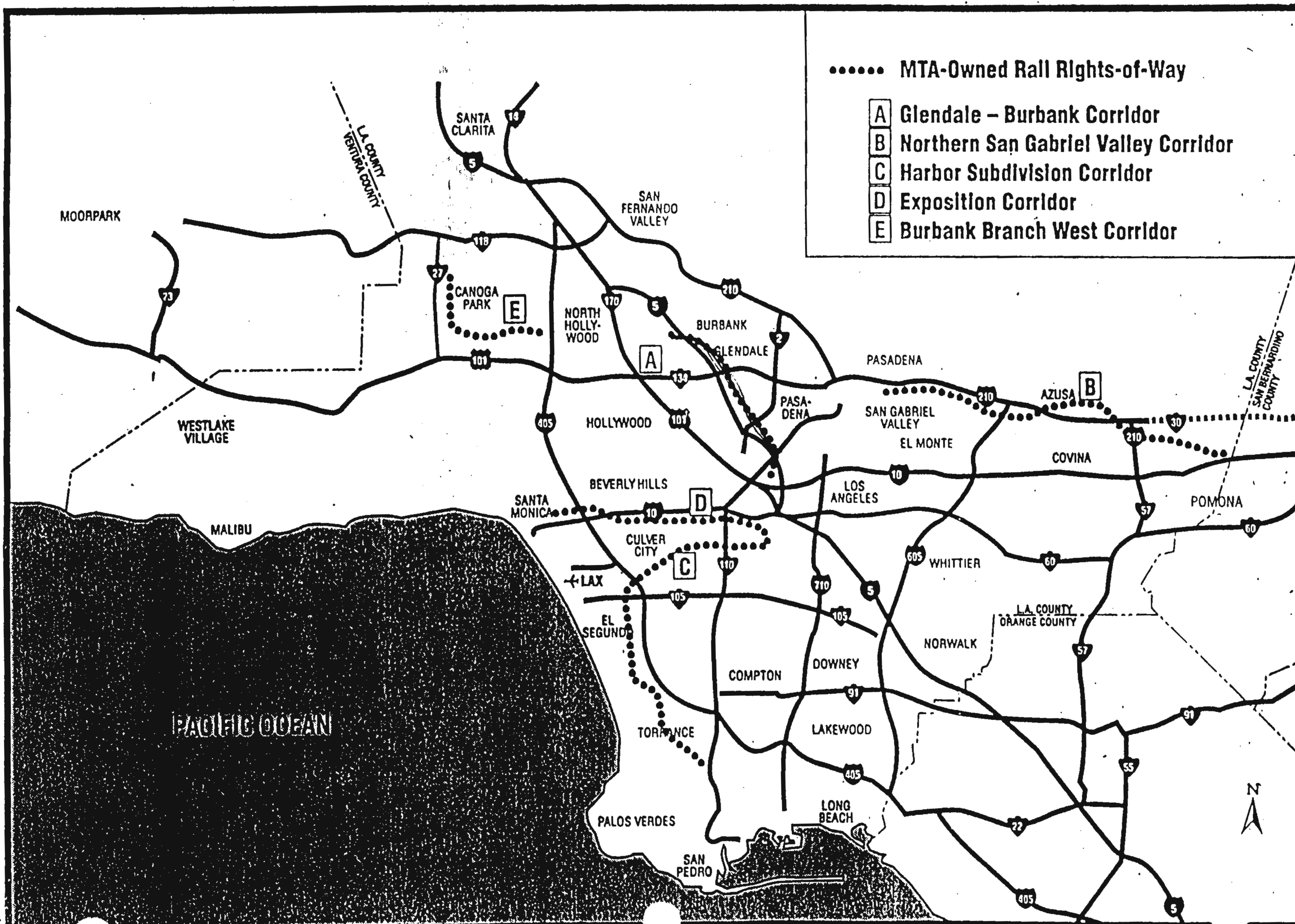
MTA BOARD PRESENTATION

JULY 1995

MTA LONG RANGE PLAN

- Adopted March, 1995
- Identified Five Corridors For Potential Alternate Rail Technology Operations
- Directed Staff To Undertake Feasibility Study Of The Technology

MTA Long Range Transportation Plan
Railbus Corridor Examples



PP-005/1.9.

WHAT IS AN ALTERNATE RAIL TECHNOLOGY VEHICLE (ARTV)

- A passenger rail car with an internal power source, commonly diesel
- Usually capable of operating in one or two car units, or as part of a larger, "diesel multiple unit" train
- Used extensively in the industrialized nations for regional and urban/suburban service
- Capable of operating in manner similar to light rail, but without the electric power infrastructure (and expense)

PROJECT STATUS

- Feasibility Study - 2 Phases:

  Phase 1 - Specific Technology Issues Applicable to All Corridors (MTA staff)

    Completed: July 1995

  Phase 2 - Burbank/Glendale/Los Angeles Corridor Operational Study

    Funding Partners: City of Burbank

    City of Glendale

    Burbank-Glendale-Pasadena Airport Authority

    MTA

    Anticipated Completion: Fall 1995

Phase 1 Study Purpose:

- Survey current worldwide usage of ARTVs
- Identify potential technical considerations for all corridors
- Identify potential institutional barriers for all corridors
- Lay groundwork for specific corridor feasibility studies

Phase 2 Study Purpose:

- Address issues raised in Phase I study

- Provide prototype ART corridor study for application to other corridors

- Evaluate operational considerations:

    - track sharing
    - patronage
    - frequency

- Identify capital improvements:

    - platforms
    - sidings
    - maintenance/fueling facilities

DEPLOYMENT HISTORY

- ARTVs predominately an American innovation to address rail service to low density areas in the early 20th century
- Prior to World War II not very reliable and had mixed results
- After World War II railroads invested in ARTV improvements
- ARTVs in U.S. operation until 1989
- Recent resurgence and interest in ART systems throughout U.S.

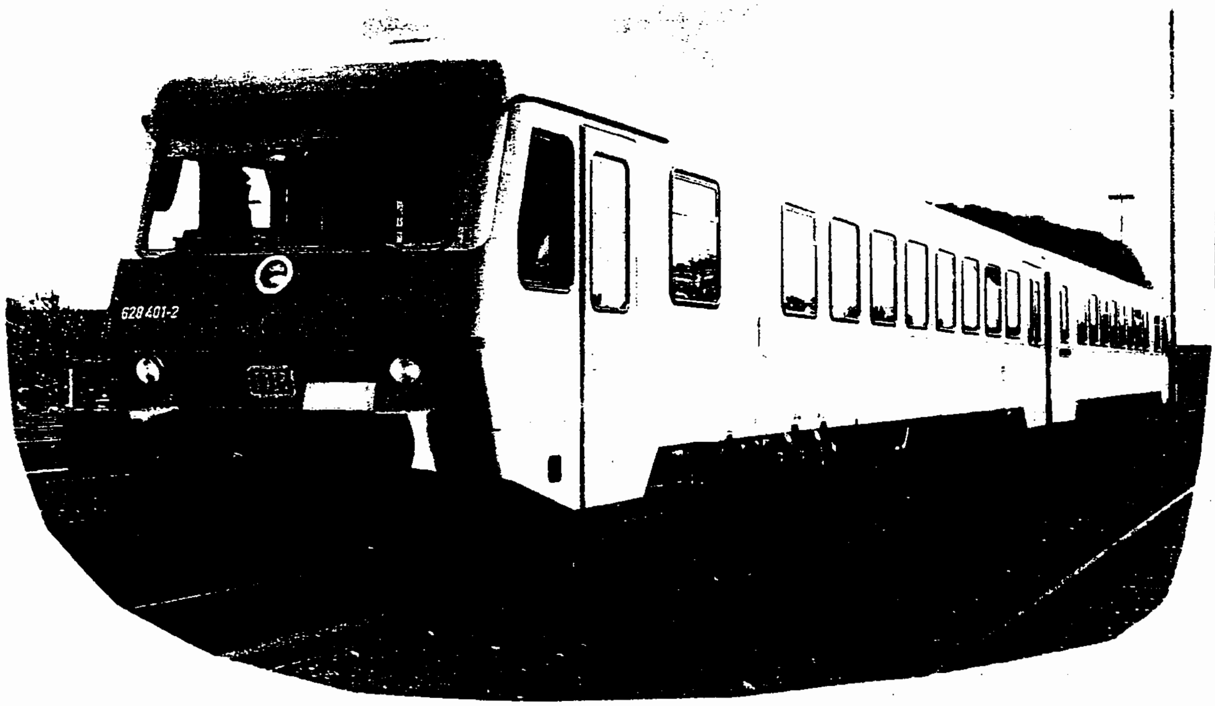
BRITISH CAR - CLASS 165 "NETWORK TURBO"

U.K. EXPERIENCE

- Use expanded in the 1950s by Great Britain and other countries.

- British Rail operates approximately 2000 of these vehicles in a wide range of services.

German Alternate Rail Technology Vehicles



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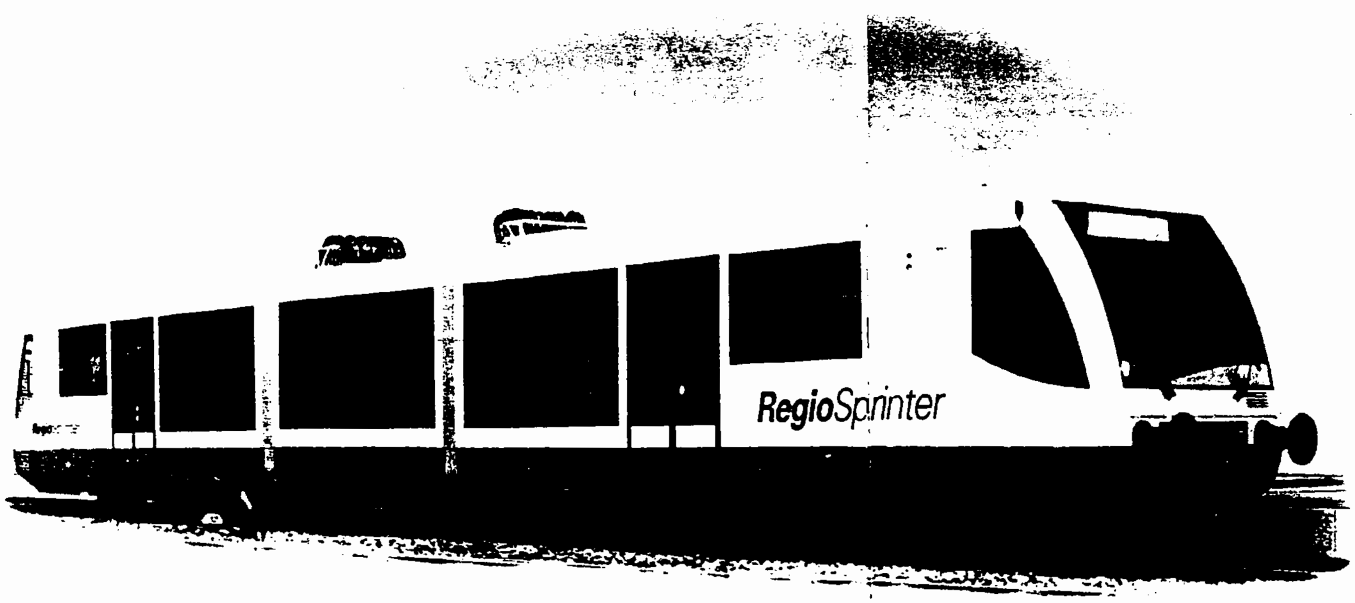

RegioSprinter

GERMAN EXPERIENCE

- German manufacturers developing ARTVs for different markets, including possibly the U.S.

- Many different vehicles being designed; two for the U.S. market including one for use on exclusive Right-of-Way and other for shared Right-of-Way use.

- German Rail agencies operate approximately 600 of these vehicles in wide range of services (1992).

CURRENT STATUS IN UNITED STATES

- Locations where ARTV systems operating or soon to be operational

  Syracuse, New York (in operation since 9/94)
  Dallas, Texas (under construction, cars purchased/anticipated operation 1996)

- Locations of current ARTV interest:

  Burlington, Vermont
  Folsom, California
  Hillsborough Area Regional Transit, Florida
  Los Angeles, California
  North San Diego County, California
  Tampa Bay Commuter Rail, Florida
  Triangle Transit Authority, Research Triangle Park, NC
  Ventura County, California

FEDERAL RAILROAD ADMINISTRATION ISSUES:

- FRA sets standards for:

  - buff strength (crashworthiness) in active railroad corridors
  - lights, whistles, horns, window glass/glazing
  - handholds
  - fire safety
  - coupling/uncoupling mechanisms
  - brakes

- Manufacturers considering building ARTVs to U.S. FRA Standards

- Applicability of specific FRA regulations versus FRA willingness to consider alternatives to buff strength such as crumple zones and energy attenuation devices

AMERICANS WITH DISABILITIES ACT ISSUES:

- Compatibility with existing Metrolink platforms/floor heights may require modifications.

- Width of doors and aisles may require modifications.

- Using lifts or Metrolink-style ramp could result in additional maintenance or operating costs.

- Many current models meet U.S. accessibility requirements.

AIR QUALITY ISSUES:

- All existing ARTVs are diesel or clean diesel powered.

- ART systems (platforms, operation, etc.) implementation is subject to RTIP air quality conformity review although ARTVs are classified as a "locomotive" and therefore exempt from state/local emissions rules.

- Technologies which reduce bus emissions are applicable to ARTV.

ALTERNATIVE FUELS

Alternative fuels can potentially reduce emissions:

- Clean Fuel Diesel - Manufacturers are meeting, or are expected to meet emission standards
- Compressed Natural Gas - Uncertain effect on performance and cost.
- Fuel Cell - Potential applicability to ARTVs.

OTHER ISSUES

Local Economic Development Potential:

- Size of procurement could be a major factor in both cost and likelihood of attracting a manufacturer to Los Angeles Area.

Selection of Operator:

- Labor Agreements

- Resources
  - Staffing
  - Dispatch capabilities/infrastructure
  - Expertise/experience

- Alternatives include:
  - MTA operation,
  - Contract with rail operator,
  - Operation by joint venture of cities,
  - Turnkey

NEXT STEPS

- Completion of Phase II Burbank/Glendale/Los Angeles Corridor Operational Analysis (Fall, 1995)

- Decision as to whether to perform feasibility studies of remaining corridors identified in Long Range Plan

- Decision as to whether to pursue ART implementation, if funds become available (Fall 1995)

- Apply for ARTV Alternative Fuel Demonstration Project (pending feasibility determination)

  Possible funding sources: AB2766, PVEA, California Energy Commission, California Air Resources Board, U.S. EPA, U.S. Department of Energy

DATE DUE
