Spokane Regional Light Rail

Let's talk about it.

Spokane Regional Light Rail Project
Shared Track Alternative – DMU

Conceptual Design Systems Engineering Report

DRAFT

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SYSTEMS ENGINEERING CONCEPTUAL DESIGN REPORT
SPOKANE REGIONAL LIGHT RAIL PROJECT

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1. INTRODUCTION

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The Spokane Regional Light Rail Project is considering two alternatives, a conventional light rail transit system using electrically propelled vehicles, and a lower cost alternative using self-propelled diesel multiple unit (DMU) vehicles. This report focuses on the lower cost DMU alternative, also known as the Shared Track Alternative.

In this document, a series of independent sections describe the various systems elements of the Shared Track Alternative; namely, diesel multiple unit (DMU) vehicles, traction electrification, signaling, communications, fare collection and the operations and maintenance facility. Traction electrification is included only to describe those features that might best be installed now for future electrification of the line. Additionally, the report includes a section on operations planning, which presents initial travel time estimates, fleet sizing requirements and operating considerations based on alignment information known at this time.

This report is intended to supplement that prepared for the light rail alternative in August 2001 and does not repeat some of the guidelines which are generic to the project, regardless of alternative.

The vehicle represents the most significant departure from the initial light rail alternative. Rather than a partial low floor light rail vehicle powered electrically, the low cost alternative is based on a partial low floor self-propelled (i.e., diesel powered) vehicle capable of multiple unit operation, hence DMU. The sections describing the remaining systems elements are organized to provide the following: a general description of the element as envisioned for the low cost alternative, the assumptions being used for developing conceptual level cost estimates, and identification of the major issues which need to be addressed during preliminary engineering. The purpose here is to provide an initial definition of what the systems features and their representative costs will be on the project absent more detailed investigations, engineering, and decision-making, which occur later in the design development process.

The preliminary engineering phase will take these definitions and apply them to the evolving route alignment, civil design and operating requirements, providing a more detailed description of their application and a more precise estimate of quantities and costs.

2. DIESEL MULTIPLE UNIT (DMU) RAIL VEHICLE
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2.1 General Description

This new lower cost alternative is based on use of self-propelled diesel multiple unit (DMU) vehicles. Such cars offer levels of performance and passenger comfort similar to electric light rail vehicles, but do not require provision of a wayside traction electrification system, because on-board diesel engines serve as the prime mover.

The light rail alternative previously studied assumed the use of typical low floor light rail vehicles (LFLRV) and has been supplied to, or is being built for, several transit agencies in the United States. These include cars from Siemens for Portland and Houston, from Kinki Sharyo for Northern New Jersey and San Jose, and from Bombardier for Minneapolis. Seattle, Charlotte and possibly Phoenix, who are soon to initiate their procurement processes, are considering the same basic designs.

Conversely, while DMUs are commonplace in Europe, no common DMU design has emerged yet in North America because there have been very few projects employing this type of technology. In fact, there are only three: Ottawa, Ontario, which is a demonstration project; New Jersey Transit’s South New Jersey Light Rail System between Camden and Trenton, which is under construction and due to open in 2003, and North County Transit District’s Oceanside-Escondido line, which is waiting for final confirmation of federal funding.

2.1.1 Types of DMUs

In general, DMUs can be classified as two types: those that are built to American railroad standards, as governed by the Federal Railroad Administration (FRA), and those that comply with European standards. We are not considering FRA-compliant vehicles in that they are meant to operate over the general railway system in the United States and as such are too massive for the application envisioned for Spokane. Also, they are clearly incompatible with in-street operation planned for Riverside Avenue in downtown Spokane and on Madelia Street and Riverside Avenue near Playfair.

There are two variants of DMUs built to European standards: those for European Railways which meet the requirements of the International Union of Railways (UIC) and are sanctioned to run on the railway systems in various European countries, and those which were built for less restrictive applications. We have dubbed the former as ‘railway’ DMUs and the latter as ‘transit’. In the case of the DMU projects in North America, the vehicles for the Ottawa project were supplied by Bombardier from their Talent line of rolling stock and are considered to be of the ‘railway’ category. Those for the Camden-Trenton service are being built by the Swiss firm of Stadler, and fall into the ‘transit’ category. It is from the ‘transit’ family of vehicles that we envision a solution for Spokane.

2.2 Alternative DMUs for Spokane

While there are a number of examples of transit DMUs in operation, the choices for Spokane are not as clear-cut as for the electrically-propelled LRVs, mainly because the designs for applications in the United States are still emerging. We propose taking two variants into preliminary engineering. The first is a concept being considered by an LRV supplier to convert an existing LRV design from all electric to a diesel-electric, and the second is essentially identical to the vehicles being built for the Camden-Trenton service. The basic differences are:

Characteristic	Converted LRV	Existing DMU
Engineering required	Add diesel generator	None
Length & width	90’-97’ x 8.7’	102.5’ x 9.84’
Floor height at entries	~14"	~23"
Entries per car side	4	2

The car body will consist of two main body sections joined by articulations to a short center section. The diesel generator and related gear may be located in the center car body, or on the roof of the vehicle. If the latter, the main (or center) portion of the main body sections and the entire center section will be low floor, while the end of the main body sections will be high floor so as to permit use of standard motor trucks. Thus, the low floor section will be continuous through the center of the car, unless it is used for equipment. All three sections are semi-permanently coupled together to form a single operating vehicle. Each vehicle will have four or eight door openings, two or four openings on each side, all in the low floor area so as to maximize accessibility to/from the vehicle. The car body will be constructed of welded low-alloy, high-tensile steel to economize on the dead weight while providing substantial collision strength. Selected elements or sections of the car body structure may be stainless steel for corrosion protection. The service life of the car bodies will be 30 years without a major overhaul.

Each end of the vehicle will have a fully equipped operator's position. Therefore, loops are not required, as the vehicles will not be turned at terminals. The vehicles will be capable of multiple unit operation in consists of up to three DMUs, with emergency operation up to six vehicles.

The specified empty weight of the vehicle will be 105,000 lbs maximum, and the "crush load" weight will be 152,900 lbs maximum.

Each vehicle will be approximately 90 to 105 ft. in length (over coupler faces), 8.7 to 9.84 ft. in width (excluding mirrors), and a maximum of 12.83 ft. in height. The DMU will be capable of negotiating 130 ft. horizontal radius curves, 6% grades, and 6 in. of superelevation.

Each vehicle will have a minimum of 70 seats. The design capacity will be approximately 190 passengers per vehicle, based on a full-seated load and 4 standees per square meter of standing area. The crush load assumes 8 standees per square meter, or about 1.25 square feet per person, for a total of about 300 passengers per vehicle.

Vehicle floor height at entrances will be 14 in. or 23 in. maximum above top-of-rail. Space will be provided in each vehicle to accommodate four wheelchairs, strollers, or bicycles, two positions of which will be clear of seats, and two positions of which will be fitted with flip up seats. The vehicles will, in conjunction with a coordinated platform configuration, comply with the Americans with Disabilities Act

(ADA). In this regard, the DMU will be configured either with a load leveling system that maintains the floor height regardless of passenger loading or with bridgeplates incorporated into the center doors on each side of the vehicle that, upon request, protrude from the vehicle and provide a ramp to a station platform approximately 10 in. or 19" in height.

Each LFLRV will have three trucks, a powered truck at each end of and trailer truck under the center body section or, alternatively, a powered middle truck and unpowered end trucks. The truck frames will be of welded steel construction. The center truck may employ a "drop axle" design with independent wheels mounted on stub axles in order to permit the low floor section to run through the center section. Both types of trucks will have a primary and secondary suspension, shock absorbers, and resilient wheels.

Dynamic braking will be the primary braking type. Friction braking will consist of electro-hydraulic or electro-pneumatic disc brakes on all trucks, with an independent friction brake controller for each truck. Proportional friction brakes will be applied in conjunction with the dynamic brakes as required providing the design decelerations. Electromagnetic track brakes for emergency stops will be incorporated into each truck. A "spin-slide" system shall be provided which adjusts tractive or braking effort during instances of low rail adhesion and reduces the likelihood of flat spots on the steel wheels.

The DMU will be designed for operation at speeds up to 55 or 60 mpg. Acceleration and braking rates are those for the soon-to-be-delivered New Jersey DMUs: 2.01 mpg/sec. maximum acceleration, 2.24 mpg/sec. service braking rate, and 4.48 mpg/sec. for emergency stops.

The heating, ventilation, and air conditioning (HVAC) system will consist of floor heat, overhead heat, and overhead cooling. Two independent overhead HVAC units, powered from three-phase ac produced by the auxiliary power supply, will be provided in each DMU.

The communications system will include radio, public access, intercom, passenger emergency, and station announcement functions. Also, both a flight records and an interior surveillance system will e provided which first records critical vehicle parameters for subsequent forensic investigations in the event of accidents, and second records video in the event of passenger incidents.

A monitoring and diagnostics system will be provided on-board each vehicle which will communicate with, link together, and assess the health of each major subsystem and report the information via monitors in each operator's cab for both operating and maintenance purposes.

Throughout the design and manufacture of the vehicles, a comprehensive inspection and test program will be conducted, both at the component level and the complete vehicle level. Also, in addition to the vehicles, the vehicle manufacturer will be required to provide various elements of system support, including a complement of spare parts, a training program for STA operators and maintainers, special test equipment, and manuals and drawings.

Finally, within the limits of standardized designs and joint procurement prospects, the vehicles will be styled uniquely for Spokane. At a minimum, this approach will include custom color selection, paint schemes, and interior appointments.

Figures J-301 and J-302 are conceptual general arrangement drawings for the Spokane DMUs consistent with the foregoing description.

3. TRACTION ELECTRIFICATION
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3.1 General Description

Diesel multiple unit (DMU) vehicles eliminate all need for traction electrification. However, certain elements of system design should provide for eventual electrification of the entire system and replacement of the DMUs with electric light rail vehicles.

Primarily, the track and right-of-way designs should allow adequate clearances for later installation of overhead contact system (OCS) support poles. Placing tangent track centers 15 feet apart will allow later installation of center poles to support an OCS over both tracks of the double track LRT system envisioned as the ultimate stage of rail development in Spokane.

4. SIGNALING
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4.1 General Description

The signal system performs important safety functions while at the same time enabling the efficient movement of trains. It provides for the safe movement of trains by preventing conflicting train movements and detecting potential problems in the train's path such as misaligned switches and broken rails. The signal system also provides warning to motor vehicles and pedestrians of the approach of a train at locations of conflict like highway-rail grade crossings and mixed-use right-of-way. These safety functions allow trains to move at faster speeds and therefore move passengers more efficiently. Signal system design is based on proven technology and design philosophy. Signal equipment directly involved with the safe movement of trains has failure modes that are known and understood. Incorporating this knowledge into the design results in a signal system that will function safely under all possible combinations of known failures.

4.1.1 Right-of-Way Types

The proposed Spokane rail system will consist of distinctive areas of operations that can be defined as exclusive right-of-way, semi-exclusive right-of-way, and mixed-use right-of-way. (Defined by the Manual of Uniform Traffic Control Devices (MUTCD), Part 10, Traffic Controls for Highway-Light Rail Transit Grade Crossings). The mixed-use areas are on the western end of the proposed system where the alignment runs on Riverside Avenue in the downtown area and on Madelia Street and Riverside Avenue just east of downtown. Exclusive right-of-way is limited to two areas that run parallel to the existing railroads, the first between Division Street and Erie Street and the second in the area of the yard. The largest portion of the right-of-way is semi-exclusive, where at-grade crossings for vehicles and pedestrians are provided at designated locations.

Trains operating in exclusive and semi-exclusive right-of-way will be governed by an automatic signal system based on fail-safe rail transit design principles and equipment. The train operator will operate at speeds corresponding to the signal information displayed. Automatic application of the train brakes will occur if the operator were to violate certain signal rules, depending on the specific type of signal system and design. These sections will typically allow train operations at 35 MPH or above.

Trains operating in mixed-use right-of-way will use the street or highway traffic signal system to coordinate train movements with motor vehicle and pedestrian movements. The train operator will be required to operate at a speed that allows for braking to a complete stop within half the available sight distance. The train operator will also be responsible for not exceeding the specified maximum speed for the section of track on which the train is operating. Train speeds in these sections are typically restricted to 25 MPH or less. Since the mixed-use areas are single-track, the rail signal system will control entrance to them to prevent conflicts between trains.

4.1.2 Rail Signal System

Rail signal systems are fail-safe systems designed in accordance with accepted industry standards and practices that have been in use for many years. These practices are documented in the American Railway

Engineering and Maintenance of Way Association's (AREMA) Manual of Recommended Signal Practice. Manufacturers of railroad and rail transit signal systems used in North America adhere to the AREMA Manual.

The foundation for any rail signal system is the train detection system. Track circuits have been and continue to be the primary means for detecting the presence of a train. New technologies under development may reduce the role of the track circuit; however, for safety and reliability at a reasonable cost the track circuit remains the only real choice in the present day market. In addition, track circuits remain as the only technology capable of detecting broken rails. Track circuits function by making the rails a part of an electrical or electronic circuit. The exact type of track circuit selected depends on a number of factors that will be evaluated during the preliminary and final design stages of the project. A system that relies on diesel powered trains has the greatest flexibility in selecting track circuit technology since there are no power return currents in the rails to be considered.

The track circuits will be a part of an automatic rail signal system that will provide information to a train operator to indicate the presence or absence of trains ahead and to advise the operator of other conditions that will affect the speed at which a train can operate safely. An important concept to the design of an automatic signal system is "safe braking distance." Safe braking distance is the distance it will take a fully-loaded train to come to a complete stop from the maximum permitted operating speed for the section of track that it is on, under the worst possible conditions of wheel/rail adhesion and brake system performance.

Information to the train operator will be conveyed by signals located alongside the tracks (wayside signals) or on displays in the train cab (cab signals). Both types of signal systems are used on light rail systems in North America, with wayside signals being the more common type. Each type has advantages and disadvantages that will need to be considered during the preliminary engineering and final engineering phases of the design to select the type of signal system that is most appropriate for the Spokane rail system.

Interlocking systems provide protection for train movements through locations where switches allow trains to change tracks or routes. A system of relays or microprocessors interlocks the switches and signals so that a "go" signal can not be displayed for an unsafe route. Wayside signals are provided at interlockings, even on a cab signal system. Normally routes through an interlocking are automatically selected by the interlocking logic circuits based on information received from the train-to-wayside communications system (TWC) or by preprogrammed automatic route selection logic. The TWC system will also allow the train operator to manually select the desired route from the cab of the lead vehicle of a train. This provides a backup to the automatic route selection system. The interlockings will have the capability to be connected to a future Control Center so that a train controller could monitor train locations and remotely select a route for a train through an interlocking.

The storage and maintenance yard will be signaled at its connection point to the main line to allow operators to move into and out of the yard without the need for additional personnel to operate switches. Switches within the yard will be hand-operated. Train operators will stop their trains at a switch and get off to manually align the switch for the proper route. The design of the yard will consider the future addition of power switches, track circuits, TWC equipment, and connection to the future Control Center to allow more automated operations as traffic increases.

Various technologies are available to provide the systems described above. The low cost alternative would allow maximum flexibility in technology selection.

5. COMMUNICATIONS
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5.1 General Description

Light rail communications systems are really a number of different systems, each of which is designed to move or provide information in some way that can be either essential to operations or a significant enhancement to operational efficiency and passenger comfort. Proper planning can allow a system to start with a minimum of communications systems and provide for economical expansion and enhancement as the transit system grows and develops. This planning will require the definition of potential future communications systems requirements and providing an infrastructure that would support the future additions.

5.1.1 Minimum Communications Systems

The minimum required communications systems for effective operations of the proposed Spokane Light Rail System would consist of a two-way radio system and telephones. The radio system would be used for voice communications between trains, operations and maintenance employees, and supervisors. Telephones would consist only of desktop telephones in operations and maintenance offices for conducting business as needed.

5.1.2 Radio Communications System

A two-way radio communications network provides the most essential communications link on any light rail system. The Tri-Met MAX system in Portland, Oregon started operations in 1986 with only radios for communications and continued to operate that way until 1998 when a fiber optic backbone system was put into service to provide additional communications capabilities. Radio channels are difficult to obtain in most urban areas and so an effective design process is required. The radio system designers will analyze the number of channels required, investigate the availability of radio frequencies in the Spokane area, and determine the viable methods for providing two-way radio communications for light rail operations and maintenance functions.

It is expected that the minimum requirement will be for five radio channels, or the equivalent capacity on a trunked radio system. One channel will be reserved for mainline train operations. The system will be configured so that all trains operating on the system will have the ability to hear all other radio transmissions to and from other trains on the system. This is an important safety feature that is used throughout the industry. Other potential radio channels will be for yard operations, maintenance, supervision, and security.

5.1.3 Communications Transmission System

There would be no communications transmission system provided as part of the original system. Any communications that might be required between fixed facilities would be handled by the public telephone network. It has been previously noted that fiber optic cables may be used between interlockings in the signal system and in that case, certain fibers would be set aside for future use by a communications transmission system.

The current trend in communications technology is to have all information, whether voice, video, or data, converted to a digital Internet Protocol (IP) data format. IP data can be easily sent over the public telephone network or private networks. By requiring all systems that may eventually need communications to be capable of digital IP communications over Ethernet, the maximum flexibility for future growth is retained at minimum cost.

5.1.4 Station Communications Systems

The light rail passenger station becomes a focal point for wayside communications systems. Communications equipment rooms may not be needed at the beginning of system operations; however planning for stations would take into account their future construction. This planning would include the allowance for connection paths to communications systems not located at a station, such as SCADA connections for signals and traction power substations.

Future station communications systems may consist of passenger amenities such as: public address systems and variable message signs; security systems such as closed-circuit television surveillance, fare vending machine alarm monitoring, and passenger emergency call telephones; passenger information systems; and employee telephones. Although none of these systems is planned for the original system, allowances would be made for their future installation so that disruptions and demolitions would be minimized. This would include determination of the locations of future equipment on the platforms and the routing for cables to connect the various systems to the future communications equipment rooms. The locations for the equipment rooms would also be established.

5.1.5 Supervisory Control and Data Acquisition

The Supervisory Control and Data Acquisition System (SCADA) is the means by which information is collected about the various systems on a rail system (for example signals, security systems, and fare collection machines) and then transmitted to a computerized Control Center for presentation to the train dispatchers, supervision, and management. The SCADA system also transmits control commands from the Control Center to the wayside systems.

A SCADA system will not be installed as part of the low cost alternative system; however provisions will be made in other systems (such as signals and fare collection) for its future connection.

5.1.6 Operations Center

The Operations Center provides the focal point for operations of the light rail system. It supervises the movement of trains and controls access to the right-of-way for maintenance purposes. The low cost alternative does not provide a computerized Control Center, but instead envisions a conveniently located office from which a supervisor can communicate by radio and telephone as necessary. Radio and telephone systems may be stand-alone desk units or they may be integrated into a simple system controlled by a desktop personal computer. A second personal computer would be provided for office-type applications such as email and reports. All software would be commercially available "off-the-shelf" packages, such as Microsoft Office.

5.2 Assumptions for Conceptual Level Cost Estimate

At this conceptual stage, it is assumed that the low cost alternative for the Spokane Regional Light Rail Project will include a minimum Communications system with two-way radio and business telephones as described above. The Operations Center is assumed to be located in the Operations and Maintenance Facility.

Conceptual level costs will generally be developed on a per-mile basis for wayside equipment and cable and on a per-station basis for station communications systems. All costs will be developed using relevant examples from recent industry experience.

6. FARE COLLECTION

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6.1 General Description

All of the new start light rail services in North America over the past twenty years have adopted a self-service, proof-of-payment method for collecting passenger fares. By this method, passengers are responsible for payment of their trip in some fashion prior to boarding trains or, in some cases, before entering areas of stations from which trains can be boarded. In addition, passengers are required to have in their possession some evidence of fare payment (such as a valid ticket, pass, transfer, etc.) that must be shown on demand to authorized inspectors who randomly circulate throughout the transit service. Failure to produce valid proof of payment results in a charge of a fine or inflated penalty fare.

Variations of this method of fare collection are numerous, a particular one being whether ticket vending machines sell pre-cancelled or uncancelled tickets. With the former, tickets are imprinted with date and time as part of the vending operation, and must be used before their time validity expires. In the latter, tickets require separate cancellation and are only valid when that action is taken. Thus, ticket cancellers, which print date and time when a ticket is inserted into them, must be provided. At the expense of additional equipment, the benefit of the latter is that multiple tickets can be purchased at a vending machine and held for future use. A further variation is whether ticket cancellers are placed on platforms or in the vehicles.

The primary benefits of self-service, proof-of-payment fare collection are that passenger stations can be designed without barriers to control access, and passengers can board trains at any door unhindered. This method is particularly compatible with low platform light rail systems.

The following is an initial description of alternative self-service, proof-of-payment fare collection systems proposed for the rail system in the Spokane region. Fare collection equipment may be placed either at stations, or on board the DMUs, the choice depending on relative numbers of units needed and anticipated utilization patterns. Refinement will be necessary as the design of the system progresses and certain policy direction is obtained.

The fare collection system will have three major components: ticket vending machines, ticket cancellers, and a central data system.

Ticket vending machines (TVM) will be ADA-compliant, vandal-resistant, free-standing cabinets installed on each station platform or on each DMU. TVMs will accept coins and bills, provide change in coins, and dispense tickets singly or in multiple quantities. Some or all TVMs may also accept bank cards, if this is deemed practical. Ticket options will cover the range of choices dictated by the fare structure and passenger convenience. Choices might include several types of full and reduced fare single trip tickets, day tickets, family tickets, and the like. Ticket options will be displayed by video screen, while ticket selection will be by touch screen or pushbuttons. Tickets will require separate cancellation.

TVMs will be placed at stations or on DMUs according to anticipated pedestrian flow and the design features of the station or vehicle. If at stations, they will be located on or off the platforms and oriented so that passengers queuing to purchase tickets will not impede normal flow between trains and the station. They will be placed under shelter where practical to protect passengers and service staff from the elements when using the machines and to provide illumination. If placed on DMUs, TVMs will be located near an entry, but out of the direct flow of passengers using the center aisle.

Quantities will be determined by anticipated passenger use; however, at a minimum, there will two TVMs at each inbound (or peak direction) platform and one at each outbound platform for side platform stations and two TVMs at each center platform station. Alternatively, there will be at least one TVM on each DMU, unless division of the car into two separate passenger compartments, as in Figure J-302, requires placing a TVM in each end section of each vehicle.

It is presumed that STA will maintain an aggressive program of pass sales through sales outlets, such as The Plaza, and by mail, and that there will be bus-to-rail transfers. This will reduce the need for ticket sales transactions at station platforms and potentially reduce the quantities of TVMs needed overall.

Ticket cancellers (TC) will be needed to allow passengers to validate their tickets. Upon ticket insertion by the passenger, TCs will imprint machine identity, date and time. At least one TC will be placed near each TVM.

Ultimately, all fare collection equipment will be connected to a centrally located data system over the most convenient communications medium available. The equipment will report status, events, alarms and other information when necessary. Ticket vending machines will be able to receive information from the central computer to update fare structures, ticket print layouts, patron display information, operating parameters, and to be remotely commanded to perform certain diagnostic functions. The equipment will also report simple status conditions to a SCADA system, including security, maintenance and revenue alarms. For this lower cost alternative, however, electronic updates such as fare structure changes will be input manually to each machine, alarms will be local, and use of credit and debit cards may not be practical.

6.2 Assumptions for Conceptual Level Cost Estimate

The conceptual design cost estimate will assume two TVMs and two TCs for each station. Where two side platforms are provided, each platform will be equipped with one TVM and one TC. Two TVMs and two TCs will be placed on the single platform provided at each center platform station. In addition, the total quantity from the foregoing will be increased by 20% to provide for additional machines for high ridership stations and locations serving special events. Another two machines of each type should be procured to use as test units by maintenance staff.

Table 6.1 includes an initial estimate of equipment quantities for in-station ticket vending. With 14 stations, a total of 28 TVMs and 28 TCs will be needed, net of any extra machines. With on-board ticket vending and a fleet of 15 DMUs, a total of 30 units of each machine type will be needed with a TVM and TC at each end,, also net of any extras. Whichever alternative is adopted, the value of the final total will be increased by 10% for spare machines, extra cash and change vaults, and replaceable components.

Based on the above comparison, it is recommended that the lowest cost alternative will be to place fare collection equipment on the DMUs. This will be so even though two more TVMs and TCs are required, for two reasons. The machines will cost less initially because they will not need to be extensively weather proofed. Once in operation, all fare collection equipment servicing and maintenance can be done at the central operations and maintenance facility, instead of having to send a crew and truck out into the field.

Because the introduction of TVMs will result in the receipt of large quantities of higher denomination bills, devices to sort and count bills may be necessary additions to the money processing systems presently in place.

7. OPERATIONS AND MAINTENANCE FACILITY

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7.1 General Description

The Operations and Maintenance (O & M) Facility, as the name implies, will serve as the nucleus for all operations and maintenance activities for the Spokane Transit Authority rail system. The initial system will have only one facility. As such, it must accommodate all of the functions essential to administration, operations, dispatch, vehicle and maintenance of the wayside (MOW). General categories of the operations and maintenance activities planned for the facility are:

Operations

- Operations Administration
- DMU Vehicle storage
- Train make-up and dispatch
- DMU adds and drops
- Train operator report area
- Operator training

Vehicle Maintenance

- Routine inspection and service
- Interior and exterior cleaning
- Fueling and sanding
- Subassembly unit repair and rebuild
- Component repair and rebuild
- Body repairs and painting

Maintenance-of-Way

- Signal system service and inspection
- Fare collection (FC) equipment storage and inspection
- Track maintenance
- Station cleaning
- Facilities maintenance
- Landscaping Maintenance

The facility building, site infrastructure and activities are best described as commercial/light industrial. Development on the site will include one building that will house all maintenance and operations activities. The initial development will reserve property for future expansion. The building will house shop areas for maintenance of the DMU fleet. The building will also include a multi-story section that will house all of the functions to support the operation and maintenance of the system.

7.2 Assumptions for Conceptual Level Cost Estimate

For the purpose of conceptual engineering plans and cost estimates the following assumptions have been made:

1. Property for the facility will be purchased to allow for storing and maintaining the initial fleet of 15 DMUs, and to provide a base for system maintenance.
2. The building will be sized initially to accommodate all operation, maintenance and repairs for the initial system. As the system grows, a separate MOW building can be constructed on the site, and MOW activities moved to the new building, leaving the main building for system operations and DMU maintenance.
3. The yard will be designed to accommodate primary and secondary ("back door") track connections from the main line. The shop and yard will be double-ended and the facility will include no dead-end tracks. Minimum track radius in the yard will be 400 ft. and the minimum allowable track switch angle will be an AREMA No. 6.
4. The multi-story portion of the building is assumed to be two stories above ground with approximately 15 ft. per story. This multi-story portion is assumed to contain all operations functions, system-wide parts storage and some maintenance activities.
5. The truck shop/component repair and engine shop areas will be high-bay shops with roof height of about 30 ft.
6. The DMU maintenance shop area of the building will require a ceiling height of 28-30 ft. Large overhead doors will be required at each track entrance to the building.
7. Day-lighting will be employed as much as practical in the DMU shop area through use of clerestory windows or roof monitors.
8. Some maintenance activities such as wheel truing would be contracted out initially and later would be accommodated in house.

Figure J-501 illustrates one possible layout for a site supporting a 15-car fleet, which is consistent with the above assumptions and will be used as the basis of the conceptual level cost estimate. The estimate will be prepared using a unit cost rate per acre for a developed yard site and a square foot cost for an equipped maintenance and administration building based on recent cost experience on other projects.

The layout illustrated provides a building of 165 ft. x 270 ft., plus a small ground level extension and a partial second floor, together comprising a building with over 50,000 sq. ft. The overall yard occupies approximately 15 acres, exclusive of the turntable area and east yard/main line connecting track. The entire site is approximately 25 acres, which provides ample room for future expansion of both the yard and the shop building, should such become necessary.

7.3 Issues to be Addressed during PE

During preliminary engineering several decisions will need to be made and issues resolved that will be pivotal to developing plans and a cost estimate germane to the STA needs. The assumptions above will need to be confirmed and the issues below will need to be addressed during PE:

1. A range of vehicle dimensions and characteristics will need to be developed from the available vehicles meeting the STA criteria. This will enable shop and yard dimensional ranges to be refined and consistent with the vehicles available.
2. A final site layout must be performed.

3. Programming of the building and site must take place through a series of meetings with STA. This will include confirmation of the maintenance activities which are to be performed by STA and those to be contracted to third parties.
4. Review the layout in Drawing J-501, and revise as may be appropriate to better accommodate potential joint development of the site. Examples might include eliminating use of the turntable, and shifting the shop building.

8. OPERATIONS PLANNING

SYSTEMS ENGINEERING CONCEPTUAL DESIGN REPORT
SHARED TRACK ALTERNATIVE
July 2002

8.1 Preliminary Travel Time Estimate

Travel time is generally based upon four major factors: first, the performance characteristics of the DMU vehicle; second, the characteristics of the alignment, including grades, curves, passenger stations, crossings and traffic conflicts, etc.; third, speed limits which may be exogenously imposed by jurisdictions, e.g. the City of Spokane; and fourth, operational requirements or practices which may be established by STA.

Using these factors as input, a computer program simulates train performance. Outputs, among other things, include travel times between stations and for the entire alignment. The diesel multiple unit (DMU) vehicle used for travel time simulations is described in Section 2. Such simulations are based on idealized conditions of acceleration and braking, dry track, and so on. Normal operations in real life introduce "friction factors" and variable conditions, which can account for a lengthening of actual travel times by 10% or more, as compared to these idealized simulations. Contributing conditions might include individual vehicle performance, operator habits, traffic controls, abnormal passenger loads, bridgeplate deployment for passengers requiring boarding assistance, and similar possibilities.

The alignment is as described in the conceptual level civil drawings. Length of the line is approximately 15.5 miles with 14 passenger stations. In general, horizontal curves for this alignment are gentle, compared to those of many light rail lines, and the line is relatively flat. The most restrictive curves are of 150 ft. radius at Madelia Street. Grades are generally in the range of 1%-3%, except that there is one short section of nearly 6% east of Napa station in Riverside Avenue.

Passenger station dwells are assumed to be 30 seconds, on average, to allow for a spectrum of operational considerations. Also, it is assumed that trains will accelerate and decelerate at maximum service rates and that there will be no explicit traffic delays at intersections. These conditions are compensated somewhat by introduction of an extended layover at the easterly terminal station.

Speed limit assumptions have been made for the entire length of the alignment, generally in accordance with the geometric characteristics of the line, the adjacent highway network, and the opportunity for competitive travel times. Speed limit assumptions are summarized as follows:

Plaza Station to Trent Station	25 mph
Trent Station Fairgrounds Station	30 mph
(Madelia & Riverside, within the above section)	(10-25 mph)
Farigrounds Station to Signal Road Terminus	55 mph*

* Exclusive of any possible speed restrictions through curves

Based on these assumptions the estimated one-way run time is approximately 38 minutes, for an average, or commercial, speed of approximately 24.5 mph. This average speed is relatively fast by light rail standards, and in part is explained by the relatively long station spacing (1.2 miles on average), the relatively low incidence of horizontal curve restrictions, and the civil speed limit assumptions, which include approximately three-fourths of the line at 55 mph.

Table 8.1 provides a tabulation of the "normalized train performance simulation, listing the station-to-station run times (in seconds), dwell time, and cumulative travel time from terminal to terminal in each direction. Interestingly, there is no difference in total running time by direction, reflecting the relatively flat terrain throughout the alignment. Table 8.2 presents the 38-minute run time in a matrix format to facilitate determination of travel times between any station pair. The numbers are rounded up to the nearest half-minute. This is particularly useful for public information.

It is considered prudent to re-visit in PE all of the many assumptions going into the travel time mix. As alignment, station location, and particularly civil speed limits become better defined, so will the travel time estimates.

8.2 Conceptual Operating Plan

Operating plans must reflect realistic estimates of running times, corresponding to the civil constraints of proposed alignments, and the performance characteristics of vehicles and support systems. In addition, they must support policy levels of service, and provide carrying capacity sufficient to meet ridership projections. Individually, changes to any of these parameters may have a significant effect on operations and operating statistics, fleet size, staffing, and overall operating and maintenance costs.

8.2.1 Operating Assumptions

This section describes the assumptions on which the Conceptual Operating Plan is based.

1. Hours of Service: TBD, likely will correspond with STA bus service hours, early morning through late evening, approximately 5:00 AM until 11:00 PM.
2. Policy Headways: Planning for this alternative is based on 15-minute peak headways. Off-peak, weekend and holiday service frequencies will be at either 15- or 30-minute intervals, depending on day and time period.
3. Forecast Patronage: TBD in a separate work task. For now, it is assumed that all trains will operate with two cars during peak times.
4. Vehicle Capacity: The DMU design capacity, for vehicle testing purposes, is based on a full-seated load and 2.5 square feet of area for each standee, for a passenger loading of approximately 190 people. Experience has shown that this degree of loading is only achievable and sustainable in the very densest transit corridors, and a practical capacity for sizing purposes for most applications is approximately 135 to 150 people per car.
5. Stations: 14 stations between Plaza (downtown) and Signal Road (Liberty Lake).
6. Alignment and Support Systems: As described in other sections on alignments and facilities design.

8.2.2 One-Way, Round Trip and Operating Cycle Times

Terminal-to-terminal run time is estimated to be 38 minutes as explained above, for a round trip running time of 76 minutes (see table on following page).

Terminal layovers for operator rest and schedule recovery are provided at each end of the line totaling 14 minutes (18% of running time), and produce a total operating cycle of 90 minutes. To avoid placing a meet between trains in the segment between the Fairgrounds and the east end of Riverside Avenue, the terminal layover time is assigned mostly (11 minutes) to Signal Road.