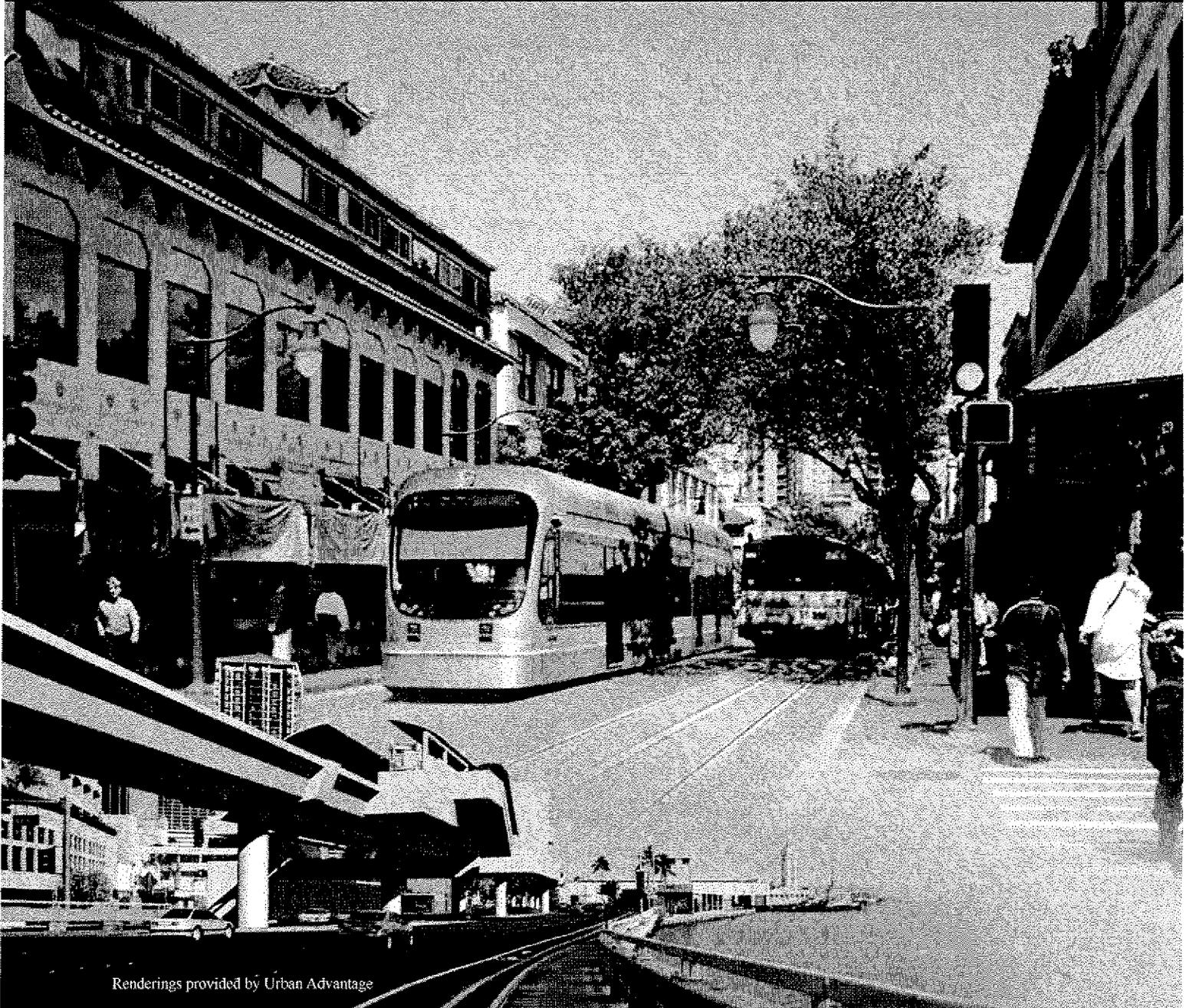


Light Rail Transit Report

The Potential of a Light Rail System with Surface-Level Segments to Better Serve Honolulu Than an Elevated Railway System

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EXECUTIVE SUMMARY

KEY FINDINGS AND EXERPTS

A flexible system will save taxpayers \$1.8 billion.

A comparison of the probable total capital investment requirements for implementing the HHCTC Project as an elevated railway using automated light metro technology or as a light rail transit system with surface-level alignments where they are feasible and cost-effective is as follows:

Project Segment (From/To)	Amounts in Millions		
	Elevated Railway	Light Rail	Savings
East Kapolei to West Loch	\$1,000	\$ 295	\$ 705
West Loch to Waipahu	\$ 295	\$ 100	\$ 195
Waipahu to Pearl Highlands	\$ 420	\$ 350	\$ 70
Pearl Highlands to Middle Street	\$2,430	\$2,375	\$ 55
Middle Street to Iwilei Road	\$ 515	\$ 200	\$ 315
Iwilei Road to Ala Moana Center	\$ 620	\$ 170	\$ 450
Yard and Shops; Miscellaneous	\$ 120	\$ 120	\$ 0
Total Project Implementation Cost	\$5,400	\$3,610	\$1,790

Estimating Assumptions

All-in construction costs for civil, structural and systems works, as well as general and administrative expenses, of:

- \$10 million for construction of an off-street Transit Center with bus-to-rail transfer facilities at Ala Moana Center;
- \$30 million per mile for single-track surface-level alignments in existing lanes of city streets;
- \$50 million per mile for double-track surface-level alignments in existing lanes of city streets or on currently undeveloped land;
- \$70 million per mile for alignments involving earthen fill embankments;
- \$80 million per mile for alignments involving widening one side of an existing thoroughfare with built-up land uses to create an additional lane;
- \$90 million per mile for surface-level alignments where a median must be created along an existing highway with built-up land uses on both sides of that highway;
- \$100 million per mile for creating a private right-of-way in a redevelopment area with existing land uses that may be retained;
- \$180 million per mile for single-track elevated structures; and
- \$270 million per mile for bridges and/or double-track elevated structures.

Through adopting Light Rail technology for the HHCTC Project and by bringing approximately 52,500 feet or about nine and nine-tenths (9.9) miles of its main line to the surface, including on-street alignments along Dillingham Boulevard and extending through Downtown Honolulu to Ala Moana Center, as well as replacing sixteen or more than two-thirds of its twenty-two massive elevated stations with simple surface-level stations

EXECUTIVE SUMMARY

In November 1999, in the Detailed Progress Report to City Council of what was then called the Primary Corridor Transportation Corridor Project, the City Administration's consultants (who continue to work on the HHCTC Project) reported that:

"Rather than considering transit technologies entailing massive and costly elevated structures and tunnels, the Primary Corridor Transportation Project is considering transit alternatives that can occur at-grade and fit within existing transportation rights-of-way. Built at a more human scale, such alternatives can preserve the City's neighborhoods and protect the environment while stimulating growth in desired areas. To meet established needs, mobility is now mixed with livability goals. Within this broader context is recognition that a network of transit-oriented improvements fitting the mobility needs and growth – or non-growth – objectives of each island community is best."

Those observations, pertinent almost a decade ago, are even more pertinent in today. Compared with the Elevated Railway currently being pushed forward by the City Administration in a "rush to judgment" intended to ensure its de facto and non-reversible implementation regardless of public concerns about its advisability, a Light Rail solution is the best way forward for achieving the mobility and livability needs of Honolulu's community at large – residents, businesses and employees, educational institutions and students, entertainment venues and their audiences, hotels and restaurants and their guests, military installations and their personnel, sports centers and their fans, and even tourists on holiday "In Our Island Paradise," all will benefit most from the adoption Light Rail. (Page 63)

SUMMARY DESCRIPTION OF HONOLULU HIGH-CAPACITY TRANSIT CORRIDOR PROJECT AND ITS CURRENT STATUS

Honolulu High-Capacity Transit Corridor (HHCTC) Project

The City and County of Honolulu, acting through its Department of Transportation Services, proposes to construct and operate an automated elevated railway along the Leeward Coast of O'ahu to connect West Kapolei with Downtown Honolulu and the University of Hawai'i-Manoa and Waikiki on the Diamond Head side of the island. The initial segment of the Elevated Railway would extend for approximately twenty miles from East Kapolei through Downtown and Kaka'ako to Ala Moana. En route it would serve Waipahu, Pearl City, Honolulu International Airport, Kapalama, Chinatown and Kaka'ako. The proposed alignment of the initial segment of the Elevated Railway would be primarily along North-South Road, Farrington Highway, Kamehameha Highway, HNL airport access roads, A'olele Street, Dillingham Boulevard, Ka'a'ahi Street, Nimitz Highway, Halekauwila Street, Queen Street and Kona Street, along with placement of elevated structures on connecting private right-of-ways.

CCH/DTS plans to open the East Kapolei to Ala Moana segment its Elevated Railway in stages between 2013 and 2018. The initial operating segment of the HHCTC Project is forecast to carry 95,700 passenger trips in the year 2030. Its currently estimated construction cost is \$5.4 billion. CCH/DTS proposes to finance this amount by \$4.0 billion collected by the State of Hawai'i on behalf of CCH through a half-cent surcharge on the general excise tax coupled with \$1.4 billion in anticipated federal grants.

Draft Environment Impact Statement (DEIS)

CCH/DTS prepared a Draft Environmental Impact Statement (DEIS) for the HHCTC Project, which was made available for public review and comment during a 45-day period that ended on February 6, 2009. The responses, verbal and written, received during that public comment period are being reviewed currently by the US Environmental Protection Agency (EPA), Federal Transit Administration (FTA) and the City and County of Honolulu's Department of Transportation Services (CCH/DTS) and the latter's project management and engineering consultants. Amongst the parties that submitted comments critical of the HHCTC Project to CCH/DTS and FTA were the Honolulu Chapter of the American Institute of Architects (AIA Honolulu) and Kamehameha Schools (KS).

Issues Raised in Response to the DEIS by the US Environmental Protection Agency (EPA)

Region IX of the EPA, having responsibility for administration of the National Environmental Protection Act (NEPA) with regard to the State of Hawai'i, already has weighed in on the DEIS for the HHCTC Project. In a letter dated February 12, 2009 addressed to Region IX of the FTA, which has the primarily responsibility for reviewing the subject DEIS, Region IX of the EPA stated:

“While EPA supports the goal of providing transportation choices to the communities of O’ahu, we have some concerns related to wetlands, water quality, environmental justice, and noise impacts. EPA has rated this document EC-2, Environmental Concerns, Insufficient Information.”

In addition, both in its letter to FTA and in its detailed comments on the subject DEIS, EPA stated:

“While we believe that most of the alternatives eliminated prior to the DEIS are documented sufficiently, we have remaining questions about why light rail or bus rapid transit in an exclusive right-of-way were not considered as reasonable alternatives in the DEIS.”

In this regard, the EPA made the following recommendation to FTA:

“Include additional information in the FEIS explaining why light rail or bus rapid transit in an exclusive right-of-way were not considered to be reasonable alternatives and were therefore not reviewed in the DEIS. If these technologies may have resulted in fewer environmental impacts, further justification is warranted to substantiate why those less damaging alternatives were not carried through for consideration.”

A Final Environmental Impact Statement (FEIS), responding to the recommendations of EPA and FTA, will be prepared by CCH, reviewed by the two federal agencies for responsiveness and legal compliance, and published by FTA by the end of 2009 or in early 2010. This action will set the stage for FTA to rank the HHCTC Project in accordance with its New Starts Criteria and then issue a Record of Decision (ROD) that will determine whether or not the project is recommended for federal assistance.

(See Appendix A-1 for February 12, 2009 Letter from Region IX EPA to Region IX FTA.)

Non-Compliance of DEIS with Notice of Intent Published by FTA in the Federal Register on March 15, 2007

An issue relating to the eligibility of the HHCTC Project for receipt of federal grants is the City Administration’s non-compliance with the requirements of the Notice of Intent to Prepare an Environmental Impact Statement for High-Capacity Transit Improvements in the Leeward Corridor of Honolulu, HI, published in the Federal Register / Vol. 72, No. 50 / Thursday, March 15, 2007 (Pages 12254 to 12257). This notice required that, in addition to a No Build Alternative, the subject DEIS address the following:

“Fixed Guideway Alternatives, which would include the construction and operation of a fixed guideway transit system in the corridor between Kapolei and UH-Manoa with a branch to Waikiki. The draft EIS would consider five distinct transit technologies: Light rail [sic] transit, rapid rail transit, rubber-tired guided vehicles, a magnetic levitation system, and a monorail system. Comments on reducing the range of technologies under consideration are encouraged. Both alignment alternatives [Airport and Salt Lake Boulevard] would operate, for the most part, on a transit-guideway structure above the roadway with

some sections at grade.”

In contrast with the requirements published in the Federal Register, the DEIS prepared by CCH/DTS and submitted to FTA addressed only the following alternatives:

- No Build Alternative
- Fixed Guideway Transit Alternative via Salt Lake Boulevard (Salt Lake Alternative)
- Fixed Guideway Transit Alternative via the Airport (Airport Alternative)
- Fixed Guideway Alternative via Airport and Salt Lake (Airport & Salt Lake).

None of these alternatives discussed technology options that exist for the HHCTC Project nor the significant issue raised by EPA about whether any of the technologies not addressed in the DEIS may have resulted in fewer environmental impacts and “...why those less damaging alternatives were not carried through for consideration.”

The failure of CCH to produce a DEIS compliant with the Notice of Intent which it and the FTA published in the Federal Register opens up the possibility, indeed high likelihood, that parties opposed to the HHCTC Project will take legal action in the Federal Courts to seek a restraining order based on procedural error against CCH and FTA in the event that the latter grants a favorable ROD based on the DEIS.

(See Appendix A-2 for March 15, 2007 Notice of Intent published in the Federal Register.)

Recent Actions by City Administration to Advance the HHCTC Project

Not wishing to wait out the DEIS process and the FTA’s determination about whether or not the HHCTC Project is found to be qualified for federal funding, the City Administration has announced its intention to proceed with construction of an initial segment of its First Project between East Kapolei and Pearl Highlands in Pearl City, a distance of approximately six and one-half (6.5) miles that would contain seven stations. The intent is to construct this portion (normally referred to as a Minimum Operable Segment or MOS) as an elevated railway using automated light metro technology and to open it for passenger-carrying service in 2013. The remainder of this First Project, serving Honolulu International Airport and Downtown en route to Ala Moana, is proposed for completion and the commencement of passenger-carrying service over the full length of the Elevated Railway no earlier than 2018.

CCH proposes to finance the construction of the East Kapolei-to-Pearl Highlands segment of its Elevated Railway project using local funds, i.e., without federal assistance. Federal funding for the remainder of its First Project – the remaining thirteen and one-half miles of line between Pearlridge and Ala Moana Center. As discussed above, this speculative assumption is entirely dependent upon the issuance of a favorable ROD by the FTA and the subsequent entering into a Full Funding Grant Agreement (FFGA) between the United States Department of Transportation (USDOT) and the City and County of Honolulu (CCH).

Future Technology Options

In response to criticisms of the DEIS by parties that submitted comments for the record, in particular that it addressed only alignment alternatives for an elevated railway and not technology alternatives, the City Administration has said that future segments of the First Project could be built using a different steel wheel-on-steel rail technology, such as Light Rail using low-floor rolling stock. The likelihood of it ever occurring is most improbable.

The reasons that changing the technology during the First Project's implementation (or that of future extensions) would be all but impossible to achieve – other than at great expense – are:

1. The seven stations along the initial segment (East Kapolei to Pearl Highlands) of the Elevated Railway are to be constructed with high-level platforms incompatible with low-floor light rail vehicles;
2. The rolling stock of the Elevated Railway would be built with high-floors matching the high-level station platforms, be equipped only with third rail contact shoes (no pantographs), and have fully-automated control (no provisions for manual control under normal operating conditions); and
3. The maintenance and storage facility would be designed and constructed to maintain and store high-floor automated light metro vehicles, not low-floor light rail vehicles capable of being controlled manually.

In essence, by proposing to use local funds to begin the implementation of its plan to build an elevated railway using automated light metro technology along the Leeward Side of O'ahu, the current City Administration would commit the technology of the HHCTC Project in a manner that will effectively preclude any subsequent City Administration from adopting light rail technology as its construction advances towards Downtown and Ala Moana Center. If implemented, it also will doom any future extensions of the fixed guideway transit system to either to the construction of environmentally-damaging elevated structures and aerial stations or to isolated feeder services connecting with the Elevated Railway, be they Light Rail or Bus Rapid Transit, that would deny passengers the advantages of "one seat rides" and thereby discourage ridership levels compared with those which could be achieved with an integrated system using more flexible Light Rail technology.

OBJECTIVES OF THIS REPORT

Kamehameha Schools (KS) decided to engage the author of this report as a consultant to help it determine the whether there is sufficient justification to determine the practicality of an ideal transit delivery system and associated vehicles that would provide sufficient flexibility to permit the significant segments of HHCTC Project to be built at-grade where appropriate, with the objective of increasing its overall effectiveness while reducing capital investment requirements; i.e. explore options to develop a “Best Fit for Honolulu” based on Light Rail technology.

As part of this report, KS requested commentary upon the relative economic, social / community, cultural, and environmental aspects of Transit-Oriented Development (TOD) potentials at its landholdings (and in general terms those of other stakeholders) between exclusively or primarily elevated railway systems versus light rail transit systems involving a mixture of at-grade alignments (including exclusive or fenced-in private rights-of-way, open private rights-of-way with grade crossings, medians, transit malls, transit-only lanes and mixed traffic lanes) and elevated structures.

ACCEPTED DEFINITIONS OF HEAVY RAIL, LIGHT METRO AND LIGHT RAIL AS DISTINCT FIXED GUIDEWAY TRANSIT SYSTEM TECHNOLOGIES

There has been a tendency in the documentation describing the HHCTC Project to refer to it generically as a fixed guideway transit system or as “Light Rail,” without defining precisely what these terms mean. To avoid confusion, this report uses the following terminology as defined by organizations and engineers with national and international repute: American Public Transportation Association (APTA); Transportation Research Board (TRB) and International Public Transport Association (UITP).

The TRB definitions are particularly succinct:

- Heavy Rail: A [high capacity] transit mode that operates on fully grade separated (separated from street level) ‘rights-of-ways.’ Unlike generic LRT, many metros, including monorail, are proprietary transit systems and cannot share their ROW with other transit modes including other metros!
- Light Metro: A transit mode that operates on a fully grade separated (separated from street level) ‘rights-of-ways.’ Unlike generic LRT, many metros, including monorail, are proprietary transit systems and cannot share their ROW with other transit modes including other metros. Light Rail systems that operate on grade separated ROWs are more commonly referred to as Light Metros.
- Light Rail Transit: A streetcar system that has extensive priority signaling at intersections and at least 30% of its route operating on ‘reserved rights-of-ways.’ LRT may be grade separated but must retain the ability to operate in mixed traffic.

The fixed guideway transit system technology that CCH proposes employ for its HHCTC Project is automated light metro, not light rail transit. As such, the infrastructure and vehicles of the Elevated Railway will lack the flexibility to operate at-grade on either exclusive transit-only lanes or in mixed traffic. This limitation has significant impacts on the capital investment required to implement the Project, on both its operating and maintenance (O&M) costs and its long-term subsidy requirements, and on the environment.

ADVANTAGES (+) AND LIMITATIONS OF EACH STEEL WHEEL-ON-STEEL RAIL MODE

Vehicle Technology	Advantages	Limitations
Heavy Rail	<ul style="list-style-type: none"> • Maximum capacity • Higher schedule speed 	<ul style="list-style-type: none"> • Maximum capital investment • Maximum environmental impact where on elevated structures or on fenced-in surface alignments
Light Metro	<ul style="list-style-type: none"> • Substantial capacity comparable to heavy rail • Schedule speed comparable to heavy rail 	<ul style="list-style-type: none"> • More capital investment compared to light rail • Greater environmental impacts compared to light rail where on elevated structures or on fenced-in surface alignments
Light Rail	<ul style="list-style-type: none"> • Same capacity as light metro • Significantly less capital investment • Lower O&M costs • Significantly lower environmental impacts on at-grade alignments compared to above-street elevated structures 	<ul style="list-style-type: none"> • Lower schedule speeds when on in-street alignments • Accident rates between light rail trains and motor vehicles or pedestrians may be less than or equal to those of buses.

CAPACITY COMPARISON BETWEEN LIGHT METRO AND LIGHT RAIL

The use of Light Rail technology would meet the projected peak period ridership volumes, both near-term and long-term, of the Honolulu High-Capacity Transit Corridor Project as set forth in the Draft Environmental Impact Statement (DEIS). Specifically, light rail vehicles (LRVs) operating in two-car consists at three-minute headways can meet or exceed the capacity criteria of 8,100 passengers per hour per direction (pphpd) called for in the recently-issued Request for Proposals (RFP) for the Core Systems Design-Build-Operate-Maintain (DBOM) Contract. As with the currently proposed use of automated light metro technology for the HHCTC Project, in the distant future, LRVs operating at three-minute headways in either two-car or three-car consists – depending upon the length of individual cars - can provide a minimum passenger carrying capacity of at least 12,000 pphpd – in excess of the maximum two-hour peak period link volume projected for the Elevated Railway in the year 2030.

In summary, there is no difference between the Light Metro and Light Rail modes in the number of people who can be transported per hour in one direction along a single track.

THE CASE FOR LIGHT RAIL IN HONOLULU

The Honolulu High-Capacity Transit Corridor (HHCTC) Project, as presently designed, is a capital-intensive project. This is a result of the selection of automated light metro technology – with its inherent inflexibility with respect to possible alignments – resulting in an almost all-elevated railway extending along the Leeward Side of O‘ahu from virtually from one end of the island to the other. With a proposed initial 20 miles-long route extending from East Kapolei through Downtown to Ala Moana, the project will require substantial investment in public funds; be they derived from local, state or federal sources, whether financed on a pay-as-you-go basis, through revenue anticipation bonds, or periodic receipt of grants.

At the present time, the HHCTC Project has a projected capital investment cost of \$5.4 billion and a planned completion date of 2018, almost a decade into the future. If the requisite funding materializes and the project is constructed as presently contemplated, it is anticipated that it will provide an end-to-end (East Kapolei to Ala Moana Center) on-vehicle running time of 42–44 minutes with an average speed of approximately 30 miles per hour. The Elevated Railway, with its planned 21 or 22 stations, is projected to carry 95,400 passengers (one-way trips) by the year 2030.

Given the high level of capital investment required, equating to approximately \$56,600 per passenger trip carried on a typical weekday (Mondays through Fridays) in the year 2030; if one assumes that ninety percent (90%) of the projected weekday riders will be making two-way trips and the remaining ten percent (10%) will be making one-way trips, approximately 52,500 individual persons would be likely to use the Elevated Railway on a typical weekday. When the latter is compared with the \$5.4 billion currently estimated as implementation cost of the HHCTC Project, the projected capital investment per person likely to use the Elevated Railway on a typical weekday equates to \$102,500.

It is questionable whether or not that level of capital investment per projected rider will satisfy the New Starts Criteria of the Federal Transportation Administration (FTA). Failure to do so could result in the FTA assigning a “Low” ranking to the HHCTC Project, tantamount to “Not Recommended” and making it de facto ineligible for federal financial assistance. If that were to occur, particularly if CCH were to embark on constructing a segment of the current project without having received a Letter of No Prejudice (LoNP) from FTA committing the Federal Government to recognize specified local and/or state expenditures as matching shares towards federal grants, Honolulu might be forced to either abandon the HHCTC Project or complete part of it – perhaps in very abbreviated length - entirely with local funds.

For example, in 2006, the FTA gave a “Low” ranking to the Triangle Transit Authority’s proposed commuter rail project that would have connected the North Carolina cities of Raleigh and Durham. That project had a proposed capital investment cost of \$500 million and a projected weekday ridership of 9,500 one-way passengers, both numbers being approximately ten percent (10 %) of the comparable values of the HHCTC Project.

After the FTA rating was announced, TTA abandoned the commuter rail project; its successor agency, the Research Triangle Public Transportation Authority (dba as “Triangle Transit”), is now in the early stages of developing a light rail transit project in the same corridor, hoping that, through reducing the capital investment requirements while at the same time increasing the ridership projections, it may satisfy FTA’s New Starts Criteria and obtain a “Medium” or “High” rating that will qualify for substantial federal assistance in the future.

INSERTING LIGHT RAIL INTO HONOLULU'S URBANIZED COMMUNITIES

The feasibility of developing a Light Rail system to serve an urbanized area like the City and County of Honolulu is dependent upon the compatibility and practicality of inserting the new infrastructure into existing urban spaces and land uses, as well as those that may be developed in the future. Initial focus is often on the effects on existing and projected motor vehicle and pedestrian movements along a given thoroughfare or in an area under study for possible introduction of surface-level Light Rail operations, be they in malls restricted to transit vehicles and pedestrian movements, in transit-only lanes along city streets, or in traffic lanes shared with motor vehicles and bicycles.

However, to make such a determination, considerations must be given to the topography along a proposed route; natural features such as bays, harbors, rivers and streams; existing street patterns; building line-to-building line street widths; the number of and width of traffic lanes; placement and width of sidewalks and crosswalks; requirements for motor vehicle and pedestrian access to and from commercial and residential buildings, as well as to other activity centers such as hotels, sporting events and entertainment venues; governmental buildings such as city halls, post offices and the like; public safety installations such as police and fire stations; hospitals and dispatch locations for emergency medical services; military installations; landmark buildings, statues, fountains and historical protected sites; beaches, parks, zoos and other sites of recreational activities; preservation of existing tree cover along thoroughfares; and avoidance, minimization or mitigation of adverse environmental impacts wherever possible.

LIGHT RAIL DESIGN CRITERIA SUITABLE FOR HONOLULU

These considerations – the pass or fail determinants of whether or not it is physically possible and feasible from an overall functionality standpoint to introduce a Light Rail line in a given corridor - requires identification of achievable design criteria for infrastructure and rolling stock (transit vehicles) and testing those criteria against mandatory site-specific requirements.

Before proposing locations where the HHCTC Project can be brought to the surface, it was necessary to identify general design criteria for Light Rail infrastructure and vehicles that would be applicable to Honolulu's environment. The criteria adopted in this "Proof of Concept" report have been drawn from that prepared for CCH/DTS by its consultants and released by CCH with a Request of Information (RFI) from potential fixed guideway suppliers. That solicitation was accompanied by a First Project Systems Characteristics Information Package that limited acceptable technology offerings to those with third rail traction power distribution (no Overhead Contact System), stations with high-level platforms, and fully automatic train operation.

While based in large measure on the City's RFI, its requirements have been modified and supplemented in this report to reflect those of a light rail transit system – as distinct from an automated light metro – with the capability of operating on surface-level alignments, as well as on private rights-of-way and elevated structures; they are provided in considerable detail in the body of this report. Suffice to say, they are suitable for use in Honolulu and are comparable to those employed on numerous over Light Rail projects in North America and overseas.

(See Appendix A-3 for Light Rail Design Criteria Suitable for Honolulu.)

WIRELESS TRACTION POWER DISTRIBUTION

This report recommends that a form of “wireless” Light Rail technology be employed where the Light Rail alignment is in city streets or transit malls, on elevated structures and elsewhere on the HHCTC Project – at a minimum from the Waipahu Transit Center Station through Downtown Honolulu to Ala Moana Center.

In city streets and along the Hotel Street Transit Mall, as well as an alternate for elevated structures and private rights-of-way, an intermittent source of traction power, such as the service-proven APS technology developed by Alstom for Bordeaux, France and subsequently adopted by three other French cities and Dubai or competitive systems on offer from AnsaldoBreda, Bombardier, CAF, Siemens and others, could be used in connection with Light Rail.

Alternatively, along elevated structures, a wireless system of traction power distribution would obviate the need for catenary, supporting poles or masts, and associated bracket arms or span wires running from one side of the guideway to the other. A constantly energized third rail – located either to the side of the tracks or between the running rails – could be employed.

(See Appendix A-4 for Transportation Research Board Report 1607 – Dual Mode Traction Power Distribution for Light Rail Transit: A Design Option.)

Alternatively, an intermittent source of traction power, such as the service-proven APS technology developed by Alstom for Bordeaux, France and subsequently adopted by three other French cities and Dubai or competitive systems on offer from AnsaldoBreda, Bombardier, CAF, Siemens and others, could be used by the HHCTC Project in connection with Light Rail. In either case, the aesthetic, environmental and safety considerations of Light Rail would not differ in any significant way from that currently planned by CCH/DTS and its consultants for the Elevated Railway.

In either case, the aesthetic, environmental and safety considerations of the traction power distribution system proposed for Light Rail would not differ in any significant way from that currently planned for the Elevated Railway.

POTENTIAL FOR SURFACE-LEVEL LIGHT RAIL ALIGNMENTS IN HONOLULU

The City Administration proposes to build an initial phase (normally referred to as a Minimum Operable Segment or MOS) extending in the Diamond Head direction for approximately twenty miles from East Kapolei through Downtown and Kaka'ako to Ala Moana Center. En route it would serve Waipahu, Pearl City, Honolulu International Airport, Kapalama, Chinatown and Kaka'ako. The proposed alignment of the initial segment of the Elevated Railway would be primarily along North-South Highway, Farrington Highway, Kamehameha Highway, HNL airport access roads, A'olele Street, Dillingham Boulevard, Ka'a'ahi Street, Nimitz Highway, Halekauwila Street, Queen Street and Kona Street, along with placement of elevated structures on connecting private right-of-ways.

A detailed examination of the full length of the proposed alignment of the HHCTC Project, conducted on foot in urban areas where street layouts and adjacent land uses present challenges, revealed that adoption of Light Rail technology for the First Project (and its likely future extensions) is both practical and feasible. As discussed elsewhere in this report, the flexibility of Light Rail – permitting it to be deployed on a variety of alignments, each best suited to site-specific conditions – and its robust passenger-carrying capacity made this steel wheel-on-steel rail mode ideally suited for Honolulu.

Using the general design criteria suitable for development of a Light Rail system discussed above and in Requirements for Inserting a Light Rail Transit System into Honolulu's Urbanized Communities of this report, the consultant examined the entire alignment of the proposed HHCTC First Project to look for opportunities to “bring it down to earth,” with a view towards achieving cost-effective trade-offs between capital investment (construction cost) and schedule speed, as well as to avoid adverse environmental impacts.

Inasmuch as CCH proposes to construct its First Project in a series of segment, the author of this report has identified the opportunities for implementing surface-level Light Rail in the following line segments, including alternative routing options, in a similar matter. The candidate segments examined, with a discussion of their potential for use as part of a Light Rail system, are:

East Kapolei to West Loch (Waipahu)

With the adoption of Light Rail technology, the HHCTC Project can be constructed at-grade between East Kapolei and the West Loch area of Waipahu following virtually the same horizontal alignment as the proposed Elevated Railway.

From the very beginning of the First Project at East Kapolei, it would be feasible to locate the LRT alignment and the East Kapolei Station in either a median of North-South Road or on the roadway's makai-side (ocean side) adjacent to its northbound lanes. The East Kapolei Station would be constructed on the surface with a low-level center platform matching the floor height of low-floor light rail vehicles.

Following a surface-level alignment comparable to that engineered for the HHCTC Project, Light Rail would curve through former agriculture lands while remaining in a median of or adjacent to the new North-South Road being built under the Ho‘opili Master Plan. Its University of Hawai‘i West O‘ahu Station would be constructed in the roadway median with a low-level center platform, instead of with two side high-level platforms and a connecting mezzanine spanning the roadway proposed for the Elevated Railway.

The proposed Light Rail alignment would continue on the surface through the former agricultural lands in medians of or adjacent to new roadways to be constructed in general accordance with the Ho‘opili Master Plan, to the Ho‘opili Station, a low-level center platform. Continuing Diamond Head, the proposed Light Rail alignment would continue on the surface in the median of the new roadway to be built through the former agricultural lands to Farrington Highway, which it would bridge. At this point, a junction would be located connecting the main line LRT tracks with a Kapolei-direction spur track leading from and to a maintenance facility and storage yard (Yard and Shops Facility) to be constructed on the mauka-side of Farrington Highway.

After crossing to the north side of Farrington Highway, the proposed Light Rail alignment would continue on earthen fill embankments towards West Loch and then bridge over the westbound lane(s) of Farrington Highway to come to grade in the highway’s median just west of Fort Weaver Road. As the result of being on the surface in the median of Farrington Highway, the LRT tracks would be able to pass under Fort Weaver Road.

This area of the Light Rail alignment would be in marked contrast with the Elevated Railway, which would ascend a three percent (3%) grade to obtain sufficient clearance to pass over Fort Weaver Road at an elevation approximately 60 feet above Farrington Highway and then descend a five percent (5%) grade before entering the West Loch Station. An apt comparison between the vertical alignments proposed at this location for Light Rail and that engineered for the Elevated Railway is one of the former going down a steady grade and latter involving a roller coast ride.

After passing under Fort Weaver Road in the median of Farrington Highway, this segment of the proposed Light Rail line would have a level crossing with Leoku Street and continue to a West Loch Station on the ‘Ewa-side (western) side of the intersection of Farrington Highway with Leokane Street. This station would be constructed in the roadway median with a low-level center platform; it may be desirable to include an ADA-compliant footbridge spanning Farrington Highway in the design of this station to facilitate bus-to-rail and vice versa transfers with buses operating along Fort Weaver Road to and from ‘Ewa Beach.

A Diamond Head-direction (eastern) shift of the location of the West Loch Station is recommended because of concerns about pedestrian safety that would arise – whether the station is elevated above Farrington Highway or in its median – because of the proximity of the highway ramps connecting Fort Weaver Road and Farrington Highway; this concern is discussed further in Transit-Oriented Development Possibilities – Light

Rail Transit versus Elevated Railways of this report.

Including the recommended eastwards shift of the location of the West Loch Station, the entire length of the East Kapolei to West Loch segment of the HHCTC Project would be approximately 19,600 feet or about three and seven-tenths (3.7) miles. Of this distance, approximately 17,100 feet or about three and three-tenths (3.3) miles would be constructed on the surface or on earthen fill embankments with the adoption of Light Rail technology; the approximately 2,500 feet or less than one-half (0.5) mile remaining would be constructed on bridges or elevated structures passing over Farrington Highway.

West Loch to Waipahu Transit Center (Mokuola Street)

Continuing in the median of Farrington Highway towards Diamond Head, the proposed Light Rail alignment can be constructed on the surface to the Waipahu Transit Center Station, located between Waipahu Depot Road and Mokuola Street. This station would be constructed in the roadway median with a low-level center platform, instead of with two side high-level platforms as proposed for the Elevated Railway. An ADA-compliant footbridge spanning Farrington Highway would be provided in the design of this station to facilitate bus-to-rail and vice versa transfers with buses using the Transit Center, to be located on the makai-side of Farrington Highway, or to provide access to and from Hikimoe Street.

The distance between the surface-level West Loch and Waipahu Transit Center Stations would be approximately 5,700 feet or about one and one-tenth (1.1) miles, all of which would have an at-grade Light Rail alignment in the median of Farrington Highway.

Waipahu Transit Center via Leeward Community College to Pearl Highlands

Diamond Head of Mokuola Street, land-uses in Waipahu adjacent to Farrington Highway shift from being predominantly commercial to predominantly residential, closing in on the roadway as it passes over the drainage canal located a short distance west of Awamoku Street. By the time Farrington Highway reaches Pawa Street, about 1,200 feet east of the drainage canal, the roadway is on a steeply ascending grade. These factors, in combination, make it appropriate for the Light Rail line to transition from an at-grade alignment in the median of Farrington Highway to an elevated structure located above it.

After crossing Mokuola Street at-grade, the Light Rail alignment would begin a transition from the highway's median onto an elevated structure. Within a distance of approximately 1,700 feet and at an average gradient of about two and thirty-five hundredths percent (2.35%), the Light Rail alignment would reach a top-of-rail elevation of 30 feet above the intersection of Farrington Highway and Pawa Street (which is about 10 feet higher than the intersection of Farrington Highway and Mokuola Street). Beyond Pawa Street, the proposed vertical alignment of Light Rail elevated structure would continue rising above Farrington Highway until matching the vertical and horizontal alignment proposed for the Elevated Railway; at this point it would be on

a four and two-tenths percent (4.2%) ascending gradient.

The Light Rail alignment would remain on elevated structure above Farrington Highway for approximately 1,300 feet, where it would curve over the eastbound lanes of Farrington Highway onto a surface-level right-of-way extending approximately 4,100 feet or about eight-tenths (0.8) of a mile to the Leeward Community College Station.

DEIS identified two potential sites of a maintenance facility and storage yard for the HHCTC Project, one in Ho‘opili on the mauka-side of Farrington Highway and the other near Leeward Community College. This report finds the Ho‘opili site superior to the LCC site as the location of a Yard and Shops Facility, being preferable from an operational standpoint as well as for environmental reasons. In particular, the position of the LCC site, overlooking Pearl Harbor and sandwiched between Leeward Community College and Waipahu High School, would make its use more suitable as parkland or for other recreational purposes as opposed to a rail transit facility – regardless of technology – that would be active 24 hours per day/365 days per year.

With Light Rail, the Leeward Community College Station would be constructed at-grade with two side platforms. However, while Light Rail would not involve fully-automated train operations or require high-level platforms, the passenger access across the tracks would be provided via a simple crosswalk at one or both ends of the westbound station platform; in contrast, the Elevated Railway – even with a surface-level station – would require either a pedestrian overpass or underpass to assure the safety of passengers.

Continuing Diamond Head from the Leeward Community College Station, the proposed Light Rail alignment would transition from the surface onto an elevated structure in the same manner as the Elevated Railway. This elevated structure would extend to the Pearl Highlands Station, which would be located above Kamehameha Highway. En route, it would pass over Ala Ike Street, the eastbound ramp connecting Farrington Highway with the H-1 Freeway, the H-1 Freeway and its ramps connecting with the H-2 Freeway and Farrington Highway, the eastbound lanes of Kamehameha Highway and Wai‘awa Stream before reaching the Pearl Highlands Station. This side platform elevated station, with a mezzanine connecting to the mauka-side of Kamehameha Highway and into a large park-and-ride lot, is proposed to displace the so-called “Banana Patch” residential housing area (a location with significant environmental justice issues).

The distance between the Leeward Community College and Pearl Highlands Stations would be approximately 2,300 feet or a little more than four-tenths (0.4) of a mile, all but approximately 200 feet of which would be on elevated structures necessitated by the complex highway interchange connecting Farrington Highway, the H-1 and H-2 Freeways and Kamehameha Highway.

The distance between the Waipahu Transit Center and Pearl Highlands Stations would be approximately 9,800 feet or about one and nine-tenths (1.9) of a mile.

Pearl Highlands via Honolulu International Airport to Middle Street

Because of the built-up land uses adjacent to Kamehameha Highway, the H-1 Freeway and A'olele Street, including military facilities and the airport and taking into account the need to pass over the H-1 Freeway and highway ramps connected to it, attempting to create a surface-level Light Rail alignment in this area does not appear to be feasible or cost-effective in the nine-mile portion of the route between its Pearl Highlands Station and the Middle Street/Kamehameha Highway/Dillingham Boulevard intersection.

In no way does this conclusion preclude the adoption of Light Rail technology for the HHCTC Project. Low-floor light rail vehicles, because of their innate flexibility, can operate on elevated structures and serve elevated stations (providing that the latter are not built with high-level platforms) just as easily as the rolling stock of an automated light metro, running at the same speed and providing the same passenger-carrying capacity.

There is one exception to this report's conclusion that the Pearl Highlands to Middle Street segment should be built on elevated structures and with elevated stations if Light Rail technology is adopted for the HHCTC Project. That exception would occur on the Diamond Head-side of Honolulu International Airport where the Elevated Railway would cross from the makai-side of A'olele Street to its mauka-side and then run parallel to it to Lagoon Drive. By increasing the descending grade of elevated structure, in the range of 1,300 feet or about one-quarter (0.25) of a mile of the alignment, including the Lagoon Drive Station, can be brought to grade.

A probable layout for a surface-level Lagoon Drive Station, designed with low-level platforms, would be to provide far-side platforms for each direction of travel at the Light Rail line's level crossing of Lagoon Drive. Compared with constructing even a "bare-bones" elevated station having only stairways and elevators for ADA compliance, substantial construction and long-term operating and maintenance (O&M) can be achieved if this option were to be adopted.

On the Diamond Head-side of Lagoon Drive, the proposed Light Rail alignment would ascend an average grade in the range of two percent (2.0%) before passing over the Moanalua Stream at an elevation about 50 feet above its banks. At this point, the Light Rail elevated structure would be at the same height above ground as that proposed for the Elevated Railway and would pass over the Makai Frontage Road, the Nimitz Highway connectors and Middle Street to return to the right-of-way of Kamehameha Highway.

Middle Street via Dillingham Boulevard to Iwilei Road

Diamond Head of the Middle Street Transit Center, the Light Rail alignment would be brought to grade between Middle Street and Pu'uhale Road using the flexibility of light rail transit technology and continue eastwards on a surface-level alignment all the way to Iwilei Road. Transitioning from elevated structure, the

Light Rail line would be brought down to the surface of Dillingham Boulevard at an average grade of two and five-tenths percent (2.5%) or less in approximately 1,600 feet or about three-tenths (0.3) of a mile.

Currently, Dillingham Boulevard experiences frequent movements of articulated and conventional buses in both directions on its curbside lanes during peak periods. Because these buses make frequent stops, motorists tend to shun the curb lanes unless they are about to make right-hand turns into cross streets (such Pu'uhale Road, Kalihi Street and Alakawa Street) or into driveways.

Inasmuch as CCH/DTS proposes taking a ten-foot wide strip along the makai-side of Dillingham Boulevard for the Elevated Railway, as shown on the DEIS drawings, such a roadway widening also could be used to provide a restricted inbound curbside lane for the exclusive use of light rail vehicles, buses and emergency vehicles; this would leave two inbound lanes for motor vehicle traffic traveling towards Downtown Honolulu and other destinations in the Diamond Head-direction.

Alternatively, Light Rail tracks could be laid in the existing curbside lanes, where both LRVs and buses would operate; the author of this report considers this sub-alternative to be undesirable unless the existing curbside lanes can be restricted to transit and emergency vehicles, along with reducing the number of closely-spaced bus stops (which increases running time significantly) and the coping with right-hand turns.

Along Dillingham Boulevard, with Light Rail tracks located in curbside lanes, a wireless system of traction power distribution would obviate the need for catenary or trolley wire, supporting poles every 100-to-200 feet, and associated bracket arms or span wires running from one side of the road to the other. Although wireless systems cost more to install than overhead wire-based systems, they have significant environmental benefits that would be particularly attractive in Honolulu. In particular, Light Rail in combination with wireless traction power distribution would permit curbside track placement without requiring the tree cover existing along Dillingham Boulevard to be cut back severely or removed entirely (as would be the case with the proposed Elevated Railway).

With Light Rail and the much more affordable surface-level stations – both to build and to operate and maintain over the long-term – that are inherent with its adoption as the technology of choice for cities like Honolulu, comes the opportunity to provide more frequent stations in better locations that will encourage higher ridership levels because of being closer to potential passengers origins or destinations.

Where a Light Rail line along Dillingham Boulevard is concerned, this report recommends that simple curbside stations – similar to those found on Phoenix's recently-opened and highly successful light rail transit system – be located at Kalihi Street, Kohou Street and Alakawa Street, with a low-level platform, shelter, fare vending/cancelling machines and informational displays being provided in a widened sidewalk on each side of the thoroughfare for travel in that direction. It also recommends that the Iwilei Station be located on land adjacent to the former Honolulu Station of the O'ahu Railway on the mauka-side of Iwilei Road.

These surface-level stations, perhaps best thought of as enhanced and elongated bus stops, are envisioned as follows:

- A curbside station located on the eastern side of Kalihi Street would serve walk-in ridership from the neighborhood, the adjacent shopping center and passengers transferring to and from buses that run on Kalihi Street. Colburn Street, located one block makai of Dillingham Boulevard with the shopping center fronting on it, would be an ideal layover point for connecting bus lines. Kalihi Street - which has Transit-Oriented Development (TOD) potential - might prove to be a better location than the proposed Middle Street for a Transit Center. If that were found to be the case, it would be advisable to delete the isolated Middle Street Station and replace it with one located at Pu'uhale Road, which would attract walk-in riders from the neighborhood and serve persons employed at or with business at the O'ahu Community Correction Center.
- Similarly, a curbside station located immediately west of Kohou Street and the Kapalama Stream would encourage TOD in that area and also serve an existing satellite city hall located on the makai-side of Dillingham Boulevard.
- Alakawa Street, where Light Rail stations adjacent to the curb lane could be located in each direction on the far side of its intersection with Dillingham Boulevard, would be a much better location to serve both the Honolulu Community College (which has its main entrance close to the intersection) and the highly-developed commercial and retail business located to the makai-side. Contrary to popular wisdom, customers of retail outlets such as Costco and Home Depot will use public transit for shopping purposes when it is convenient to where they intend to make their purchases and when they do not plan to be carrying bulky items home. And in addition to such persons, there also are employees of such businesses that will choose to use Light Rail for journey-to-work travel, compared with driving, when it is more affordable, convenient and operates at times that coincide with their work schedules.
- Iwilei, where an ideal Transit Center can be created adjacent to the former Honolulu Station of the O'ahu Railway on land owned by the State of Hawai'i. The O'ahu Railway Station, an architecturally and historically significant building constructed in 1925, still stands forlornly on the mauka-side of Iwilei Road, its upper floor being used for state offices and its ground floor seemingly vacant. This location, currently fenced-off on all sides, has ample room for both a surface-level Light Rail station and off-street platforms and maneuvering space for buses that currently operate along North King Street and Iwilei Road. Restoration of this site and its station building for use as a public transportation facility would respect both this relic's place in the history of O'ahu during the first half of the 20th Century and enable it to play a vital role for Honolulu and the Island throughout the remainder of the 21st Century and beyond; it is an opportunity not to be missed.

Summary: Constructing a surface-level Light Rail line along Dillingham Boulevard is feasible and could be built in a manner that would not adversely affect motor vehicle traffic using that thoroughfare. Ideally,

inasmuch as CCH/DTS plans to take a ten-foot strip along the makai-side of Dillingham Boulevard in order to provide space for the support columns required by an Elevated Railway, this land-taking – should it occur – can be devoted to creating a curbside inbound transit-only lane for light rail vehicles, buses and emergency vehicles. Surface-level stations should be provided at Kalihi Street, Kohou Street and Alakawa Street to better serve nearby residential neighborhoods and commercial and educational activity centers. In particular, an opportunity would exist to coordinate Transit-Oriented Development (TOD) in the area between Kalihi Street and the Kapalama Stream, where Kamehameha Schools has significant property holdings that would benefit from enhanced access to Light Rail stations located along Dillingham Boulevard.

Iwilei Road through Downtown via Hotel Street Transit Mall to Ala Moana Center

Leaving the Iwilei Transit Center Station at the former Honolulu terminal of the O‘ahu Railway, Light Rail would curve towards Downtown into Iwilei Road, turn right into the center of North King Street, enter its left-hand turn lane and cross over Nu‘uana Stream into the Hotel Street Transit Mall, which it would follow to Richards Street. Two curbside Light Rail stations are proposed along the Hotel Street Transit Mall: in Chinatown between River and Maunakea Streets; and at Hotel and Bishop Streets.

Although other on-street Light Rail alignment options between Richards Street and Ala Moana Center are possible, the following appear to be particularly attractive:

- Diamond Head-bound, from Hotel Street makai via Richards Street to South King Street, South King Street to Kapi‘olani Boulevard, and Kapi‘olani Boulevard to an off-street terminal in a Transit Center located near the intersection of Kapi‘olani Boulevard and Atkinson Drive. Returning ‘Ewa-bound via Kapi‘olani Boulevard to South Street, South Street to South Beretania Street, South Beretania Street to Richards Street, and Richards Street makai to Hotel Street; and
- Diamond Head-bound, from Hotel Street makai via Richards Street to Queen Street, Queen Street to Ward Avenue, mauka via Ward Avenue to Kapi‘olani Boulevard and Kapi‘olani Boulevard to an off-street terminal in a Transit Center located near the intersection of Kapi‘olani Boulevard and Atkinson Drive. Returning ‘Ewa-bound via Kapi‘olani Boulevard to Ward Avenue, makai via Ward Avenue to Queen Street, Queen Street to Alakea Street, and Alakea Street mauka to Hotel Street.

By either routing, the distances between the Hotel Street Transit Mall and the Ala Moana Center area primarily via Queen Street, Ward Avenue and Kapi‘olani Boulevard are approximately two and three-tenths (2.3) miles with slight variations in each direction.

With the use of wireless traction power distribution, it would be feasible to construct the Light Rail tracks along curbside lanes throughout its proposed alignment without causing significant damage to the beautiful trees lining these thoroughfares. Because a centrally-located Light Rail median would not be required along

Chapter 10: Potential for Surface-Level Light Rail Alignments in Honolulu

Kapi'olani Boulevard (as assumed in the 1999-era studies), the current practice of deploying traffic cones during weekday peak hours to create “Zipper” lanes for motor vehicles could be continued.

Currently, Kapi'olani Boulevard experiences frequent movements of articulated and conventional buses in both directions on its curbside lanes during peak periods. Because these buses make frequent stops, motorists tend to shun the curb lanes unless they are about to make right-hand turns into cross streets (such Ward Avenue, Pensacola Street and Pi'ikoi Street) or into driveways. Right-hand turns can be accommodated by traffic engineering measures such as shifting the tracks outwards by one lane on the near side of selected intersections, allowing curbside right-hand turn lanes to be created, or through the use of traffic light cycles that preclude right-hand turns across the tracks when a light rail vehicle is present.

Simple stations – similar to those found on Phoenix’s light rail transit system – with low-level platforms, shelters, fare vending and cancelling machines, and informational displays - would be placed near key intersections in locations where they would not interfere with motor vehicle access to adjacent properties.

In both directions, considering destinations and origins within walking distance of stops either of these alignments would serve the Post Office, the Neal Blaisdale Center, the Design Center, Nordstrom’s and numerous office buildings, shops, and residential apartment houses and condominiums, and terminate (at least initially) in a Transit Center on the makai-side of Kapi'olani Boulevard close to its intersection with Atkinson Drive, a location convenient to both the Ala Moana Center and the Honolulu Convention Center.

Summary

With the use of Light Rail technology, the first 20.5 miles of the HHCTC Project can be constructed as follows:

Line Segment	Surface	Elevated	Total
East Kapolei to West Loch	3.2	0.5	3.7
West Loch to Waipahu Transit Center	1.1	None	1.1
Waipahu Transit Center to Pearl Highlands	0.8	1.1	1.9
Pearl Highlands via Airport to Middle Street	0.3	8.7	9.9
Middle Street to Iwilei Road	1.6	0.3	1.9
Iwilei Road to Hotel & Richard Streets	0.6	None	0.6
Hotel & Richards Streets to Ala Moana Center	2.3	None	2.3
TOTALS	9.9	10.6	20.5

Chapter 10: Potential for Surface-Level Light Rail Alignments in Honolulu

As recommended in this report, 25 Light Rail stations would be located along the initial route of the HHCTC Project as follows:

Off-Street Surface	Highway Median	Street Sidewalk	Elevated
East Kapolei	West Loch	Pu'uhale Street	Pearl Highlands
UH West O'ahu	Waipahu (Mokuola)	Kalihi Street	Pearlridge
Ho'opili		Kapalama	Aloha Stadium
Leeward CC		Alakawa Street	Arizona Memorial
Lagoon Drive		Chinatown	Pearl Harbor
Iwilei Road		Hotel & Bishop	HNL Airport
Ala Moana Center		King & Punchbowl (e.b.)	
		Beretania & Miller (w.b.)	
		Kapi'olani & Ward	
		Kapi'olani & Pi'ikoi	

Notes: e.b. assumes Ala Moana Center-bound routing from Hotel Street via Richards Street and South King Street to Kapi'olani Boulevard
w.b. assumes 'Eva-bound routing from Kapi'olani Boulevard and South Street via Alapai Street, South Beretania Street and Richards Street to Hotel Street.

COMPARATIVE IMPACTS OF AN ELEVATED RAILWAY VERSUS LIGHT RAIL IN HONOLULU

Cost/Benefit Tradeoffs

In nearly every category, an elevated railway – such as that proposed for the HHCTC Project - will have greater negative impacts than an at-grade light rail transit system. Advocates of the currently proposed plan argue that the choice is between having an impactful elevated railway or nothing at all. The choice should not be so simply drawn. Using the correct technology, Honolulu can achieve a “best fit” for its fixed guideway transit system.

It would be untrue to argue that speed and efficiency are not worthwhile considerations. Honolulu probably could not have an efficient transit system with positive cost/benefit ratio that would run entirely in mixed traffic throughout the entire First Project, from East Kapolei through Downtown Honolulu to the Ala Moana Center. Schedule speeds high enough to attract discretionary riders to a fixed guideway transit system are unlikely to be achievable from a fully at-grade system running only in mixed traffic conditions.

The alternative proposal advanced in this report is for adoption of a system using Light Rail technology that is capable of running either at-grade or on exclusive right-of-ways and elevated structures where appropriate. The goal of this proposal is to achieve a value-for-money balance between the capital investment required to construct a fixed guideway transit system and its ridership generation potential, the latter being determined largely by its time competitiveness – both from station-to-station and from the potential rider’s point of origin to his or her destination.

The negative impacts of the Elevated Railway would be felt most keenly in the more fragile, more intimate urban environments Diamond Head of Middle Street, such as along Dillingham Boulevard, through Downtown and its waterfront, and bisecting Kaka’ako en route to Ala Moana Center. Future extensions to UH-Manoa and Waikiki also are quite unsuitable for the construction of massive elevated railway viaducts and large aerial stations. The choice of automated light metro-type technology, if perpetuated, will forever prevent the system from coming to grade and operating in an open environment consistent with Honolulu’s urban scale.

In Kapolei and future extension areas, there is no justification for the use of elevated structures. Cost differentials between constructing an elevated railway versus an at-grade Light Rail system and such impacts as storm water runoff and aesthetic impacts have not been adequately addressed in the DEIS. At the current level of land development, and given available rights-of-way, significant cost and impact savings could be realized by the ability to run at-grade in either exclusive, separated rights-of-way or through mixed traffic areas when accessing stops at transit nodes. There is ample opportunity at this stage of development in the ‘Ewa plain for transit-oriented development (TOD) to be designed into new projects in a mutually beneficial way using Light Rail.

In the central portion of the proposed First Project, from West Loch to Middle Street, the level of automobile-oriented development, speed, traffic volume and configuration of roadways, as well as the constrained transit corridor, tend to favor the use of elevated guideways and aerial stations. This will yield the schedule speed necessary for successful operation of the system. The impacts such as shading of guideway, viewshed degradation, column placement conflicts and impacts to historic buildings, trees, etc. are much less in this portion, given the existing conditions, particularly along Kamehameha Highway and through the Honolulu International Airport.

The cost savings of constructing a fixed guideway transit system using the newest light rail transit technology – in particular the potential for deploying a “wireless” system in environmentally-sensitive areas – will also be felt in the preserved ability to add planned future extensions. The high cost and high negative impacts of the currently proposed Elevated Railway may serve to preclude forever the building of any extensions

Aesthetic, Cultural and Environmental

Beautiful trees and plants, views of the ocean, bird life and sparkling sunshine, including the misting liquid sort that provides rainbows, are the natural adornments of Hawai‘i. Extensive concrete viaduct structures and football field-size aerial stations are the antithesis to any semblance of paradise. Honolulu simply cannot afford the disastrous aesthetic impact of a fully elevated transit system, particularly in the downtown and Waikiki areas.

Size of the elevated structures and placement of their support columns and straddle bents has served to constrain the choice of alignment, dictating that the proposed Elevated Railway will run along the waterfront from River Street to Halekauwila Street. Thus, the small scale, harborside entrance to Chinatown at Nu‘uanu Stream will be shadowed by an elevated railway viaduct and each cross street will terminate with a view of makai-side columns and guideway.

In contrast, a Light Rail system would pass through Downtown along Hotel Street, similar to the buses that currently operate there. With the absence of overhead wires, and the much more silent running of the modern light rail vehicles, noise and visual impacts could actually decrease on that street, and in any case, be far less than the negative effects of elevated transit to the urban core. There would be no such impacts to any of the historic or culturally significant buildings or landscape features alongside.

There were enough outcries over the previously proposed placement of the elevated Downtown Station in front of the Aloha Tower that it has been moved to a new location beside the HECO power plant. Unfortunately, however, the new location is directly adjacent to the historic Dillingham Transportation Building. The Dillingham Transportation Building already suffers from being surrounded on three sides by much larger structures; the proposed Elevated Railway will complete the enclosure by obscuring the fourth

façade, and creating a tangle of columns and overhead structure, where Ala Moana Boulevard blends into Nimitz Highway.

In the Ala Moana neighborhood and others, concerns for noise have been continually voiced. The impact will be exacerbated by the elevated position of trains running at the level of adjacent condominiums and will be heard by everyone. Light rail vehicles (LRVs) running at-grade through such close-in areas will have far less noise impact. In point of contrast, Light Rail systems have been noted to be “too quiet.” Because they take some getting used to by pedestrians due to sometimes not being audible within the ambient noise level, LRVs are operated with caution in areas with dense pedestrian movements – such as transit malls – with occasional use of gongs to get the attention of a non-observant person.

Environmental and aesthetic concerns inevitably merge. Halekauwila Street will suffer the loss of its exceptional trees if the current project is constructed. Wherever the elevated alignment goes, it will destroy trees along the right-of-way. The proposed future extension of the Elevated Railway to UH-Manoa along Kapi'olani Boulevard past McCully Street will take down a number of existing trees and the same is true for Waikiki. The DEIS enumerates over 650 tree removals along the First Project alone and is woefully inadequate in its graphic depiction of the result. It is far from clear that the citizens of Honolulu realize, or would accept, the extent to which the proposed Elevated Railway will impact the trees of their city. It also should be kept in mind that the DEIS lists direct tree removals, it does not indicate the many additional trees that will eventually succumb to the ill effects of trauma during the construction period and then shading by the Elevated Railway's guideway structure once it is in place.

Light Rail running along streets at-grade will impact very few trees. It is generally possible to provide modest surface-level stations or stops (in lieu of massive aerial stations) without taking down any trees. A wireless Light Rail system would run beneath the branches of most of the large trees to be encountered in Honolulu in a manner no different than done currently by city buses. Indeed, it could run along streets with existing tree cover by choice, in order to provide cool shade and a pleasingly beautiful experience of Honolulu for visitors and residents as they make their daily trips.

In addition to their natural beauty, the trees of Honolulu provide other vital functions: they provide habitat for birds and other animal life, including endangered species and their canopies help to cool the areas which they shade and to provide transpiration with air cleansing properties. Along with other vegetation, storm water is handled by ground percolation, helping to naturally mitigate critical storm-water runoff impacts.

Sustainability

Energy use mitigation and the inclusion of sustainable features have not been well explored in the engineering for the proposed Elevated Railway. Certainly this would be desirable in a rail transit system for Honolulu, as Hawai'i functions from the standpoint of limited energy production self-sufficiency - wind power is being

gradually incorporated - and solar is mostly limited to residential hot water use.

Examples for the use of wind-power technology can be found in Light Rail, such as the Calgary system, which could be explored for Honolulu.

For segments of some Light Rail systems, notably in Nice, France, battery-powered running is used in environmentally sensitive areas, with re-charging occurring while on the powered portions of the line.

Storm-water handling will be a concern for the Elevated Railway. Handling all runoff on-site for the stations may prove difficult with the size of the concrete structures involved; catchment capability should be investigated, currently no plans seem to indicate retention basins. Runoff from the guideway will cause an impact along the length of the alignment.

In the at-grade portions of its alignment, Light Rail does not significantly alter the environment along the streets. There are no significant increases to storm-water runoff; a small amount may occur from building additional street-side shelters, similar to bus shelters. Rail is laid in the existing street paving and curbing may be re-worked in place, so the volume of runoff is not increased.

Accessibility, Safety and Security

Capable of providing more frequent stops, particularly along Hotel Street, and more direct access to desired work, education and shopping destinations, Light Rail's advantages over an elevated railway system are great. Walking distances between the proposed Elevated Railway's aerial stations and downtown workplaces, shopping destinations such as Chinatown and educational institutions are not convenient, and will result in many potential transit riders making the decision to drive or remain on TheBus.

Readily accessible to police, firefighters and EMS personnel, at-grade stops for Light Rail would also provide much greater visibility for easier surveillance than the more isolated platforms of elevated systems. The necessity of making the vertical transfer, by stair, escalator or elevator, to the platform may be daunting or difficult to a significant percentage of potential riders. Traveling at-grade, Light Rail would provide low-floor, roll-on/roll-off capability for elderly and disabled riders, as well as mothers with strollers and small children. The inclusion of riders with bicycles or surfboards also is more easily accomplished at surface-level Light Rail stations.

Economic and Traffic Impacts

The degradation of aesthetics alone will have an adverse economic impact on Honolulu. The investment in landscaping, street-scaping and building design upgrades expended in Waikiki indicate that a beautiful environment is believed to be advantageous for Honolulu in attracting tourists. The negative aesthetic impact

of an elevated transit system will diminish the beauty of Honolulu relative to competing destinations.

Conversely a “best fit” Light Rail system that avoids the placement of ponderous structural elements in delicate areas, could provide a competitive advantage without the ugliness; increasingly so as the system is extended to Waikiki, enabling easy tourist access to the Convention Center, Ala Moana Center, art museums, the Blaisdell Entertainment Center, Chinatown and the airport.

Wherever an elevated railway is located, it can be expected to have a deteriorating effect on surrounding enterprises. This is one of the primary reasons why there are no other all-elevated systems being planned anywhere in the US, and none having been built in the past 30 years.

In constrained rights-of-way, columns and straddle bents will further constrain access to properties. Areas directly beneath or to the sides of the alignment experience an “under the highway” type environment, with shading, increased storm-water runoff, maintenance issues, homeless encampments and graffiti as possible accompaniments.

Traffic patterns will change if the Elevated Railway is built. Access to businesses may be blocked or negatively altered. Congestion on roadways beneath the guideway may actually increase due to elimination of continuous turning capability and the additional element of “surface friction” that occurs with the introduction of the large support structures to the right-of-way. As along Nimitz Highway, beneath the viaduct of the H1, traffic signalization becomes less readily visible, columns obscure sight lines, street lighting becomes more difficult and the driving environment becomes harsher and more dangerous to pedestrians.

When running on streets, Light Rail does not introduce permanent physical barriers to access; it would have a similar impact as that of several buses traveling in a row, something that occurs now in Honolulu with considerable frequency.

Operation of an automated light metro system on fully grade-separated alignment provides the singular benefit of separation from surface traffic, with no impediment to running times. Particularly during rush hours, the long-distance commuter would be accommodated by an elevated railway running in exclusive right-of-way segments through outlying areas and delivering shorter station-to-station running times. The latter, however, are not the same as origin-to-destination travel times.

Light Rail can provide equivalent running-time characteristics along elevated or exclusive rights-of-way in outlying areas; however, it will operate at reduced speeds when running in the medians of highways, in curbside lanes along city streets, along the Hotel Street Transit Mall, or in mixed traffic. This, however, is desirable in denser, closer-in urban areas, as transportation utility is enhanced by greater frequency of transit stops and delivery closer to ultimate destinations. The more flexible use of Light Rail for shorter trips during the work day around Downtown and to nearby destinations such as Kaka’ako, Ala Moana Center and the

Convention Center, as well as in the future to Mo'ili'ili, UH-Manoa and Waikiki would become feasible and convenient with Light Rail. Light Rail can do this well; an elevated railway using automated light metro technology cannot.

Construction Impacts

Disruptions caused by construction activities, particularly those required for an elevated railway, will add to negative economic outcomes because some businesses may not survive.

Construction duration and add-on impacts will be significant. Elevated railway construction durations per line segment through neighborhoods can be expected to be measured in months and years versus the weeks/months that Light Rail can take once utilities are relocated, if necessary. (Kaka'ako, for instance, may not have extensive in-street utilities requiring relocation. Surface power lines may or may not require relocation for Light Rail; in many blocks this may not be necessary.) The depth required in streets for Light Rail tracks is sufficiently shallow to avoid many utility conflicts.

Construction durations and add-on impacts will be significant. Per line segment, the construction durations of an elevated railway passing through neighborhoods can be expected to be measured in months and years versus the weeks or months that construction of a light rail transit line can take once utilities are relocated. Many local businesses will not be able to survive the anticipated durations and disruptions of the construction activities required for an elevated railway. However, if light rail transit technology were to be adopted with its minimal excavation depth requirements for track and power source installations, Kaka'ako, for instance, potentially not having extensive major in-street utilities requiring relocation, would experience a significantly shorter construction duration. And surface power lines may or may not require relocation for Light Rail installation, again enabling much shorter periods of construction.

Re-routing of traffic would be required for these time periods, impacting access and deliveries to local businesses, residents and existing traffic patterns. This is not a minor concern. Given the constraints of the transit corridor in Honolulu, alternate detour routes for traffic are quite limited.

Construction of an elevated railway also requires significant, large lay-down areas for construction equipment and materials, heavy vehicle traffic (including mobile cranes) for delivery and/or placement of precast guideway segments and other system components, etc., as well as noise and dust impacts from construction of column foundations. Aside from the nuisance imparted, temporary land takings will be required all along the Elevated Railway's alignment; these will be significant and of long duration.

Mitigation of these construction impacts has not been well considered in the DEIS for Honolulu's proposed Elevated Railway project. Needed are: solidly conceived maintenance-of-traffic plans for the neighborhoods through which construction will occur, sample wording for construction contract clauses dealing with staging

and hours of operation, dust and noise mitigation planning clearly defined and contractually required, and business assistance programs clearly defined and committed to by the City and County. These have not been carried forward (such as actually defining alternate traffic routes) at this point, with the result that the community stakeholders cannot adequately assess sufficiency.

Because the Elevated Railway is proposed to be located above Kona Street, which is narrow and very constrained while serving as a major access to Ala Moana Center for automobiles and buses as well as pedestrians, the impacts during construction of the elevated guideway and station can be expected to be of long duration and wide extent. Additionally, the key intersection of Kona and Pi'ikoi Street will also be significantly impacted during construction negatively effecting vehicular access to the Center.

As proposed in this report, Light Rail also would terminate initially at Ala Moana Center but at an off-street terminal near the intersection of Kapi'olani Boulevard and Atkinson Drive. Due to its inherent flexibility, Light Rail will not need to be routed along Kona Street on an elevated structure. Light Rail construction activities would occur along Kapi'olani Boulevard, but be of much smaller duration and magnitude, more akin to those experienced during street curb and pavement replacement and the construction of bus shelters. Properly managed, as occurred during the construction of the Portland Streetcar system, they will occur for limited periods of time, on a block-by-block basis.

TRANSIT-ORIENTED DEVELOPMENT POSSIBILITIES – ELEVATED RAILWAY VERSUS LIGHT RAIL

Introduction

Transit-oriented development or TOD can be defined as compact, mixed-use development near transit within a pedestrian-friendly environment.

In many older, urban locales, such an environment already exists, often the result of transit-centered development from an earlier time. Many cities, including Honolulu, grew around the focus of seaports, then railways, streetcars and other transportation modes.

The American Planning Association (APA), on its website, has defined the modern, planned version of TOD:

“Transit-oriented development results from deliberate planning and code provisions drafted to produce a mix of uses in close proximity to transit that facilitates access to transit.

TOD is intended to:

- *Create active walkable streets*
- *Regulate the intensity of development to support transit*
- *Properly integrate transit into the landscape and within surrounding projects”*

- definition from APA website 2008

The Honolulu City Council has charged the Department of Planning and Permitting (DPP) with producing a TOD ordinance in anticipation of the proposed transit system now under development by the City and County of Honolulu. A “shell” ordinance has been enacted and a program of station area planning is underway, on a neighborhood-by-neighborhood basis, projected to take several years.

Type of Transit System Determines the Type of TOD

Transit-oriented development presents different opportunities when associated with an automated light metro-type elevated railway versus an at-grade light rail transit system. This is directly attributable to the type of technology employed by each system. The City Administration is proposing an almost fully elevated railway utilizing “automated fixed guideway transit system” technology, in which the stations will be elevated above streets, generally within the right-of-way. An alternative under exploration in this report is the use of Light Rail technology in which stops may either be fully at-grade or can be elevated where necessary.

To understand the differences in TOD between elevated railways and light rail transit systems, an understanding of the system characteristics is needed.

Elevated railway systems use a “hot” third rail for traction power distribution, which must be isolated from human, animal and vehicular contact. Thus, this type of railway is either elevated, located below grade in a subway or fenced-in open cut, or runs at-grade along an exclusive, fenced right-of-way (ROW). The system may be a variation of either heavy rail systems, such as San Francisco’s BART or Miami’s Metrorail, or automated light metro systems, such as the Vancouver SkyTrain, which is viewed by CCH as the prototype for Honolulu. All must run in isolated and secured right-of-ways, accessible only at station locations, which are very much separated from their surrounding environments. Except for subways, which would be a prohibitively expensive consideration for Honolulu, both the guideway and stations of elevated railway systems inflict a significant negative impact throughout the surrounding neighborhoods, due to the large structures involved.

TOD Opportunities Occur at Station Locations

This fact drives some of the major differences between transit-oriented development associated with at-grade or elevated systems.

In an elevated railway system, due to their high expense and often-significant land acquisition needs, only a comparatively limited number of rather widely separated elevated stations can be built. Each elevated station for the proposed Elevated Railway will cost in excess of \$20M (twenty million dollars). These stations are, by their nature, separated from their individual neighborhood environments, elevated from 30 to 40 feet or more above grade, and require vertical access by transit riders involving elevators, stairways and escalators.

Since they are infrequently located, each station will need to accommodate a concentrated “delivery” of riders: by bus transfer, automobile parking or drop-off, pedestrian and bicycle access, etc. The station area elements needed to accommodate such a concentration of access requirements take up significant space around each station.

This will be accomplished in two ways: either through careful and neighborhood-sensitive station area planning; or, in the absence of such planning and foresight, through uncontrolled access by riders. The impacts of the latter would include:

- unauthorized parking in surrounding neighborhood streets and business parking lots
- curbside bus drop-off within the existing right-of-way impacting competing traffic
- random kiss-and-ride drop off wherever drivers find space to pull over and drop their passenger(s)
- non-priority access for EMS and other official personnel and vehicles resulting in longer emergency response times

- impeded access for pedestrians, particularly the very old and very young, handicapped or disabled riders.

Other aspects of elevated railway stations that carry negative impacts involve the emphatic aesthetic impact of such structures:

- disruption to the scale of surrounding neighborhoods
- jarring clashes with cultural amenities and landmarks
- introduction of shadowing, noise and vibration at levels that conflict with an attractive ambience

These make for conflicts when development interests attempt to design in context with the locale and yet accommodate transit connectivity. Particularly in Honolulu, elevated rail is deeply at odds with the local aesthetic.

Parking is quite problematic. If the transit system is remiss in not providing sufficient parking to meet the need of initial and future ridership at elevated station locations, spill-over into neighboring commercial and residential areas will occur. Contrary to the idea of forming “shared parking arrangements,” this is not always easy for business to accommodate.

In Honolulu, as in some other places, the issue of homelessness must be taken into account. Large elevated structures create sheltered areas which attract encampment; when this occurs at station areas, surrounding development will be forced to deal with various impacts to cleanliness, access obstruction and negative consumer perception.

Further conflicts and challenges to accomplishing successful, cost-effective TOD are those of environment and sustainability. According to the DEIS, the Elevated Railway and the large elevated stations it requires necessitate the removal of a large number of significant trees – in excess of 650 - and the introduction of immense quantities of concrete for the entire 20 miles-long First Project and eventually more for its proposed extensions. As TOD is attempted, these impacts will be felt. At transit nodes, large trees will be missing – and their cooling shade, landscaping effect and stormwater retention qualities will be difficult if not impossible to replace. Runoff from the elevated guideway and station structures will increase stormwater runoff for surrounding development, which can be a difficult and expensive impact to deal with.

Light Rail and TOD

Light Rail, in contrast, is characterized by at-grade running with more frequent stops. This serves to distribute the advantage of transit access over a greater proportion of the alignment, both distributing the benefit of transit and diluting the impacts of concentration. Transit “nodes” or points of focus at stations or stops, where TOD can occur, can be more flexibly located along a light rail transit system. Transit nodes can occur throughout the at-grade area, including transit stops in places where an elevated station might not be able to be built.

Without the need for large station structures, the area around Light Rail stops presents less complication, less cost and more numerous opportunities for developing attractive TOD components. Retail and commercial buildings can be designed at a more human, neighborhood scale, often incorporating transit shelters (similar to bus shelter design) within the design of the surrounding development or neighborhood. Shared parking may actually become a win-win reality near the smaller capacity, more distributed LRT stops. Landscaping materials will not need to compete with the need for extensive areas of paved surface or blocked sunlight.

Overall, the level of investment that may be required for successful TOD in the immediate station vicinity can be less with light rail transit than elevated railway systems. Particularly in the current economic climate, individual, incremental or phased development at Light Rail stations or stops should be easier to successfully implement than large-scale elaborate mixed-use schemes with parking structures that are often seen as desirable at elevated railway stations.

Transit Flexibility and Expansion as Economic Development Occurs

Adding intermediate stations is very unlikely with an elevated railway system, owing to the difficulty and expense of locating and constructing such large structures and guideway interfaces, whereas Light Rail stops can be readily added in flexible locations when found to be advantageous. The ability to add new stops at locations with good TOD potential is one of Light Rail's tremendous advantages. In Honolulu, areas of high development potential that will be coming on-line in the future, such as Mapunapuna, could be accessed with an at-grade light rail transit system at far less cost and impact than an elevated railway system, enabling both transit's and TOD's full potential to be realized downstream.

And as far as expansion of the fixed guideway transit system to future extensions is concerned, this is relatively easy to accomplish with Light Rail and, again, costly and difficult with an elevated railway.

TOD Success is not Automatic

The availability of transit does not automatically mean that development will occur.

The Miami Metrorail example is indicative of an elevated railway system that has had less than universal success in stimulating adjacent development and redevelopment.

The Martin Luther King and Brownsville stations along 27th Ave have been utter failures with regard to TOD and also ridership generation. The surrounding areas are and have been economically depressed and have continuing safety and security problems. There was great environmental justice rationale for locating stations in those neighborhoods with the clear intention of fostering redevelopment and the provision of work access opportunities. These goals have not been realized and ridership remains low.

Developers have not found reasons to invest in those station areas. Therefore, transit alone will not work miracles for the redevelopment of areas that have little else to offer investors.

Even the Dadeland Stations, adjacent to a top-tier mall (Dadeland) and an affluent population, are only recently experiencing TOD-type investment, and this is after over twenty-five years of system operation. Prior to the building of Metrorail, Dadeland was already an area of concentrated mall development, with already existing nearby residential neighborhoods and business areas, including the large Baptist Hospital complex. It is a heavily automobile-oriented environment, in which many transit riders use the Metrorail park-and-ride facilities, often driving in from further-out residential areas. New transit-oriented residential units are recent developments and are occurring adjacent to transit because it has, at long last, come to be considered a desirable living environment.

In the first case, the 27th Avenue corridor is an economically depressed area with a racially-differentiated population and the Dadeland area is part of a highly concentrated automobile-oriented landscape. Neither presents an ideal location for successful TOD although Dadeland is now experiencing a greater mix of uses owing in part to the presence of rail transit.

Joint Development and Lack of Opportunities in Honolulu

Joint Development (JD) is a specific kind of development that can occur adjacent to transit lines. As a rule, a prerequisite for JD is that real estate is owned by the public entity and made available to private development interests to mutual advantage. Examples include shared parking facilities built on transit-owned land, privately developed transit centers containing transit-supportive retail and commercial components using transit-owned land or buildings, and public/private joint development of mixed use or residential adjacent to transit, including an affordable housing component and business incubator space. The transit agency is involved in the development by making a contribution of land or building(s) through beneficial lease or sale, or can assist with the land assembly needed where small lots have been taken due to transit need.

Other related forms of development are actually “transit-adjacent” private development which may have “joint-use agreements” governing access hours, safety/security operations, and other connectivity issues between the private facility and the transit facility; these, however, do not embody a public investment per se and are not Joint Development.

One of the least favorable implications to either TOD or JD in Honolulu is the decision by the City Administration to avoid land takings for transit, even where it is justifiable from a transit need standpoint. This is exemplified by the unwillingness to take land adjacent to most of the suburban elevated stations for park-and-ride facilities, bus drop off/pick up, kiss and ride drop off/pick up, improved pedestrian and bicycle access and EMS access. Indeed the FTA does not allow gratuitous or excessive land takings; however, land

needed for the station access facilities noted above is an approved justification. In fact, current proposed land takings for Honolulu's Elevated Railway are focused on the minimal requirement to construct elevated guideway and station structures.

With regard to both lessening negative impacts and fostering development around stations, this is very short-sighted on the part of the planners of Honolulu proposed fixed guideway transit system.

Honolulu will be lacking in public real estate offerings with which to jump start TOD. Without the incentive of a publicly provided real estate component, primarily land parcels, private development may not prove feasible around all stations. Even other proffered incentives, such as favorable zoning, FAR bonuses, and tax increment financing, are by no means certain to provide sufficient stimulus to secure the necessary private investment. In the competition for scarce development dollars, areas that are less attractive to developers and their potential customers, both residential and commercial, will not win out over "better" areas, despite the presence of a rail transit line.

Direct Public Investment as a Stimulus for TOD

Government-funded development around transit is never a panacea. Although public investment in transit-supportive infrastructure will give a boost to development, large public projects built at transit nodes may not have the desired result.

As with other types of TOD, scale and fit within the neighborhood are important factors. Government centers and similar complexes may be well-populated during working hours, but not so lively after hours, which may negatively impact existing communities. Unless it can be assured, never an easy task, that a large number of employees will actually take transit to work rather than driving, traffic and parking impacts will also be felt in direct relation to the size of the complex. Aggressive use of programs that provide transit passes and other incentives, shuttle buses interior to large complexes and a resistance to providing extensive parking will be required.

IMPLEMENTATION SCHEDULE AND PROJECT PHASING – ELEVATED RAILWAY VERSUS LIGHT RAIL

Elevated Railway (As Currently Planned)

The City Administration, as stated in the recently-issued RFP for the Core Systems Design-Build-Operate-Maintain Contract (from which the following is quoted directly), plans to deliver the 20 miles-long Minimum Operable Segment in four design and construction segments:

- Segment I – West O‘ahu/Farrington Highway: East Kapolei to Pearl Highlands
- Segment II – Kamehameha Highway: Pearl Highlands to Aloha Stadium (Airport)
- Segment III – Airport Stations: Aloha Stadium to Lagoon Station; and
- Segment IV – City Center: Lagoon Station to Ala Moana Center.

“Segment I is planned to be delivered using the Design-Build delivery method. This section is scheduled to begin construction in December 2009 at the western end of the alignment. The guideway section between the Waipahu and Leeward Community College stations is scheduled to open with limited service in December 2012. The full Segment I section from East Kapolei to Pearl Highlands, as well as the Maintenance and Storage Facility, are scheduled to open in May 2014. [It may be inferred from this statement that a decision has been made to locate the Maintenance and Storage Facility at the LCC site, instead of at the alternate site in Ho‘opili discussed in the DEIS.]

“Segment II from Pearl Highlands to Aloha Stadium is planned to be delivered using the Design-Bid-Build method. This section is scheduled to begin construction in May 2011 and open in January 2017.

“Segment III from Aloha Stadium to Lagoon Station is planned to be delivered using the Design-Bid-Build delivery method. This section is scheduled to begin construction in September 2011 and open in October 2017.

“Segment IV City Center from Lagoon Station to Ala Moana Center, including stations, also is planned to be delivered using the Design-Bid-Build delivery method. This section will begin construction in September 2011 and open in December 2018. While the Middle Street Transit Center Station is included in Segment IV, its opening is scheduled to coincide with the opening of Segment III since it provides a better interim terminus location than the Lagoon station.

“The Core Systems will be designed, constructed and administered under a design-build-operate-maintain (DBOM) contract. All applicable FTA requirements will be incorporated into the DBOM Contract. The maintenance yard/shops and storage facilities, guideway, and stations will be constructed under separate contracts concurrently with the Core Systems Contract.”

This nine-year construction schedule and plan for phasing the Elevated Railway into passenger-carrying service will result in the most important and yet environmentally-sensitive segment of the HHCTC Project – that between the Middle Street Transit Center and Ala Moana Center stations - being the last to open. As a result, the taxpayers of the City and County of Honolulu will be called upon to absorb at least six years (December 2012 to December 2018) of the operations and maintenance (O&M) expenses of the Elevated Railway – even if they are included within the DBOM Contract – with very low ridership levels and marginal fare box revenue.

The Core Systems RFP also states that “Vehicles and systems elements are planned to be manufactured, delivered and installed to meet the specific needs of each segment. A single DBOM contract is planned for all vehicles, train control, communications and traction power, and operations and maintenance for at least ten years following the full operation in 2018.”

Light Rail Alternative

In order to bring the benefits of rail transit to the largest number of potential riders as soon as possible, this report proposes that – with the adoption of Light Rail technology – the HHCTC Project be implemented from east-to-west in the following seven Minimum Operable Segments (MOS's) between Ala Moana Center and East Kapolei:

- MOS-1 – Dillingham Boulevard, Ka‘a‘ahi Street, Iwilei Road, North King Street and Hotel Street Transit Mall: Dillingham Boulevard and Middle Street to Hotel and Richards Streets, terminating temporarily at that location;
- MOS-2 – Hotel and Richards Street to Ala Moana Center either via Richards Street, South King Street / Alapai and South Berentania Streets, and Kapi‘olani Boulevard or via Richards Street / Alakea Street, Queen Street, Ward Avenue and Kapi‘olani Boulevard, terminating at an off-street Transit Center near the intersection of Kapi‘olani Boulevard and Atkinson Drive;
- MOS-3 – Dillingham Boulevard, bridge over Moanalua Stream, private right-of-way and A‘olele Street: Middle Street to Honolulu International Airport;
- MOS-4 – A‘olele Street, private right-of-way adjacent to Nimitz Highway and H-1 Freeway, and Kamehameha Highway: Honolulu International Airport to Aloha Stadium
- MOS-5 – Kamehameha Highway: Aloha Stadium to Pearl Highlands;
- MOS-6 – Kamehameha Highway/H-1 Freeway/Farrington Highway Interchange, private right-of-way through Leeward Community College area, and Farrington Highway: Pearl Highlands to West Loch Station to Ho‘opili Maintenance and Storage Facility); and
- MOS-7 – Farrington Highway and North-South Road: Ho‘opili Maintenance and Storage Facility to East Kapolei.

The civil and structural works, including stations, for each of these MOS segments can be delivered using the Design-Bid-Build delivery method with separate contracts being awarded on a low-bid basis for each line segment. As proposed in the Core Systems RFP, this report also recommends that the systems elements, i.e. rolling stock (light rail vehicles), signals, communications and traction power, would be best delivered via a single Design-Build-Operate-Maintain (DBOM) Contract. However, major interface issues have occurred with some DBOM contracts, in particular due to failure to properly coordinate the design of the maintenance and storage facility with the design of the vehicles, as well as to match wheel and rail profiles, the author of this report recommends in the strongest terms that the scope of the Core Systems DBOM Contract be expanded to include maintenance and storage facilities and system-wide track design and installation.

Changing the vehicle selection of the HHCTC Project from automated light metro technology to more flexible light rail transit technology and re-packaging proposed contracts, as well as preparing a Supplementary Environmental Impact Statement (SEIS) and placing it in circulation for 45 days to receive comments, would delay project implementation by approximately one year from the December 2009 date when the City Administration optimistically hopes to begin construction.

The following construction schedule and commencement of passenger-carrying service is anticipated:

MOS-1: Dillingham Boulevard and Middle Street to Hotel and Richards Streets. Work on this two and one-half (2.5) miles-long segment would begin in January 2011 (after the Christmas shopping period) and would have a thirty-three months duration, including construction of a light maintenance and storage facility at Middle Street on the current DTS Handi-Van parking site. Passenger-carrying service would commence in October 2014, in advance of that year's holiday season.

[Note: Construction of the first three miles-long segment of the Portland Streetcar line began in May 1999; twenty-seven months later, in July 2001, it began carrying passengers.]

MOS-2: Hotel and Richards Streets to Ala Moana Center: Construction of this two and three-tenths (2.3) miles-long segment also would begin in January 2011 but is assumed to require thirty-six months. Passenger-carrying service between Dillingham Boulevard and Middle Street and Ala Moana Center via the Hotel Street Transit Mall would commence in January 2015. By that date four and eight-tenths (4.8) route miles of the Light Rail system would be in service.

MOS-3: Dillingham Boulevard to Honolulu International Airport: Construction of this two and three-tenths (2.3) miles-long line segment, mostly on elevated structure with one elevated and one surface-level station, also would begin in January 2011 but is assumed to require forty-two months to complete and commission. Passenger-carrying service from Honolulu International Airport through Downtown to Ala Moana Center would commence in July 2015. By that date, seven and one-tenth (7.1) route miles of the Light Rail system

would be in service.

MOS-4: Honolulu International Airport to Aloha Stadium: Construction of this three and two-tenths (3.2) miles-long line segment, entirely on elevated structure with three elevated stations, would also begin in January 2011 but is assumed to require forty-eight months to complete and commission. Passenger-carrying service from Aloha Stadium through Honolulu International Airport and Downtown to Ala Moana Center would commence in January 2016; by that date, ten and three-tenths (10.3) route miles of the Light Rail system would be in service.

MOS-5: Aloha Stadium to Pearl Highlands: Construction of this three and sixth-tenths (3.6) miles-long line segment, entirely on elevated structures with two elevated stations, would begin in April 2011 but is assumed to require fifty-four months to complete and commission. Passenger carrying service from Pearl Highlands through Honolulu International Airport and Downtown would commence in October 2016; by that date, thirteen and nine-tenths (13.9) route miles of the Light Rail system would be in service.

MOS-6: Pearl Highlands through the West Loch Station in Waipahu to the recommended Ho'opili Maintenance and Storage Facility (HMSF): Construction of this four and one-half (4.5) miles-long line segment also would begin in April 2011. To be built largely on elevated structures over the Kamehameha Highway/H-1 Freeway/Farrington Highway interchange and along Farrington Highway, as well as with a short surface-level segment in the Leeward Community College area and a longer one from the Waipahu Transit Center through West Loch to the HMSF, construction of this line segment will be complicated and require careful staging. Sixty months are assumed to complete and commission this line segment. Passenger-carrying service from the West Loch Station through Honolulu International Airport and Downtown to Ala Moana Center would commence in April 2017; by that date, sixteen and eight-tenths (16.8) route miles of the Light Rail system would be open to the public.

[One and six-tenths (1.6) miles of completed and commissioned line segment between the Ho'opili Maintenance and Storage Facility would be in operation only for non-revenue train movements pending the commencement of passenger-carrying service on MOS-7)

MOS-7: West Loch to East Kapolei. Construction of this western-most line segment of the First Project, because it will take place largely on undeveloped lands formerly used for agriculture, will be the simplest of the HHCTC Project. Forty-eight months are assumed to be required to complete and commission this two and one-tenth (2.1) miles-long line segment. If construction were to begin in June 2013, this line segment could be carrying passengers by June 2017; by that date the initial twenty and one-half (20.5) miles of the Light Rail system would be both fully operational and collecting revenue to offset a major portion of its O&M expense over its full length.

Comment: Were there a willingness to spend some of the savings that would result from the adoption of

Light Rail technology to do so, the scope of MOS-7 could be extended by up to another five and three-tenths miles (as discussed in Future Extensions) to the proposed West Kapolei Station. In that scenario, sixty months are assumed for completion and commissioning, with construction to begin in June 2012. This earlier start-date would enable passenger-carrying service from West Kapolei through Honolulu International Airport and Downtown to Ala Moana Center also to commence by June 2017; by which date the Light Rail system would be either twenty-four and eight-tenths (24.8) miles-long or twenty-five and eight-tenths (25.8) miles-long, the one-mile difference being the routing chosen through Kapolei.

Conclusion Concerning Implementation Schedule and Project Phasing

Notwithstanding an assumed thirteen-month delay from December 2009 to January 2011 for the beginning of construction on the HHCTC Project, the adoption of Light Rail technology and re-programming its construction and commissioning sequencing from east-to-west, passenger-carrying service can commence over the full length of the rail transit line extending from East Kapolei through Honolulu International Airport and Downtown to Ala Moana Center by June 2017; that date would be approximately eighteen months or a year and one-half earlier than the December 2018 full-service date anticipated for the Elevated Railway.

IMPLEMENTATION COST COMPARISON BETWEEN ELEVATED RAILWAY AND LIGHT RAIL ALTERNATIVES FOR HHCTC PROJECT

A comparison of the probable total capital investment requirements for implementing the HHCTC Project as an elevated railway using automated light metro technology or as a light rail transit system with surface-level alignments where they are feasible and cost-effective is as follows:

Project Segment (From/To)	Amounts in Millions		
	Elevated Railway	Light Rail	Savings
East Kapolei to West Loch	\$1,000	\$ 295	\$ 705
West Loch to Waipahu	\$ 295	\$ 100	\$ 195
Waipahu to Pearl Highlands	\$ 420	\$ 350	\$ 70
Pearl Highlands to Middle Street	\$2,430	\$2,375	\$ 55
Middle Street to Iwilei Road	\$ 515	\$ 200	\$ 315
Iwilei Road to Ala Moana Center	\$ 620	\$ 170	\$ 450
Yard and Shops; Miscellaneous	\$ 120	\$ 120	\$ 0
Total Project Implementation Cost	\$5,400	\$3,610	\$1,790

Estimating Assumptions

All-in construction costs for civil, structural and systems works, as well as general and administrative expenses, of:

- \$10 million for construction of an off-street Transit Center with bus-to-rail transfer facilities at Ala Moana Center;
- \$30 million per mile for single-track surface-level alignments in existing lanes of city streets;
- \$50 million per mile for double-track surface-level alignments in existing lanes of city streets or on currently undeveloped land;
- \$70 million per mile for alignments involving earthen fill embankments;
- \$80 million per mile for alignments involving widening one side of an existing thoroughfare with built-up land uses to create an additional lane;
- \$90 million per mile for surface-level alignments where a median must be created along an existing highway with built-up land uses on both sides of that highway;
- \$100 million per mile for creating a private right-of-way in a redevelopment area with existing land uses that may be retained;
- \$180 million per mile for single-track elevated structures; and
- \$270 million per mile for bridges and/or double-track elevated structures.

Through adopting Light Rail technology for the HHCTC Project and by bringing approximately 52,500 feet or about nine and nine-tenths (9.9) miles of its main line to the surface, including on-street alignments along Dillingham Boulevard and extending through Downtown Honolulu to Ala Moana Center, as well as replacing sixteen or more than two-thirds of its twenty-two massive elevated stations with simple surface-level stations or stops the capital investment required to implement the Project can be reduced in the range of one billion eight hundred million dollars.

FUTURE EXTENSIONS

East Kapolei to West Kapolei

Elevated Railway (As Shown on Pre-EIS Drawings)

In a future phase of its HHCTC Project, CCH/DTS proposed to extend the Elevated Railway from its first-phase (the so-called “First Project”) terminal at the East Kapolei Station to West Kapolei. According to Pre-Draft EIS drawings, it be of 27,800 feet long or slightly less than five and three-tenths (5.3) miles. Its all-elevated alignment would follow North-South Road to Independence Avenue, curve through currently undeveloped property to an alignment above Independence Road, Enterprise Avenue, Saratoga Avenue and Franklin Avenue, continue above Wakea Street to Kapolei Parkway and follow the latter across Kamokila Boulevard to an end-of-track located approximately 2,000 feet beyond Kala’eola Boulevard.

En route from its East Kapolei Station, the West Kapolei Extension would serve four intermediate stations: Kapolei Parkway, Fort Barrette Road, Kala’eola and Kapolei Transit Center, all of which would have high-level side platforms and mezzanines.

Using the same assumptions as those for the First Project, the cost of constructing five and three-tenths (5.3) miles of the Elevated Railway between East Kapolei and West Kapolei would be approximately one billion, four hundred and thirty million dollars (\$1,430,000,000).

Light Rail Alternatives

Two options appear feasible for constructing a Light Rail extension between East Kapolei and West Kapolei. These are:

- Follow the proposed Elevated Railway alignment but construct the Light Rail extension on the surface, serving the same station locations; these would be simple low-level stations like those proposed elsewhere for Light Rail.

The length of this alternative also would be approximately 27,800 feet or about five and three-tenths (5.3) miles. Of this distance, approximately 5,200 feet or about one mile would follow North-South Road; approximately 12,000 feet or about two and three-tenths (2.3) miles would be on newly-created private rights-of-way; and the remaining 10,600 feet or about two miles would follow Wakea Street and Kapolei Boulevard.

- Follow the proposed Elevated Railway’s alignment along North-South road to its intersection with Kapolei Parkway, construct a sweeping right-hand curve through currently undeveloped land (avoiding the

Hawaiian Railway Society's Museum), cross the remnant of the O'ahu Railway, which is protected by its listing on the National Register of Historic Places, and follow the undeveloped 100 feet-wide right-of-way between the O'ahu Railway all the way to the park-and-ride lot beyond Kala'eola Boulevard proposed for the Elevated Railway.

The length of this alternative would be approximately 27,800 feet or about four and three-tenths (4.3) miles. Of this distance, approximately 5,200 feet or about one mile would follow North-South Road; approximately 1,060 feet or about two-tenths (0.2) would be on earthen fill embankments; about 500 feet or one-tenth (0.1) of a mile would be on a bridge; and approximately three (3.0) miles would be on a private right-of-way between the O'ahu Railway and Roosevelt Avenue.

Using the same assumptions as those for the First Project, the cost of constructing a Light Rail extension between East Kapolei and West Kapolei would be approximately four hundred and ten million dollars (\$410,000,000) following the alignment proposed for the Elevated Railway or two hundred and forty million dollars (\$240,000,000) following the one-mile shorter alignment along the O'ahu Railway and Roosevelt Avenue.

Summary: Compared with an extension of the proposed Elevated Railway to West Kapolei, the potential savings are in a range of \$1,020,000,000 and \$1,190,000,000. For discussion purposes in order of magnitude terms, this range can be considered to be from one billion dollars to one billion, two hundred million dollars depending upon whether a shorter or more round-about alignment is adopted between East Kapolei and West Kapolei.

Ala Moana Center to University of Hawai'i-Manoa (UH-Manoa)

Elevated Railway (As Shown on Pre-EIS Drawings)

Worthy of note at the outset is the fact that the elevation of the Ala Moana Center station at approximately 40 feet above the surface of Kona Street, due to the existence of a pedestrian overpass connecting commercial buildings facing Kapi'olani Boulevard within the shopping center, would preclude extension of the HHCTC Project eastwards towards UH-Manoa and/or Waikiki. CCH/DTS propose, as shown on the DEIS drawings, to get around this impediment by future construction of a third track at the intersection of the Queen Street Extension with Waimanu Street. This additional track, connected to the First Project by a trailing point crossover between its main tracks and a facing point turnout on its eastbound track, would rise on a four and eight-tenths percent (4.8%) grade on a new single-track elevated structure to be constructed above Kona Street. The single-track elevated structure would continue eastwards towards an upper level Ala Moana Center station, to be constructed with a center platform serving two tracks at a top-of-rail elevation in excess of 80 feet above Kona Street and about 40 feet above the three-track First Project terminal. When its high-level platforms and their canopies are added, this station - if proven constructible and actually built - would

tower over 90 feet above Kona Street.

Although the future elevated structure would transition from single-track to double track immediately west of the proposed upper level Ala Moana Center station, it would create a 1,000 foot-long “pinch point” on the HHCTC Project. Notwithstanding the ability to turn-back trains towards Downtown at the lower level station, proposed to be built as part of the First Project, the single-track stretch would severely limit capacity for train service running east of Ala Moana Center, either to UH-Manoa or Waikiki or both; most likely, no more than ten trains per hour in each direction would be able to pass through it under the best of operating conditions. Assuredly, it also would be the cause of irregular operations affecting the reliability of the entire Elevated Railway.

This potential fatal flaw to any extension of the Elevated Railway in the Diamond Head-direction having been identified, this report nevertheless will describe its future extensions as proposed by CCH/DTS.

From the upper level platform at the Ala Moana Center Station, the Elevated Railway would begin to descend a four percent (4.0%) grade and cross diagonally through an extended reverse or S-curve from an alignment above Kona Street to the mauka-side of Kapi‘olani Boulevard. This would require the taking of five properties on the makai-side of Kapi‘olani Boulevard near the corner of Kapi‘olani Boulevard, Atkinson Drive and Kona Street, as well as four properties on the mauka-side of Kapi‘olani Boulevard adjacent to Kala‘uokalani Way and on the ‘Ewa-side of the intersection with Kalakaua Avenue.

Continuing Diamond Head along Kapi‘olani Boulevard, the Elevated Railway would have a McCully Station between Pumehana Street and McCully Street, requiring land takings on both sides of Kapi‘olani Boulevard. At Wiliwili Street, the alignment of the double-track Elevated Railway would shift into the center of Kapi‘olani Boulevard, where the support columns for its concrete guideway would be located in the existing tree-lined median.

Approximately 1,500 feet east of McCully Street at Isenberg Street, the Elevated Railway’s guideway would transition from double-track to single-track before curving mauka into University Avenue. The single-track elevated structure would continue through the Date Street Station to a point between Kuilei Street and South King Street where a double-track alignment would be resumed; the length of single track would be approximately 2,500 feet or almost one-half (0.5) a mile. In the vicinity of University Avenue and Ka‘aha Street, the Elevated Railway would begin to ascend a three percent (3.0%) grade, taking its top-of-elevation from approximately thirty feet to approximately sixty feet above University Avenue as it passes over South King Street and enters the Mo‘ili‘ili Station. Departing from the Mo‘ili‘ili Station and continuing to rise slightly, the Elevated Railway would curve sharply to the right to pass over the H-1 Freeway with clearance of approximately twenty feet and enter into an alignment above Lower Campus Road and terminate at its UH-Manoa Station, located in the University’s South Campus, at engineering station 1506+33.

As shown on the Pre-DEIS drawings, this extension would have a length of approximately 10,533 feet long or about two (2.0) miles. As noted above, approximately one-half mile of the alignment of this branch would be on single-track elevated structures with one station (Date Street), with the remaining approximately mile and one-half (1.5) miles with three stations (McCully Street, Mo'ili'ili and UH-Manoa).

The cost of implementing an extension of the Elevated Railway between Ala Moana Center and UH-Moana, including its four elevated stations, would be approximately four hundred and ninety-five million dollars (\$495,000,000).

Light Rail Alternative

A comparable Light Rail Extension from Ala Moana Center to UH-Manoa would commence at the off-street Transit Center, located near the makai-side of Kapi'olani Boulevard near its intersection with Atkinson Drive recommended for the First Project (East Kapolei to Ala Moana Center). It would be desirable for light rail vehicles traveling in both directions to pass through the Ala Moana Center Transit Center, most probably via a looping track arrangement, to facilitate convenient transfers to and from buses, as well as access to the shops and restaurants at Ala Moana and the Honolulu Convention Center.

Continuing Diamond Head from the intersections of Kapi'olani Boulevard with Atkinson Boulevard and Kalakaua Avenue, the Light Rail alignment would be located in curbside lanes in each direction along Kapi'olani Boulevard to McCully Street. Ideally, Light Rail stations would be located on the far-side of this intersection to facilitate the retention of right-hand turn lanes from Kapi'olani Boulevard into McCully Street.

Beyond McCully Street, Kapi'olani Boulevard currently has a divided configuration with a narrow tree-lined median. From this point to University Avenue, the Light Rail alignment could be located either in a widened median or along curbside lanes. After curving on the surface into University Avenue, the Light Rail alignment would follow the curbside lanes of that street mauka. After traversing the intersection of University Avenue and South King Street at-grade, the Light Rail alignment would pass under – not over – the H-1 Freeway, cross Dole Street and terminate in front of the main campus of UH-Manoa in the off-street loop currently used by buses.

The proposed Light Rail alignment between Ala Moana Center and the Main Campus of UH-Moana would be approximately two and one-tenth (2.1) miles long, about 500 feet or about one-tenth (0.1) of a mile longer than the proposed Elevated Railway but would better serve the entire University, as well as the adjacent residential neighborhoods.

The cost of implementing a Light Rail extension between Ala Moana Center and UH- Moana would be approximately one hundred and five million dollars (\$105,000,000).

Summary: Compared to the probable implementation costs of four hundred and ninety-five million dollars (\$495,000,000) for extending the Elevated Railway between Ala Moana Center and UH-Manoa, a comparable Light Rail extension – one that would better serve both the University and the Mo‘ili‘ili neighborhood – would cost approximately one hundred and five million dollars (\$105,000,000). The potential savings for implementing this extension with Light Rail technology are likely to be approximately three hundred and ninety million dollars (\$390,000,000). For discussion purposes, in order of magnitude terms, this can be considered in the range of four hundred million dollars.

Ala Moana Center to Waikiki

Elevated Railway (As Shown on Pre-EIS Drawings)

The Pre-Draft EIS drawings show an even more complicated concept for an extension of the Elevated Railway from Ala Moana Center to Waikiki than that proposed for its extension to UH-Manoa. It would be a primarily single-tracked branch of approximately 8,000 feet or about one and one-half (1.5) miles long, with two short stretches of double-track serving as points where trains traveling in opposite directions would have to meet and pass one another.

A single-track elevated structure, to be used by trains en route to and coming from Waikiki, would begin in the middle of the intersection of Kapi‘olani Boulevard and Kalakaua Avenue. The track to be built on it would be connected to the remainder of the Elevated Railway only by a facing-point turnout from the eastbound track of the UH-Manoa Extension; this arrangement would require bi-directional (two-way) operations or, in railway parlance “wrong rail” running, to allow trains coming from Waikiki to continue towards Ala Moana Center. Approximately 800 feet west of the intersection of Kapi‘olani Boulevard and Kona Street, a scissor crossover between the two main line tracks of the UH-Manoa Extension would be the first point where it would be possible for a train making this low-speed move to enter the normal westbound track before ascending the four percent (4%) grade leading to the planned upper level of the Ala Moana Center Station.

The single-track elevated structure would cross over the Ala Wai Canal and Ala Wai Boulevard on the Diamond Head-side of the Kalakaua Avenue Bridge over the Ala Wai Canal. On the far side of the intersection of Ala Wai Boulevard and Kalakaua Avenue, it would transition into a double-track elevated structure, only to resume a single-track configuration at the intersection of McCully Street and Kalakaua Avenue. In essence, this short stretch of double-tracked structure would provide a passing siding needed to permit bi-directional train operations on the Waikiki Branch.

The single-track elevated structure would then curve from Kalakaua Avenue into Kuhio Avenue in the vicinity of Kuamo‘o Street. From Kuamo‘o Street to Olohana Street, the elevated structure would be constructed above the mauka-side of Kuhio Avenue. At the latter location, the Elevated Railway would enter into another

short stretch of double-track structure that would permit both a second passing siding and the Kala'imoku Street Station to be constructed; the latter would have side platforms and would require land takings on both sides of Kuhio Avenue.

Continuing Diamond Head, the Waikiki Branch of the Elevated Railway would revert to a single-track elevated structure located above the mauka-side of Kuhio Avenue that would end just east of Pao'akalani Avenue. The Lili'u'okalani Avenue Station, to be constructed on the makai-side of Kuhio Avenue, would actually be located above Ohua Avenue on the Diamond Head-side of Lili'u'okalani Avenue.

Viewed as a whole, of its overall length of approximately 8,000 feet or about one and one-half (1.5) miles, the proposed Waikiki Branch of the Elevated Railway would have approximately 6,400 feet or about one and two-tenths (1.2) miles constructed on single-track elevated structure and approximately 1,600 feet or about three-tenths (0.3) of a mile constructed on double-track elevated structures.

Assuming "all-in" construction costs for civil, structural and systems works, including general and administrative expenses, of \$ 180 million per mile for single-track elevated structures with stations and \$270 million per mile for double-track elevated structures with stations, the cost of implementing an extension of the Elevated Railway between the intersection of Kapi'olani Boulevard and Kalakaua Avenue and the end of the line above Kuhio Avenue, the Waikiki Branch, including its two elevated stations, would be approximately two hundred and ninety-five million dollars (\$295,000,000). For discussion purposes, this amount can be considered to be in the range of three hundred million dollars (\$300,000,000).

Calculation: $(1.2 \times \$180M) + (0.3 \times \$270M) = \$297M$; or $\$216M + \$81M = \$297M$, round down to \$295M

Comment: Beyond capital investment-related issues, the author of this report has extremely serious doubts that the proposed Elevated Railway's Waikiki Branch, when considered in conjunction with the proposed UH-Manoa Extension, would be operationally-viable. As discussed above, a section of single-track is proposed on the Downtown and 'Ewa-side of the future high-level Ala Moana Center Station; the UH-Manoa Extension would have two single-track sections along University Avenue; and the Waikiki Branch would have three single-track sections along Kalakaua Avenue and Kuhio Avenue, as well as a need to run bi-directionally on the UH-Manoa-bound track on the Ala Moana Center-side of the intersection of Kapi'olani Boulevard and Kalakaua Avenue. Constructability does not create operational feasibility. Attempting to operate the Elevated Railway with trains running to and from UH-Manoa and Waikiki under operational constraints of this nature, even with full automation, most assuredly can be expected to create unstable operating conditions – especially during peak periods – that would ripple westward all the way to Kapolei and compromise the reliability of the entire rail transit system.

Light Rail Alternative

In the Diamond Head-direction, a Light Rail extension from Ala Moana Center to Waikiki would branch from the UH-Manoa Extension at the intersection of Kapi'olani Boulevard and Kalakaua Avenue; in the Ala Moana Center-direction, light rail vehicles coming from Waikiki would merge at this intersection with those from UH-Manoa.

In order to avoid taking lanes away from motor vehicular traffic using the existing Kalakaua Avenue bridge over the Ala Wai Canal, this report proposes that two single-track bridges – each about 200 feet long and designed to match both the appearance and profile of the existing bridge – be constructed over the canal for the Light Rail extension. On the Waikiki-side of Ala Wai Boulevard, with the benefit of a protecting traffic light phase, the Diamond Head-bound track would be brought to the left-side of the tree-lined median that runs down the center of Kalakaua Avenue and follow it to Kuhio Avenue; the Ala Moana Center-bound track would be located along the curbside lane from Kuhio Avenue to Ala Wai Boulevard, crossing the latter with the benefit of a traffic light phase prohibiting right-hand turns from Ala Wai Boulevard into Kalakaua Avenue while a light rail vehicle is passing through the intersection, to gain access to the inbound Light Rail bridge across the Ala Wai Canal.

Beyond the intersection of Kalakaua Avenue and Kuhio Street, the proposed Light Rail extension to Waikiki would assume a double-track alignment along the curb lanes of Kuhio Avenue. In the Diamond Head-direction, Light Rail would follow Kuhio Avenue as far as Uluniu Avenue, turn right into the center of that street and follow it to Kalakaua Avenue and turn left into the curb lane on the makai-side of that main thoroughfare. Light Rail would continue in this lane for about 2,000 feet to Kapahulu Avenue, where – again with the benefit of a traffic light phase prohibiting right-hand turns with a light rail vehicle is traversing the intersection – it would turn left (mauka) into an unobtrusive off-street terminal (constructed with grass track and simple platforms and shelters) located along the Diamond Head-side of Kapahulu Avenue. In the Ala Moana Center-direction, the Light Rail alignment would turn left from its Waikiki-Honolulu Zoo terminus into Kuhio Avenue and follow it towards Uluniu Avenue, where double-track would resume.

Light Rail stations along Kuhio Avenue would be located out of the main traffic lanes where recessed bus stops currently exist, with the tracks in each direction curving into and out of these recesses. Given the flexibility of Light Rail, Kuhio Avenue - depending upon the wishes of the Waikiki community - could remain open to all forms of motor vehicle traffic, bicycles, etc. or be restricted, for example to buses, taxis and local access to hotels, following the introduction of Light Rail service.

The proposed Light Rail routing, most of which is located along Kuhio Avenue, would provide excellent access to high quality public transit service through the heart of Waikiki for virtually anyone who resides, works or visits there, being located but one block on the makai-side from Kalakaua Avenue and on the mauka-side from Ala Wai Boulevard. It avoids traversing Kalakaua Avenue in the most congested area of Waikiki

while at the same time bringing the Light Rail to a terminal point in close proximity to one of Honolulu's premier attractions – its Zoo – in a manner that would be beneficial to both residents of O'ahu and its visitors.

And most significant, from an environmental perspective, a Light Rail extension to Waikiki would not introduce the blight and degradation that would certainly follow the proposed extension of the Elevated Railway into the heart of Honolulu's world-famous, high-end tourist destination.

As described above, the proposed Light Rail extension to Waikiki would be approximately two (2.0) miles long, consisting of 6,900 feet or about one and three-tenths (1.3) miles of double-track located in existing lanes of city streets (Kalakaua Avenue and Kuhio Avenue); another 5,000 feet or about one (1.0) mile of single-track alignments in existing lanes of city streets (Uluniu Avenue, Kalakaua Avenue and Kuhio Avenue); two single-track bridges over the Ala Wai Canal with a combined length of about one-tenth (0.1) of a mile; and an off-street terminal serving the Honolulu Zoo on the Diamond Head-side of Kapahulu Avenue.

Assuming all-in construction costs for civil, structural and systems works, as well as general and administrative expenses, of \$5 million for construction of an off-street Transit Center with bus-to-rail transfer facilities in Waikiki along the Diamond Head-side of Kapahulu Avenue near the entrance to the Honolulu Zoo; \$30 million per mile for single-track surface-level alignments in existing lanes of city streets; \$50 million per mile for double-track surface-level alignments in existing lanes of city streets; and \$180 million per mile for the two single-track bridges over the Ala Wai Canal, the cost of implementing a Light Rail extension between Ala Moana Center and Waikiki, would be approximately one hundred and twenty million dollars (\$120,000,000).

Calculation: $(1 \times \$5M) + (1.0 \times \$30M) + (1.3 \times \$50M) + (0.1 \times \$180M) = \$118M$; or
 $\$5M + \$30M + \$65M + \$18M = \$118M$, round up to \$120M.

Summary: Compared to the probable implementation costs in the range of three hundred and million dollars (\$300,000,000) for extending the Elevated Railway between Ala Moana Center and Waikiki, a superior Light Rail extension – one that would better serve O'ahu's most important tourism-related venue – would cost approximately one hundred and twenty million dollars (\$120,000,000). The potential savings for implementing this extension with Light Rail technology are likely to be approximately one hundred and eighty million dollars (\$180,000,000).

LONG RANGE POTENTIAL FOR A MORE EXTENSIVE LIGHT RAIL SYSTEM

Adoption of Light Rail technology for the HHCTC Project, unlike the proposed Elevated Railway, would enable its flexibility for use on a wider range of alignments, would open up the possibility for affordable development of a more extensive rail transit system. The potential for future expansion of the Light Rail system – in addition to the West Kapolei, UH-Manoa and Waikiki extensions discussed above – includes:

- West Loch to 'Ewa Beach via Fort Weaver Road;
- Aloha Stadium to Downtown via Salt Lake Boulevard, North King Street and the Hotel Street Transit Mall;
- Hotel Street Transit Mall to UH-Manoa via Richards Street, South King Street (eastbound), South Beretania Street (westbound) and University Avenue; and
- Waipahu Transit Center through Mililani to Wahi'awa, following the right-of-way where possible of the abandoned O'ahu Railway branch to Wahi'awa and Scholfield Barracks through former agricultural lands.

STATION-TO-STATION TRAVEL TIMES – ELEVATED RAILWAY VERSUS LIGHT RAIL

Station-to-Station Travel Times – Elevated Railway versus Light Rail

Adoption of Light Rail technology for the HHCTC Project and bringing approximately nine and nine-tenths (9.9) miles of its twenty and one-half (20.5) miles length to ground level will undeniably have an effect on station-to-station travel times when compared with those proposed for the Elevated Railway. Origin-to-destination travel times, however, are a different matter. As discussed elsewhere in this report, access time from and to points of origin and destination – taking into account walking from or to elevated stations and using escalators, elevators or stairways between platform and street levels – can be an offsetting factor favoring Light Rail in many instances.

For example, the passenger traveling on foot between the Elevated Railway’s Downtown Station, to be located along Nimitz Highway between Bishop and Alakea Streets, would experience an eight-minute walk, including waiting for the pedestrian light cycles at Merchant Street and South King Street, to reach the heart of Downtown Honolulu at Hotel and Bishop Streets.

The following table takes into account both the station-to-station travel times for the Elevated Railway shown in Table 3-15 of the DEIS for the HHCTC Project and comparable estimates factored to reflect the differences in horizontal and vertical alignments for Light Rail, including segments where it is proposed to operate on the surface – either in the median of a roadway, such as along Farrington Highway in Waipahu, or in a curbside environment, such as along Dillingham Boulevard, the Hotel Street Transit Mall and Kapi’olani Boulevard.

Where the Light Rail is concerned, the following maximum operating speeds between stations and station-to-station average speeds can be achieved with good design:

Line Segment for LRT	Maximum Speed	Average Speed
East Kapolei to West Loch	65 MPH	32.5 MPH
West Loch to Waipahu TC	45 MPH	22.5 MPH
Waipahu TC to Pearl Highlands	65 MPH	30.0 MPH
Pearl Highlands to Aloha Stadium	65 MPH	32.5 MPH
Aloha Stadium to Honolulu Intl. Airport	65 MPH	32.5 MPH
Honolulu Intl. Airport to Middle Street	50 MPH	25.0 MPH
Middle Street to Iwilei Road	30 MPH	15.0 MPH
Hotel Street Transit Mall	20 MPH	10.0 MPH
Hotel Street to Ala Moana Center	25 MPH	12.5 MPH

Chapter 17: Station-to-Station Travel Times – Elevated Railway versus Light Rail

Table 15.1 Station-to-Station Travel Times in Minutes – Elevated Railway System versus a Flexible Light Rail System (approximately 9.3 miles at grade, and 11.2 elevated)

Time	EK		UW		HO		WL		WP		LCC		PH		PR		AS		AM		PB	
	ER	LR	ER	LR	ER	LR	ER	LR	ER	LR	ER	LR	ER	LR								
EK			2	2	4	4	8	8	11	12	14	14	14	15	18	19	21	22	23	24	25	26
UW	2	2			2	2	6	6	9	10	11	12	12	13	16	17	19	20	21	22	23	24
HO	4	4	2	2			4	4	7	8	9	10	8	9	14	15	17	18	17	18	21	22
WL	8	8	6	6	4	4			3	4	5	6	6	7	10	11	13	14	14	14	17	18
WP	11	12	9	10	7	8	3	4			2	2	3	3	7	7	10	10	13	13	14	14
LC	13	14	11	12	9	10	5	6	2	2			1	1	5	5	8	8	10	10	12	12
PH	14	15	12	13	10	11	6	7	3	3	1	1			4	4	7	7	9	9	11	11
PR	18	19	16	17	14	15	10	11	7	7	5	5	4	4			3	3	6	5	7	7
AS	21	22	19	20	17	18	13	14	10	10	8	8	7	7	3	3			3	3	4	4
AM	23	23	21	21	19	20	15	16	12	12	10	10	9	9	5	5	2	2			2	2
PB	25	26	23	24	21	22	17	18	14	15	12	12	11	11	7	7	4	4	2	2		
HA	28	29	26	27	24	25	20	21	17	17	15	15	14	14	10	10	7	7	5	5	3	3
LD	30	31	28	29	26	27	22	23	19	19	17	17	16	16	12	12	9	9	7	7	5	5
MS	32	33	30	31	28	29	24	25	21	21	19	19	18	18	14	14	11	11	9	9	7	7
KS	34	36	32	34	30	32	26	28	23	24	21	22	20	21	16	17	13	14	11	12	9	10
KL	36	39	34	37	32	35	28	30	25	27	23	25	22	24	18	20	15	17	13	14	11	13
IR	38	41	36	39	34	37	30	33	27	29	25	27	24	27	20	22	17	19	15	17	13	15
CT	39	43	37	41	35	37	31	35	28	31	26	29	25	29	21	24	18	21	16	19	14	17
DT	40	45	38	43	36	39	32	37	29	33	27	31	26	31	22	26	19	23	17	21	15	19
CC	41	48	39	46	37	42	33	39	30	36	28	34	27	34	22	29	20	26	18	24	16	22
KA	42	51	40	49	38	44	34	42	31	39	29	37	28	36	24	32	21	29	19	27	17	25
AC	44	56	42	54	40	52	36	46	33	44	31	42	30	41	26	37	23	34	21	32	19	30

Time	HA		LD		MS		KS		KL		IR		CT		DT		CC		KKA		AC	
	ER	LR	ER	LR	ER	LR																
EK	28	29	30	31	32	33	34	36	36	39	38	41	39	43	40	45	41	48	42	51	44	56
UW	26	27	28	29	30	31	32	34	34	37	36	39	37	41	38	43	39	46	40	49	42	54
HO	24	25	26	27	28	29	30	32	32	35	34	35	35	39	36	41	37	44	38	47	40	52
WL	20	21	22	23	24	25	26	28	28	31	30	33	31	35	32	37	33	40	34	43	36	48
WP	17	17	19	19	21	21	23	24	25	27	27	29	28	31	29	33	30	36	31	39	33	44
LC	15	15	17	17	19	19	21	22	23	25	25	27	26	29	27	31	28	34	29	37	31	42
PH	14	14	16	16	18	18	20	21	22	24	24	26	25	28	26	30	27	33	28	36	30	41
PR	10	10	12	12	14	14	16	17	18	20	20	22	21	24	22	26	23	29	24	32	26	37
AS	7	7	9	9	11	11	14	15	15	17	17	19	18	21	19	23	20	26	21	29	23	34
AM	5	5	7	7	9	9	12	13	13	15	15	17	16	19	17	21	18	24	19	27	21	32
PB	3	3	5	5	7	7	9	10	11	13	13	15	14	17	15	19	16	22	17	25	19	30
HA			2	2	4	4	6	7	8	10	10	12	11	14	12	16	13	19	14	22	16	27
LD	2	2			2	2	4	5	6	8	8	10	9	12	10	14	11	17	12	20	14	25
MS	4	4	2	2			2	3	4	6	6	8	7	10	8	12	9	15	10	18	12	23
KS	6	7	4	5	2	3			2	3	4	5	5	7	6	9	7	12	8	15	10	20
KL	8	10	6	8	4	6	2	3			2	2	3	4	4	6	5	9	6	12	8	17
IR	10	12	8	10	6	8	4	5	2	2			1	2	2	4	3	7	4	10	6	15
CT	11	14	9	12	7	10	5	7	3	4	1	2			1	2	2	5	3	8	5	13
DT	12	16	10	14	8	12	6	9	4	6	2	4	1	2			1	3	2	6	4	11
CC	13	19	11	17	9	15	7	12	5	9	3	7	2	5	1	3			1	3	3	8
KA	14	22	12	20	10	18	8	15	6	12	4	10	3	8	2	6	1	3			2	5
AC	16	27	14	25	12	23	10	20	8	17	6	15	5	13	4	11	3	8	2	5		

Station Identification Codes

EK=East Kapolei
 PH=Pearl Highlands
 LD=Lagoon Drive
 DT=Downtown
 UW=University of Hawai'i – West Oahu
 PR=Pearlridge
 MS=Middle Street Transit Center

CC=Civic Center
 HO=Ho'opili
 AS=Aloha Stadium
 KS=Kalibi Street
 KA=Kaka'ako
 WL=West Loch
 AM=Arizona Memorial

KL=Kapalama
 AC=Ala Moana Center
 WP=Waipahu Transit Center
 PB=Pearl Harbor Naval Base
 IR=Iwilei Road
 LC=Leeward Community College
 HA=Honolulu International Airport
 CT=Chinatown

Travel Time Codes

ER=Elevated Railway LR=Light Rail

Notes

Station-to-Station travel times include twenty seconds dwell times except at terminals.
 Station-to-Station travel times have been rounded upwards to the nearest minute.

Table 15.1- Station-to-Station Travel Times in Minutes – Elevated Railway versus Light Rail

demonstrates that Light Rail is capable of providing end-to-end travel between East Kapolei and Ala Moana Center in fifty-six minutes, including an allowance of twenty seconds for each of the twenty intermediate station stops. This would be twelve minutes longer than the forty-four minutes end-to-end travel time proposed for the Elevated Railway, which would make the same station stops with the same dwell time. The average speed of Light Rail, including intermediate station stops, would be 21.96 miles per hour; that of the Elevated Railway, including intermediate station stops, would be 27.95 miles per hour.

The lower average speed of Light Rail compared to the Elevated Railway is the direct result of the former having approximately five and six-tenths (5.6) miles of its alignment at-grade in city streets, either in highway medians, curbside lanes, or along the Hotel Street Transit Mall.

Comparatively few passengers will ride end-to-end, regardless of whether Honolulu's rail transit system is the proposed Elevated Railway or Light Rail; the overwhelming majority will board and alight at the intermediate stations or one or the other of the terminal stations. In some cases, the station locations proposed for Light Rail will be more attractive to potential passengers, offering shorter access time (walking origins or destinations). This will result in overall travel time – from origin to destination – being shorter for many passengers with Light Rail than with the Elevated Railway.

For example, a passenger boarding at Waipahu Transit Center whose destination is in Downtown Honolulu in the vicinity of Hotel and Bishop Streets would experience the following depending upon which rail transit mode is chosen for the HHCTC Project:

Light Rail Alternative (As Proposed in this Report)

On-board travel time between Waipahu Transit Center and Hotel and Bishop Streets (Downtown Honolulu): forty-five minutes.

Elevated Railway (As Currently Planned)

On-board travel time between Waipahu Transit Center and Downtown Station (Nimitz Highland and Bishop Street): forty minutes. Plus eight minutes walking time including waiting for pedestrian crossing cycles of traffic lights at Merchant Street and South King Street: eight minutes. Total travel time including access time: forty-eight minutes.

In this example, Light Rail would offer passengers destined for the heart of Honolulu's Central Business District three minutes less total travel time than an Elevated Railway with its station on the periphery of the Downtown area. In other cases, such as for short trips between points on the Diamond Head-side of Downtown Honolulu, the Elevated Railway – by virtue of its full grade-separation – would provide shorter

travel times. In the 'Eva-direction, beyond Middle Street, Light Rail would offer travel times comparable to those of the Elevated Railway or, at most, a minute longer.

This discussion leads to a fundamental question relating to the cost-effectiveness of the HHCTC Project as currently proposed: “How much is a minute less of travel time worth in terms of capital investment?” Light Rail can reduce the capital investment requirements of the First Project substantially, allowing it to be built for less money or allowing a larger rail transit system benefiting a greater percentage of the residents of Honolulu to be built with the same total amount.

Funding for rail transit projects does not come for free; it must be provided at the taxpayer's expense through federal, state and/or local taxes and hence should be expended prudently and wisely, especially so under the current nation-wide economic conditions.

The trade-off before Honolulu – where the choice between an Elevated Railway and Light Rail is concerned – comes down to this:

“Is reducing twelve minutes of end-to-end travel time on a twenty miles-long rail transit project worth spending an additional implementation cost of \$1,800,000,000 or \$150,000,000 per minute?”

CONCLUSION

At this critical junction in development of modern rail transit system to serve the Leeward Side of the Island of O'ahu, Light Rail provides the City and County of Honolulu, as well as its citizens, with an opportunity to obtain a "best fit" that will allow the initial phase of the Honolulu High-Capacity Transit Corridor Project to be implemented at significantly lower cost, in fewer years and with far less adverse environmental impacts. Light Rail can provide the same passenger-carrying capacity as the automated light metro technology. Light Rail, by virtue of its ability to access the very heart of Downtown Honolulu via the Hotel Street Transit Mall, can offer origin-to-destination travel times competitive with the proposed Elevated Railway when walking time to and from elevated stations located along Nimitz Highway is taken into consideration.

By providing better use of and value for limited sources of money, the adoption of Light Rail technology also can facilitate expansion of the rail transit system to West Kapolei, UH-Manoa and Waikiki. In contrast, attempting to proceed with extending the Elevated Railway for an additional nine miles to these areas of Honolulu would add at least an additional \$2.4 billion to its current implementation cost of \$5.4 billion, raising the total cost to \$7.8 billion – in all likelihood to an amount in excess of \$8 billion.

In November 1999, in the Detailed Progress Report to City Council of what was then called the Primary Corridor Transportation Corridor Project, the City Administration's consultants (who continue to work on the HHCTC Project) reported that:

"Rather than considering transit technologies entailing massive and costly elevated structures and tunnels, the Primary Corridor Transportation Project is considering transit alternatives that can occur at-grade and fit within existing transportation rights-of-way. Built at a more human scale, such alternatives can preserve the City's neighborhoods and protect the environment while stimulating growth in desired areas. To meet established needs, mobility is now mixed with livability goals. Within this broader context is recognition that a network of transit-oriented improvements fitting the mobility needs and growth – or non-growth – objectives of each island community is best."

Those observations, pertinent almost a decade ago, are even more pertinent in today. Compared with the Elevated Railway currently being pushed forward by the City Administration in a "rush to judgment" intended to ensure its de facto and non-reversible implementation regardless of public concerns about its advisability, a Light Rail solution is the best way forward for achieving the mobility and livability needs of Honolulu's community at large – residents, businesses and employees, educational institutions and students, entertainment venues and their audiences, hotels and restaurants and their guests, military installations and their personnel, sports centers and their fans, and even tourists on holiday "In Our Island Paradise," all will benefit most from the adoption Light Rail.

"It's the way to go."

Region IX of the U.S. Environmental Protection Agency to Region IX of the Federal Transit Administration,
Subject: Draft Environmental Impact Statement for the Proposed Honolulu High-Capacity Transit Corridor
Project, Oahu, Hawaii (CEQ#20080469), February 12, 2009



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

February 12, 2009

Mr. Ted Matley
U.S. Department of Transportation
Federal Transit Administration
201 Mission Street, Suite 1650
San Francisco, California 94105

Subject: Draft Environmental Impact Statement for the Proposed Honolulu High-Capacity Transit Corridor Project, Oahu, Hawaii (CEQ #20080469)

Dear Mr. Matley:

The Environmental Protection Agency (EPA) has reviewed the above-referenced document pursuant to the National Environmental Policy Act (NEPA), Council on Environmental Quality (CEQ) regulations (40 CFR Parts 1500-1508), and Section 309 of the Clean Air Act. Our detailed comments are enclosed.

While EPA supports the goal of providing transportation choices to the communities of Oahu, we have some concerns related to wetlands, water quality, environmental justice, and noise impacts. EPA has rated this document EC-2, *Environmental Concerns, Insufficient Information*. Please see the attached *Rating Factors* for a description of our rating system.

We are particularly concerned that the Draft Environmental Impact Statement (DEIS) does not contain any quantitative information about the location, acreage, and potential impacts to aquatic resources, hydrology, and waters of the United States in the project area. Impacts to waters of the United States will be subject to Clean Water Act (CWA) Section 404 (b)(1) Guidelines (40 CFR 230). If it is determined that an Individual Permit is required, only the Least Environmentally Damaging Practicable Alternative (LEDPA) can be permitted pursuant to the 404 (b)(1) Guidelines. In addition, without any data regarding potential impacts to hydrologic flows and potential downstream impacts, it is difficult to determine whether significant impacts may occur and what mitigation commitments are needed. EPA recommends that a meeting be scheduled with our wetlands staff and staff of the U.S. Army Corps of Engineers Regulatory Branch to discuss CWA requirements and potential project impacts to hydrology in the area.

We are also concerned that required consultation processes, such as 1) Section 106 consultation for potential impacts to historic and archaeological resources, 2) the water quality assessment associated with the sole source aquifer, and 3) the determination of consistency with the Hawaii Coastal Zone Management Program, have not been completed. These processes should be completed prior to publication of the Final Environmental Impact Statement (FEIS) in order to determine whether or not significant impacts will result. The FEIS should document the specific consultation processes, any additional impacts identified through this coordination, and all resulting mitigation commitments.

Finally, while we believe that most of the alternatives eliminated prior to the DEIS are documented sufficiently, we have remaining questions about why light rail or bus rapid transit in an exclusive right-of-way were not considered as reasonable alternatives in the DEIS. Additional information should be included in the FEIS explaining why these technologies were not considered to be reasonable alternatives and were therefore not reviewed in the DEIS.

We appreciate the opportunity to review this DEIS and look forward to future coordination on the project. When the FEIS is released for public review, please send two copies to the address above (mail code: CED-2). If you have any questions, please contact Connell Dunning, Transportation Team Leader, at 415-947-4161, or Carolyn Mulvihill, the lead reviewer for this project, at 415-947-3554 or mulvihill.carolyn@epa.gov.

Sincerely,



For

Kathleen M. Goforth, Manager
Environmental Review Office (CED-2)

Enclosures:
Summary of EPA Rating Definitions
EPA's Detailed Comments

cc: Wayne Y. Yoshioka, Department of Transportation Services, City and County of Honolulu
Susan Meyer, U.S. Army Corps of Engineers

EPA DETAILED COMMENTS ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR THE PROPOSED HONOLULU HIGH-CAPACITY TRANSIT CORRIDOR PROJECT, FEBRUARY 12, 2009

Alternatives Analysis

EPA recognizes that a significant amount of analysis of alternatives has taken place and has been documented prior to the Draft Environmental Impact Statement (DEIS). While we believe that most of the alternatives eliminated prior to the DEIS are documented sufficiently, we have remaining questions about why light rail or bus rapid transit in an exclusive right-of-way were not considered as reasonable alternatives in the DEIS. The Final Environmental Impact Statement (FEIS) should identify the specific rationale behind the elimination of these technologies from consideration.

Recommendation:

- Include additional information in the FEIS explaining why light rail or bus rapid transit in an exclusive right-of-way were not considered to be reasonable alternatives and were therefore not reviewed in the DEIS. If these technologies may have resulted in fewer environmental impacts, further justification is warranted to substantiate why those less damaging alternatives were not carried through for consideration.

It is also our understanding that modifications to the alignment described in the DEIS are being considered in order to avoid federal facilities in the current project area. These changes and the impacts associated with them should be described in the FEIS, along with the reasons for considered modifications. If significant variations from the analyzed alternatives are proposed, the Federal Transit Administration (FTA) and the Department of Transportation Services (DTS) should consider preparing a Supplemental DEIS for public review. EPA is available to discuss with FTA and DTS the appropriate level of environmental documentation needed should new information be incorporated into the document.

Recommendation:

- Include information in the FEIS about any changes to the proposed alignment and impacts associated with those changes. Consult EPA regarding the appropriate level of documentation.

We understand that the project will eventually include extensions of the proposed project on both ends of the initial segment. However, the extensions to the project were not analyzed in this DEIS. It is critical that selection of the alternative for the initial segment not preclude a reasonable range of alternatives for those future extensions. Given that the proposed project is an elevated structure, there are few remaining alternative sites where the subsequent extension projects can "link" to the project. The extensions should be viewed as reasonably foreseeable future actions and, as such, should be analyzed thoroughly in the cumulative impact analysis. Specifically, what additional

resources of concern will be affected should the proposed action be carried forward and should the proposed extensions be built?

Recommendation:

- Ensure that selection of the alternative for the initial segment will not preclude a reasonable range of alternatives for future extensions. Include an analysis of potential impacts, and mitigation for those impacts, that would occur should the extensions to the project be built. Identify all reasonably foreseeable future actions associated with the placement of the proposed project as well as the impacts to resources from those future actions. Provide any mitigation for these identified cumulative effects.

Wetlands and Waters

In our January 6, 2006 and April 13, 2007 scoping comments, EPA stated that the DEIS should disclose the approximate area of waters of the United States that occur within the study area of the proposed project, including permanent and intermittent streams and wetlands. The Clean Water Act (CWA) Section 404(b)(1) Guidelines at 40 CFR Part 230.10(a) state that "... no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences." While the DEIS states that "no direct impacts to wetlands are expected" (page 4-134), EPA believes that it is likely that the project will have both direct and indirect impacts to waters of the United States. FTA and DTS will have to demonstrate that potential impacts to waters of the United States have been avoided and minimized to the maximum extent practicable prior to obtaining a CWA Section 404 permit (40 CFR 230.10(a) and 230.10(d)). Our scoping comments further recommended that the following information be included in the DEIS, and we reiterate that this information should be included in the FEIS.

We also recommend that DTS meet with EPA wetlands staff and staff of the U.S. Army Corps of Engineers to discuss Section 404(b)(1) requirements. Please contact Wendy Wiltse of EPA's Honolulu office at 808-541-2752 to arrange a meeting.

Recommendations:

- Work with EPA and the Corps to acquire a jurisdictional delineation of waters of the United States and impacts to those waters in the project area.
- Demonstrate that all potential impacts to waters of the United States have been avoided and minimized. If these resources cannot be avoided, clearly demonstrate how cost, logistical, or technological constraints preclude avoidance and minimization of impacts.
- Quantify the benefits from measures and modifications designed to avoid and minimize impacts to water resources; for example, number of stream crossings avoided, acres of waters of the United States avoided, etc.

- Identify all protected resources with special designations and all special aquatic sites¹ and waters within state, local, and federal protected lands. Additional steps should be taken to avoid and minimize impacts to these areas.
- Identify and commit to mitigation for any unavoidable impacts. Include a timeframe for implementation of mitigation commitments along with the responsible party.

Water Quality

The DEIS states that a Water Quality Impact Assessment is underway, as required in areas that depend upon a sole source aquifer for drinking water. The results of this assessment should be included in the FEIS.

The DEIS also states that the project's consistency with the objectives and policies of the Hawaii Coastal Zone Management Program will be reviewed by the Department of Business, Economic Development & Tourism (DBEDT) Office of Planning. This review should be completed and documented in the FEIS.

While we support DTS's plan to implement permanent best management practices (BMPs) to manage stormwater runoff, we do not believe that there is sufficient information in the DEIS to document that the project will have no adverse impacts on water quality due to increased pollutants in stormwater. Additional information is needed in the FEIS to support the conclusion that there will be no adverse impacts to water quality. Where the proposed project will widen existing roads, the current stormwater detention basins and structures should be evaluated to determine if they will continue to be effective. We also recommend the use of green infrastructure as part of stormwater management. Detailed information about green infrastructure approaches is available at <http://cfpub.epa.gov/npdes/greeninfrastructure/technology.cfm>.

The FEIS should also include a discussion of other impacts the project may have on local hydrology, such as sediment transport, groundwater recharge, and flood attenuation, and how these impacts would be minimized or mitigated.

Recommendations:

- Include the results of the sole source aquifer water quality assessment in the FEIS and confirm that no significant impacts will result. Identify specific mitigation measures for any potential impacts.
- Include a discussion of the DBEDT Office of Planning review of the project's consistency with the Coastal Zone Management Program and confirm that the project is consistent with the program.

¹ Special aquatic sites are defined at 40 CFR 230.40 – 230.45 and include wetlands, mud flats, vegetated shallows, coral reefs, and riffle and pool complexes.

- Consider including green infrastructure in the permanent BMPs for stormwater management and document the BMPs in the FEIS.
- Identify the project's impacts on local hydrology, such as sediment transport, groundwater recharge, and flood attenuation in the FEIS rather than waiting to analyze these impacts at a future date. Include specific mitigation commitments in the FEIS and identify how these mitigation actions will reduce impacts to surface hydrology. Include an analysis of potential hydrological impacts due to the reasonably foreseeable future extensions of the proposed project.

Noise Impacts

The DEIS, including the visual impact simulations, indicate that residents in a number of areas may experience significant noise impacts due to the proximity of the project to homes. EPA encourages DTS to consider noise abatement measures not specified in the DEIS, such as noise insulation of receptor sites.

EPA also recommends that particular attention be given to potential noise impacts and mitigation in the vicinity of Pearl Harbor and the USS Arizona Memorial.

Recommendations:

- Consider additional noise abatement measures, such as noise insulation of receptor sites, for residences and other sensitive receptors that would experience noise impacts. Provide quantitative information in the FEIS on the decrease in noise impacts from additional mitigation strategies.
- Provide additional noise mitigation in the vicinity of Pearl Harbor and the USS Arizona Memorial, if necessary to preserve the contemplative nature of the site.

Environmental Justice

EPA previously provided feedback on the environmental justice (EJ) analysis methodology proposed for this project, which was based on the Oahu Metropolitan Planning Organization's method for determining EJ areas. While we believe that the DEIS appropriately identifies EJ areas, we have concerns about the proposed relocation of residents of the Banana Patch community, which is identified in the DEIS as an EJ area of concern. We encourage DTS to choose an alternative alignment that would avoid relocation of this community. If no reasonable avoidance alternative exists, EPA recommends that extensive efforts be made to communicate and consult with the community in planning and implementing the project, and that all past and future consultation activities with this community be documented in the FEIS.

In addition, EPA recommends that additional assistance be provided to any other residents of environmental justice communities who will be relocated.

Recommendations:

- Identify an alternative alignment that would avoid the Banana Patch community and alter the proposed action to accommodate this modification.
- Document the content and outcomes of the community meeting held with the Banana Patch community, as well as any other past or planned communication with the community, in the FEIS.
- Identify and commit to specific mitigation measures to minimize the impacts of relocation on low-income and minority populations.
- Conduct interviews with all potential displacees who have special needs to ensure that issues are fully identified and a plan for assistance is prepared. Based on the results from these interviews, identify and commit to additional measures to minimize the impacts of relocation, such as providing translation services, transportation to visit potential replacement housing, and/or additional relocation specialists to work with these communities.

Section 106 Consultation

The DEIS states that Section 106 consultation is ongoing. The consultation process should be completed prior to release of the FEIS and the process and required mitigation should be documented. This is critical to the determination of whether the project will have significant impacts on historical resources.

Recommendation:

- Complete the Section 106 process and document all related mitigation commitments in the FEIS. Confirm in the FEIS that the Section 106 consultation process included analysis of potential impacts from the reasonably foreseeable future action of the proposed extension of the project. Identify what, if any, additional impacts to historical properties may occur with future extensions of the project.

Invasive Species

EPA's January 6, 2006 and April 13, 2007 scoping comments included recommendations for minimizing the spread of invasive species. The islands of Hawaii are particularly vulnerable to invasive species, and construction associated with the project has the potential to aid in the establishment of invasive plants along any newly disturbed corridors. We reiterate our recommendations below and request that they be addressed in the FEIS.

Recommendations:

- In accordance with Executive Order 13112, identify proposed methods to minimize the spread of invasive species and utilize native plant and tree species where revegetation is planned.

- Coordinate invasive species management with local agencies and organizations, such as the Oahu Invasive Species Committee: a voluntary partnership organized to prevent new invasive species infestations on the island of Oahu, to eradicate incipient invasive species, and to stop established invasive species from spreading on Oahu (<http://www.hear.org/oisc/>).
- Coordinate measures to reduce the potential for the spread of invasive species with other ongoing planning efforts. Additional resources related to Federal and State programs to address invasive species can be found at: <http://www.invasivespeciesinfo.gov/>

Visual Impacts

The DEIS indicates that there may be significant visual impacts resulting from the project. Context sensitive design can be used to mitigate these impacts.

Recommendation:

- Utilize context sensitive design, including neighborhood-based design guidelines and community input, as much as possible to mitigate the project's visual impacts.

Climate Change

Research on global climate change indicates that many coastal areas may be impacted in the future by sea level rise. The IPCC projects that global sea level will rise between 7 and 23 inches by the end of the century (2090–2099) relative to the base period (1980–1999). According to the IPCC, the average rate of sea level rise during the 21st century is very likely to exceed the 1961–2003 average rate. Storm surge levels are also expected to increase due to projected sea level rise. Combined with non-tropical storms, rising sea level extends the zone of impact from storm surge and waves farther inland, and will likely result in increasingly greater coastal erosion and damage.²

Recommendation:

- Include a discussion in the FEIS of the potential impacts of climate change on the proposed project and identify adaptive management strategies to protect the project area from those impacts.

² IPCC, 2007b: Summary for Policymakers. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Notice of Intent to Prepare an Environmental Impact Statement for High-Capacity Transit Improvements in the Leeward Corridor of Honolulu, HI, published in the Federal Register / Vol. 72, No. 50 / Thursday, March 15, 2007 (Pages 12254 to 12257)

[Federal Register: March 15, 2007 (Volume 72, Number 50)] [Notices] [Page 12254-12257] From the Federal Register Online via GPO Access [wais.access.gpo.gov] [DOCID:fr15mr07-124]

DEPARTMENT OF TRANSPORTATION

Federal Transit Administration

Intent To Prepare an Environmental Impact Statement for High- Capacity Transit Improvements in the Leeward Corridor of Honolulu, HI

AGENCY: Federal Transit Administration, DOT.

ACTION: Notice of Intent to prepare an Environmental Impact Statement (EIS).

SUMMARY: The Federal Transit Administration (FTA) and the City and County of Honolulu. Department of Transportation Services (DTS) intend to prepare an EIS on a proposal by the City and County of Honolulu to implement a fixed-guideway transit system in the corridor between Kapolei and the University of Hawai'i at Manoa with a branch to Waik'ik'i. Alternatives proposed to be considered in the draft EIS include No Build and two Fixed Guideway Transit alternatives.

The EIS will be prepared to satisfy the requirements of the National Environmental Policy Act of 1969 (NEPA) and its implementing regulations. The FTA and DTS request public and interagency input on the purpose and need to be addressed by the project, the alternatives to be considered in the EIS, and the environmental and community impacts to be evaluated.

DATES: Scoping Comments Due Date: Written comments on the scope of the NEPA review, including the project's purpose and need, the alternatives to be considered, and the related impacts to be assessed, should be sent to DTS by April 12, 2007. See ADDRESSES below.

Scoping Meetings: Meetings to accept comments on the scope of the EIS will be held on March 28 and 29, 2007 at the locations given in ADDRESSES below. On March 28, 2007, the public scoping meeting will begin at 6:30 p.m. and continue until 9 p.m. or until all who wish to provide oral comments have been given the opportunity. The meeting on March 29, 2007 will begin at 5 p.m. and continue until 8 p.m. or until all who wish to provide oral comments have been given the opportunity.

The locations are accessible to people with disabilities. A court reporter will record oral comments. Forms will be provided on which to submit written comments. Project staff will be available at the meeting to informally discuss the EIS scope and the proposed project.

Governmental agencies will be invited to a separate scoping meeting to be held during business hours. Further project information will be available at the scoping meetings and may also be obtained by calling (808) 566-2299, by downloading from <http://www.honolulutransit.org>, or by e-mailing info@honolulutransit.gov.

ADDRESSES: Written comments on the scope of the EIS, including the project's purpose and need, the alternatives to be considered, and the related impacts to be assessed, should be sent to the Department of Transportation Services, City and County of Honolulu, 650 South King Street, 3rd Floor, Honolulu, HI 96813, Attention: Honolulu High-Capacity Transit Corridor Project, or by the Internet at <http://www.honolulutransit.org>.

The scoping meetings will be held at Kapolei Hale at 1000 Uluohia Street, Kapolei, HI 96707 on March 28, 2007 from 6:30 p.m. to 9 p.m. and at McKinley High School at 1039 South King Street, Honolulu, HI 9814 on March 29, 2007 from 5 p.m. to 8 p.m.

FOR FURTHER INFORMATION CONTACT: Ms. Donna Turchie, Federal Transit Administration, Region IX, 201 Mission Street, Room 1650, San Francisco, CA 94105, Phone: (415) 744-2737, Fax: (415) 744-2726.

SUPPLEMENTARY INFORMATION:

I. Background

On December 7, 2005, FTA and DTS issued a notice of intent to prepare an Alternatives analysis followed by a separate EIS. The TS has now completed the planning alternatives analysis and, together with FTA, is proceeding with the NEPA review initiated through this scoping notice.

The planning Alternatives analysis, conducted in accordance with 49 United States Code (U.S.C.) 5309 as amended by the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) (Pub. L. 109-59, 119 Stat. 1144), evaluated transit alternatives in the corridor from Kapolei to the University of Hawai'i at Manoa and to Waik'ik'i. Four alternatives were studied, including No build, Transportation system Management, Bus operating in a Managed Lane, and Fixed Guideway Transit. Fixed Guideway Transit was selected as the Locally Preferred Alternative. The planning Alternatives Analysis is available on the project's Web site at <http://www.honolulutransit.org>.

The Honolulu City Council has established a fixed-guideway transit system connecting Kapolei and University of Hawai'i at Manoa, with a branch to Waik'ik'i, as the locally preferred alternative. The O'ahu Metropolitan Planning Organization (OMPO) has included construction of rail transit system between Kapolei and the University of Hawai'i at Manoa and Waik'ik'i in the 2030 O'ahu Regional Transportation Plan, April 2006.

II. Scoping

The FTA and DTS invite all interested individuals and organizations, and Federal, State, and local governmental agencies and Native Hawaiian organizations, to comment on the project's purpose and need, the alternatives to be considered in the EIS, and the impacts to be evaluated. During the scoping process, comments on the proposed statement of purpose and need should address its completeness and adequacy. Comments on the alternatives should propose alternatives that would satisfy the purpose and need at less cost or with greater effectiveness or less environmental or community impact and were not previously studied and eliminated for good cause. At this time, comments should focus on the scope of the NEPA review and should not state a preference for a particular

alternative. The best opportunity for that type of input will be after the release of the draft EIS.

Following the scoping process, public outreach activities with interested parties or groups will continue throughout the duration of work on the EIS. The project Web site, <http://www.honolulutransit.org>, will be updated periodically to reflect the status of the project.

Additional Opportunities for public participation will be announced through mailings, notices, advertisements, and press releases. Those wishing to be placed on the project mailing list may do so by registering on the Web site at <http://www.honolulutransit.org>, or by calling (808) 566-2299.

III. Description of Study Area

The proposed project study area is the travel corridor between Kapolei and the University of Hawai'i at Manoa (UH Manoa) and Waik'ik'i. This narrow, linear corridor is confined by the Wai'anae and Ko'olau mountain ranges to the north (mauka direction) and the ocean to the south (makai direction). The corridor includes the majority of housing and employment on O'ahu. The 2000 census indicates that 876,200 people live on O'ahu. Of this number, over 552,000 people, or 63 percent, live within the corridor between Kapolei and Manoa/Waik'ik'i. This area is projected to absorb 69 percent of the population growth projected to occur on O'ahu between 2000 and 2030, resulting in an expected corridor population of 776,000 by 2030. Over the next twenty-three years, the 'Ewa/Kapolei area is projected to have the highest rate of housing and employment growth on O'ahu. The 'Ewa/Kapolei area is developing as a "second city" to complement downtown Honolulu. The housing and employment growth in 'Ewa is identified in the General Plan for the City and County of Honolulu.

IV. Purpose and Need

The purpose of the Honolulu High-Capacity Transit Corridor Project is to provide high-capacity, high-speed transit in the highly congested east-west transportation corridor between Kapolei and the University of Hawai'i at Manoa, as specified in the 2030 O'ahu Regional Transportation Plan (ORTP). The project is intended to provide faster, more reliable public transportation services in the corridor than those currently operating in mixed-flow traffic, to provide basic mobility in areas of the corridor where people of limited income live, and to serve rapidly developing areas of the corridor. The project would also provide an alternative to provide automobile travel and improve transit linkages within the corridor. Implementation of the project, in conjunction with other improvements included in the ORTP, would moderate anticipated traffic congestion in the corridor. The project also supports the goals of the O'ahu General Plan and the ORTP by serving areas designated for urban growth.

The existing transportation infrastructure in the corridor between Kapolei and UH Manoa is overburdened handling current levels of travel demand. Motorists and transit users experience substantial traffic congestion and delay at most times of the day, both on weekdays and on weekends. Average weekly peak-period speeds on the H-1 Freeway are currently less than 20 mph in many places and will degrade even further by 2030. Transit vehicles are caught in the same congestion.

Travelers on O'ahu's roadways currently experience 51,000 vehicle hours of delay, a measure of how much time is lost daily by travelers stuck in traffic, on a typical weekday. This measure of delay is projected to increase to more than 71,000 daily vehicle hours of delay by 2030, assuming implementation of all the planned improvements listed in the ORTP (except for a fixed guideway system). Without these improvements, ORTP indicates that daily vehicle-hours of delay could increase to as much as 326,000 vehicle hours.

Currently, motorists traveling from West O'ahu to Downtown **Honolulu** experience highly congested traffic conditions during the a.m. peak period. By 2030, after including all of the planned roadway improvements in the ORTP, the level of congestion and travel time are projected to increase further. Average bus speeds in the corridor have been decreasing steadily as congestion has increased. "TheBus" travel times are projected to increase substantially through 2030. Within the urban core, most major arterial streets will experience increasing peak-period congestion, including Ala Moana Boulevard, Dillingham Boulevard, Kalakaua Avenue, Kapi'olani Boulevard, King Street, and Nimitz Highway. Expansion of the roadway system between Kapolei and UH Manoa is constrained by physical barriers and by dense urban neighborhoods that abut many existing roadways. Given the current and increasing levels of congestion, a need exists to offer an alternative way to travel within the corridor independent of current and projected highway congestion.

As roadways become more congested, they become more susceptible to substantial delays caused by incidents, such as traffic accidents or heavy rain. Even a single driver unexpectedly braking can have a ripple effect delaying hundreds of cars. Because of the operating conditions in the study corridor, current travel times are not reliable for either transit or automobile trips. To get to their destination on time, travelers must allow extra time in their schedules to account for the uncertainty of travel time. This lack of predictability is inefficient and results in lost productivity. Because the bus system primarily operates in mixed-traffic, transit users experience the same level of travel time uncertainty as automobile users. A need exists to reduce transit travel times and provide a more reliable transit system.

Consistent with the General Plan for the City and County of **Honolulu**, the highest population growth rates for the island are projected in the 'Ewa Development Plan area (comprised of the 'Ewa, Kapolei and Makakilo communities), which is expected to grow by 170 percent between 2000 and 2030. This growth represents nearly 50 percent of the total growth projected for the entire island. The more rural areas of Wai'anae, Wahiawa, North Shore, Waimanalo, and East **Honolulu** will have lower population growth of between zero and 16 percent if infrastructure policies support the planned growth in the 'Ewa Development Plan area. Kapolei, which is developing as a "second city" to Downtown **Honolulu**, is projected to grow by nearly 600 percent to 81,100 people, the 'Ewa neighborhood by 100 percent, and Makakilo by 125 percent between 2000 and 2030. Accessibility to the overall 'Ewa Development Plan area is currently severely impaired by the congested roadway network, which will only get worse in the future. This area is less likely to develop as planned unless it is accessible to Downtown and other parts of O'ahu; therefore, the 'Ewa, Kapolei, and Makakilo area needs improved accessibility to support its future growth as planned.

Many lower-income and minority workers live in the corridor outside of the urban core and commute to work in the Primary Urban Center Development Plan area. Many lower-income workers also rely on transit because of its affordability. In addition, daily parking costs in Downtown **Honolulu** are among the highest in the United States, further limiting this population's access to Downtown. Improvements to transit capacity and reliability will serve all transportation system users, including moderate- and low-income populations.

V. Alternatives

The alternatives proposed for evaluation in the EIS were developed through a planning Alternatives Analysis that resulted in selection of a Fixed Guideway Transit Alternative as the locally preferred alternative (LPA). FTA and DTS propose to consider the following alternatives:

Future No Build Alternative, which would include existing transit and highway facilities and planned transportation projects (excluding the proposed project) anticipated to be operational by the year 2030. Bus service levels consistent with existing transit service policies is assumed for all areas within the project corridor under the Future No Build Alternative.

Fixed Guideway Alternatives, which would include the construction and operation of a fixed guideway transit system in the corridor between Kapolei and UH Manoa with a branch to Waik'ik'i. The draft EIS would consider five distinct transit technologies: Light rail transit, rapid rail transit, rubber-tired guided vehicles, a magnetic levitation system, and a monorail system.

Comments on reducing the range of technologies under consideration are encouraged. The draft EIS also would consider two alignment alternatives. Both alignment alternatives would operate, for the most part, on a transit-guideway structure elevated above the roadway, with some sections at grade. Both alignment alternatives generally follow the route: North-South Road to Farrington Highway/Kamehameha Highway to Salt Lake Boulevard to Dillingham Boulevard to Nimitz Highway/ Halekauwila Street. Both alignment alternatives would have a future extension from downtown **Honolulu** to UH Manoa with a future branch to Waik'ik'i, and a future extension at the Waianae (western) end to Kalaeloa Boulevard in Kapolei. The second alignment alternative would have an additional loop created by a fork in the alignment at Aloha Stadium to serve **Honolulu** International Airport that rejoins the main alignment in the vicinity of the Middle Street Transit Center. The first construction phase for either of the Fixed Guideway Alternatives is currently expected to begin in the vicinity of the planned University of Hawai'i West O'ahu campus and extend to Ala Moana Center via Salt Lake Boulevard. The Build alternatives also include the construction of a vehicle maintenance facility, transit stations and ancillary facilities such as park-and-ride lots and traction-power substations, and the modification and expansion of bus service to maximize overall efficiency of transit operation.

Other reasonable alternatives suggested during the scoping process may be added if they were not previously evaluated and eliminated for good cause on the basis of the Alternatives Analysis and are consistent with the project's purpose and need. The planning Alternatives Analysis is available for public and agency review on the project

Web site at <http://www.honolulutransit.org>. It is also available for inspection at the project office by calling (808) 566-2299 or by e-mailing info@honolulutransit.org.

VI. Probable Effects

The EIS will evaluate and fully disclose the environmental consequences of the construction and operation of a fixed guideway transit system on O'ahu. The EIS will evaluate the impacts of all reasonable alternatives on land use, zoning, residential and business displacements, parklands, economic development, community disruptions, environmental justice, aesthetics, noise, wildlife, vegetation, endangered species, farmland, water quality, wetlands, waterways, floodplains, hazardous waste materials, and cultural, historic, and archaeological resources. To ensure that all significant issues related to this proposed action are identified and addressed, scoping comments and suggestions on more specific issues of environmental or community impact are invited from all interested parties. Comments and questions should be directed to the DTS as noted in the ADDRESSES section above.

VII. FTA Procedures

The EIS will be prepared in accordance with the National Environmental Policy Act of 1969 (NEPA), as amended, and its implementing regulations by the Council on Environmental Quality (CEQ) (40 CFR parts 1500-1508) and by the FTA and Federal Highway Administration ("Environmental Impact and Related Procedures" at 23 CFR part 771). In accordance with FTA regulation and policy, the NEPA process will also address the requirements of other applicable environmental laws, regulations, and executive orders, including, but not limited to: Federal transit laws [49 U.S.C. 5301(e), 5323(b), and 5324(b)], Section 106 of the National Historic Preservation Act, Section 4(f) ("Protection of Public Lands") of the U.S. Department of Transportation Act (49 U.S.C. 303), Section 7 of the Endangered Species Act, and the Executive Orders on Environmental Justice, Floodplain Management, and Protection of Wetlands.

Dated: March 12, 2007.

Leslie T. Rogers, Regional Administrator.

[FR Doc. 07-1237 Filed 3-14-07; 8:45 am] BILLING CODE 4910-57-M

LIGHT RAIL DESIGN CRITERIA SUITABLE FOR HONOLULU

General Light Rail Transit (LRT) System Characteristics

The following design criteria have been drawn from that prepared for CCH/DTS by its consultants and released by CCH with a Request of Information (RFI) from potential fixed guideway suppliers. That solicitation was accompanied by a First Project Systems Characteristics Information Package that limited acceptable technology offerings to those with third rail traction power distribution (no Overhead Contact System), stations with high-level platforms, and fully automatic train operation. Results of that solicitation were made public by on January 29, 2009.

While based in large measure on the City's RFI, its requirements have been modified and supplemented in this report to reflect those of a light rail transit system – as distinct from an automated light metro – with the capability of operating on surface-level alignments, as well as on private rights-of-way and elevated structures.

Route Length

- Minimum Operating Segment (MOS) or First Project (East Kapolei to Ala Moana Center) – approximately 20.5 miles
- Future Extensions – (West Kapolei, UH-Manoa, Waikiki, etc.) – to be determined but approximately nine miles of additional LRT routes

Line Capacity

- Initial requirement – 8,100 passengers per hour per direction (pphpd)
- Long-term growth capability (contingency) – 12,150 passengers per hour per direction (pphpd) between Kapolei and Downtown Honolulu

Minimum headway

- Initial requirement – 3 minutes
- Future requirements
 - Kapolei to Downtown Honolulu – 2 minutes
 - Downtown Honolulu to Ala Moana Center – 3 minutes

Hours of Operation

- Mondays through Thursdays – 4:00 AM to 12:00 Midnight (first Ala Moana Center-bound departure from

- East Kapolei and last East Kapolei-bound departure from Downtown Honolulu)
- Fridays, Saturdays and Minor Holidays – 4:00 AM to 2:00 AM (first Ala Moana Center-bound departure from East Kapolei and last East Kapolei-bound departure from Downtown Honolulu)
- 6:00 AM to 9:00 AM weekday morning peak period (Ala Moana Center-bound arrivals in Downtown Honolulu)
- 3:00 PM to 6:00 PM weekday afternoon peak period (East Kapolei-bound departures from Downtown Honolulu)
- Sundays and Major Holidays – 6:00 AM to 12:00 Midnight (first Ala Moana-bound departure from East Kapolei and last East Kapolei-bound departure from Downtown Honolulu bound)

Average Speed

- Twenty miles per hour (20 mph) minimum for full length of the First Project, with desired end-to-end trip time of no more than one hour – preferably 50 minutes – making all stops with a 20-second dwell time at each station; East Kapolei to Downtown Honolulu to be achieved within 35 minutes (30 mph average speed)

Alignment

- Mixture of exclusive private right-of-way, fenced-in private right-of-way, open private right-of-way, elevated structures, roadway medians, reserved transit-only lanes in streets and malls, and mixed traffic lanes in streets, as determined by public policy decisions and site specific requirements

Rolling Stock

- Light rail vehicles capable of operating on all of the alignment options listed above and as described below

Station Spacing

- Approximately one-mile average but varying between two miles and one-quarter mile depending upon route, activity centers and site specific requirements.

Fare Collection

- Self-service Proof-of-Payment (POP) system with random fare media/ticket collection; transit system passes and date/time limited passes as valid fare media
- Ticket vending machines and ticket validators located in at all stations

Infrastructure

Station Types

- Surface Alignments – side or center low-level platforms equipped with simple shelters, ticket vending and canceling machines, informational displays, communications equipment, and lighting
- Elevated Alignments – side or center low-level platforms equipped with canopies, ticket vending and canceling machines, informational displays, communications equipment, and lighting. Access to / egress from elevated stations required to both sides of streets or highways over which elevated alignments are constructed. Elevators, escalators and stairways required between street level and mezzanines and between mezzanines and platforms.

Guideway

- Double-tracked on private rights-of-way, elevated structures, medians, transit-only malls.
- Double-tracked or single-tracked in transit-only lanes or in mixed traffic lanes dependent upon site-specific requirements, including location on one-way streets.
- Standard gauge (4'-8½" or 1435mm) track.

Right-of-Way Types/Maximum Allowable Speeds

- Completely exclusive surface-level private rights-of-way – 65 mph wherever achievable within geometric constraints
- Fenced-in surface-level private rights-of-way – 65 mph wherever achievable within geometric constraints
- Elevated structures – 65 mph wherever achievable within geometric constraints
- Open private rights-of-way with protected level crossings of intersecting streets – 45 mph
- Roadway medians with protected level crossings of intersecting streets – 45 mph or posted speed limits for motor vehicles, whichever is lower
- Transit-only malls with open pedestrian access – 20 miles per hour
- Transit-only lanes along public streets – 30 mph or posted speed limits for motor vehicles, which ever is lower
- Mixed traffic lanes 30 mph or posted speed limits for motor vehicles, which ever is lower

Route Geometric Constraints

- Minimum Horizontal Track Radii:
 - Exclusive, Fence-In or Open Private Rights-of-Way – 400 feet
 - Elevated Structures – 400 Feet
 - Maintenance and Storage Facilities – Preferably 150 feet where achievable but not less than 100 feet

- Medians – Preferably 125 feet where achievable but not less than 100 feet if required by roadway alignment
- Existing Transit-Only Malls – As required by existing alignments but not less than 60 feet
- New Transit Malls – Preferably 125 feet if compatible with other design elements but not less than 60 feet
- Transit-Only Lanes in Streets – Preferably 100 feet if compatible with other requirements but not less than 60 feet
- Mixed Traffic Lanes in Streets – Preferably 82 feet but not less than 60 feet where slow-speed right-hand or left hand turns are required

Note: Seventy percent (70%) low-floor light rail vehicles built for in use in the United States that can negotiate horizontal radius curves as low as 42 feet (AnsaldoBreda- built cars in service on the Massachusetts Bay Transportation Authority's Green Line system). Similar low-floor LRVs in service on New Jersey Transit's Newark City Subway (built by Kinki-Sharyo) were designed for 59-foot minimum radius curves and negotiate a 61-foot radius at Newark's Pennsylvania Station. Other manufacturers have delivered LRVs designed to negotiate minimum radius curves of 82 feet for use on numerous "new start" North American light rail transit systems. One hundred percent (100 %) low-floor light rail vehicles designed to negotiate minimum radius curves of 18 meters (59 feet) or less are in use throughout Europe and in some Asian cities.

Minimum Horizontal Track Lengths

- Private rights-of-way and elevated structures
 - Curves – 100 feet
 - Tangents – 100 feet
 - Spirals – 100 feet
- Maintenance and Storage Facilities
 - Curves – As required by site-specific conditions
 - Tangents – As required by site-specific conditions but not less than 20 feet
 - Spirals – Preferably 100 feet but down to a minimum of 20 feet if required by site-specific conditions
- Medians, transit malls, transit-only lanes and mixed traffic lanes in public streets:
 - Curves – As required by existing roadway alignments
 - Tangents – As required by existing alignments but not less than 20 feet where reverse curves (S curves) are required
 - Spirals – Preferably 100 feet but down to a minimum of 20 feet if required by existing roadway alignments

Vertical Alignments

- Maximum gradient on private rights-of-way and elevated structures – six percent (6%)
- Maximum gradient on medians, transit malls, transit-only lanes and mixed traffic lanes in public streets – Preferably eight percent (8%) but up to ten percent (10%) if required to match an existing roadway gradient for a short distance
- Maximum gradient at station platforms located on private rights-of-way and elevated structures – one percent (1 %)
- Maximum gradient at station platforms located on medians, transit malls, transit-only lanes and mixed traffic lanes in public streets – Preferably two percent (2%) but up to five percent (5%) if required to match an existing roadway gradient
- Zero gradient mandatory in maintenance and storage facilities (with the exception of lead (entry and exit) tracks upon which unmanned trains or cars will not be parked, stabled or subject to any form of maintenance activity

Diverging/Converging/Crossing Requirements

- Private rights-of-way and elevated structures – minimum turnout equivalent to AREMA No. 10 (25 mph capability) for diverging and converging track switches
- Maintenance facilities and storage yards – minimum turnout equivalent to AREMA No. 6 (12 mph capability) for diverging and converging track switches
- Paved tracks using grooved (girder) rails located in transit malls and streets – in accordance with APTA Trackway Infrastructure Guidelines for Light Rail Circulator Systems (See Appendix A-5 to this report.)
- Track crossings (diamonds) shall be fixed, i.e. without moveable rails or other components

Station Dimensions

- Platform heights – 13.8 inches (350mm) above top-of-rail elevation at all locations
- Platform lengths at all locations:
 - Initial requirement – 240 feet; and
 - Future expansion capability – 300 feet.
- Center platform widths at stations located on private rights-of-way and elevated structures:
 - Desirable minimum (including adequate provisions for elevators, escalators and stairways) – 30 feet
 - Absolute minimum (with constrained provisions for elevators, escalators and stairways) – 24 feet
- Side Platform widths at stations located on private rights-of-way and elevated structures
 - Desirable minimum (including adequate provisions for elevators, escalators and stairways) – 20 feet; and
 - Absolute minimum (with constrained provisions for elevators, escalators and stairways) – 12 feet
- Platform edge screen doors at stations located on private rights-of-way and elevated structures:
 - Mandatory with full automated train operations or where traction power distribution is by energized third rails; or

- Optional with manually-controlled train operations or where traction power distribution is by catenary, trolley wire or third rail that is energized only when under a moving or stationary light rail vehicle or consist.
- Mezzanine widths at stations located on elevated structures located above streets, highways or other public thoroughfares:
 - Of sufficient width to allow all vertical access elements (escalators, elevators and stairways to be located at least with four feet clearance from any street curb or other fixed object other than a building;
 - Of a width that will allow all vertical access elements (escalators, elevators and stairways to be located at least with ten feet clearance from the face of any building; and
 - Of a width that will allow a sidewalk of at least six feet width between any vertical access element (escalators, elevators and stairways to be and the face of any building or permanent object that cannot be negotiated around via a direct route by either an able-bodied person on foot or a wheelchair user.

Platform widths of stations located on medians of streets, highways or other thoroughfares:

- Center platforms (serving two tracks)
 - If designed with access or egress in a grade-separated manner by elevators, elevators and/or stairways leading from an overhead mezzanine or footbridge – 24 feet absolute minimum.
 - If designed with access or egress through end loading/egress via a traffic light-protected crosswalk or crosswalks – 16 feet absolute minimum.
- Side platforms (serving a single track)
 - If designed with access or egress in a grade-separated manner by elevators, elevators and/or stairways leading from an overhead mezzanine or footbridge – 16 feet absolute minimum
 - If designed with access or egress through end loading/egress via a traffic light-protected crosswalk or crosswalks – 12 feet absolute minimum

Platform widths of stations located in transit malls and along transit-only lanes or in mixed traffic lanes of public streets

- Center platforms (serving two tracks)
 - If designed with access or egress in a grade-separated manner by elevators, elevators and/or stairways leading from an overhead mezzanine or footbridge – 24 feet absolute minimum
 - If located with access or egress through end loading/egress via a traffic light-protected crosswalk or crosswalks – 16 feet absolute minimum
- Side platforms (serving a single track)
 - If located along a sidewalk – Preferably 12 feet to allow for a shelter from sunshine and rain and for the placement of fare vending equipment but 8 feet as absolute minimum to provide both holding space for passengers and the movement of pedestrians, persons with wheelchair and other users of the public way requiring unimpeded passage

- If designed with access or egress through end loading/egress via a traffic light-protected crosswalk or crosswalks – 12 feet absolute minimum

Emergency Evacuation Walkways on Elevated Structures and along Exclusive or Fenced-In Private Rights-of-Ways

- Must be continuous along the entire guideway.
- Must be located:
 - Between tracks on elevated structures (left side in normal direction of travel); and
 - Adjacent to tracks (right side in normal direction of travel) on private rights-of-way and roadway median alignments.
- Not required in transit malls or transit-only lanes located adjacent to roadway curbs or in mixed traffic lanes in public streets
- Must be accessible from light rail vehicles
- Minimum evacuation walkway width – 32 inches (2'-8") to permit unimpeded evacuation by wheelchair users as well as able-bodied persons
- Evacuation walkway height – 13.8 inches (350mm) matching floor height of light rail vehicles at doorway thresholds
- Minimum maintenance walkway width – two feet (2'-0")
- Minimum maintenance walkway height – equal to top-of-rail elevation of nearest rail.
- Evacuation and maintenance walkway widths must be clear of the vehicle dynamic envelope (including those of light rail vehicles or other rail-mounted vehicles moving in either direction on adjacent tracks)
- Evacuation and maintenance walkways around track switches must meet state and local requirements

Traction Power Distribution System

- Regeneration capability provided on all main line and storage yard tracks
- Wireless in environmentally-sensitive areas such as transit malls, transit-only or mixed traffic lanes where use of an overhead line-based system would require removal or massive trimming of trees, or where historically-significant buildings, statues, fountains, etc. are present (acceptable technologies include vehicle-mounted batteries, third rail that is energized only when under a moving or stationary light rail vehicle or consist or other methods achieving same result)
- Simple trolley wire with buried feeders permissible on medians, transit-only or mixed traffic lanes where considered to be environmentally-acceptable (where wireless technology is not used)
- Simple catenary with exposed feeder cables permitted on exclusive or fenced in private rights-of-way
- Simple trolley wire with exposed feeders cables preferred at maintenance and storage facilities
- Third rails, when employed on exclusive private rights-of-way or elevated structures, shall be either centrally-located between running rails (preferred) or of the side-mounted under-running (bottom contact) type. In either case, insulation material capable of protecting humans and animals from high-voltage

shocks, as well as to preclude inadvertent grounding, shall be provided on three sides (sides and either top or bottom as appropriate to the design). Sides shall be marked no less than every 20 feet with the “Danger High Voltage” in English, Hawaiian and Chinese/Japanese characters.

Note: Dual Mode Traction Power Distribution for Light Rail Transit – A Design Option, a paper written Jack W. Boorse of Parsons, Brinckerhoff, Quade and Douglas, Inc. reviews historic and current practice with electric railway vehicles equipped to draw electrical energy from both overhead catenary or trolley wire and third rail traction power distribution systems; it also presents technology options for contemporary light rail transit systems and their rolling stock. This paper was published by Transportation Research Board as Record 1677, Paper 99-0593 and is included as A-4 in the Appendices to this Report.

- Voltages
 - 750 volts direct current (750 VDC) required along transit malls, in transit-only and or traffic lanes along public streets, and at maintenance facilities and storage yards regardless of method of supply to light rail vehicles
 - 1,500 volts direct current (1500 VDC) as a preferred alternate to 750 volts direct current (750 VDC) along private rights-of-way and roadway medians in order to minimize the number of substations and to enhance light rail vehicle performance capabilities
- Substation spacing
 - Approximately one mile where 750 volts direct current (750 VDC) is being supplied to light rail vehicles
 - Between one and one-half miles and three miles where 1,500 volts direct current (1500 VDC) is being supplied to light rail vehicles
- Substation sizes – one to four megawatts (1.0 to 4.0 MW) as required to support operational requirements including desired vehicle performance; and
- Blue light system to allow localized emergency de-energizing of traction power distribution system in selected geographic zones.

Train Control/Signal Systems

- Bi-directional operations capability mandatory on all tracks
- Automatic Train Operation (ATO) permissible on exclusive private rights-of-way and elevated structures
- Automatic Train Protection (ATP) with Automatic Train Stop (ATS) mandatory on all private rights of way and medians
- Line-of-Sight (LOS) operations mandatory on transit malls, transit-only lanes and mixed traffic lanes on public streets. GPS-based proximity detection to preclude closing-in on another light rail vehicle or bus without first coming to a complete stop and then limiting speed to five miles per hour (5 mph) required
- Central control of interlocking of track switches and crossings mandatory on private rights of way, elevated structures and medians
- Light rail vehicle-activated interlocking of track switches and crossings (using Vetag or equivalent

technology) mandatory in transit malls, transit-only lanes and mixed traffic lanes in public streets. Wayside over-ride of interlocking to permit manual throwing of track switches required

- Line-of-Site (LOS) operations on all tracks in maintenance facilities and storage yards limited to ten miles per hour (10 mph) except on test tracks and entrance and exit (yard lead) tracks
- All track switches in yards to be interlocked and activated by light rail vehicles (using (using Vetag or equivalent technology)

Communications

- An Operations Control Center (OCC) in a location central to the light rail transit system is mandatory.
- The OCC shall control all light rail vehicle operations; all interlocked switches and crossings on private rights-of-way, elevated structures and median alignments; access to all tracks, exclusive or fenced-in private rights-of-way, elevated structure and median alignments by maintenance or other vehicles (including road-rail vehicles); the presence of maintenance, security or emergency response personnel or their equipment on any portion of the system; traction power distribution; and communications with employees, passengers, and first responders.
- The OCC must be equipped to provide closed circuit television coverage (in color and recorded on continuous 48 hour basis overlapping every 24 hours) of all station entrances, mezzanines and platforms, as well as two-way voice communications with passengers, maintenance, security and emergency response personnel,
- A visual display in the OCC of the location of all light rail vehicles, either individually or in consists of more than one car, while on main line tracks is mandatory.
- The OCC also must contain or control the following communications equipment
 - High-speed cable transmission system
 - Public address system allowing real-time or recorded announcements to be made at all stations and selected other locations
 - Variable message signs (VMS) located on all station platforms and selected other locations, such as in HNL airport. Message capability must provide “next three departures” on a predictive basis in each direction at each VMS location
 - Two-way radio between OCC and LRV drivers, maintenance personnel and security forces, with separate channels for each user pair
 - Internal and external telephone systems (land lines), including hot line to CCH’s emergency response center to immediate response by police, fire and emergency medical services when required to manage an incident
 - Fire and emergency management systems for light rail transit system stations, railway structures, maintenance facilities and storage yards, etc.

Noise and Vibration

- The light rail transit system must be designed and maintained to satisfy or better the noise and vibration levels and criteria established by the Federal Transit Administration (FTA) in its Transit Noise and Vibration Impact Assessment Guidance Manual. The First Project should have a maximum combined goal of 75 dBA at stations (exclusive of any noise generated by adjacent uses such as motor vehicle traffic).

Other Characteristics

- Light rail vehicles and facilities, including stations, must be fully accessible and meet all of the requirements of the Americans with Disabilities Act, including U.S. Department of Transportation regulations as contained in 49 CFR Part 38, Transportation for Individuals with Disabilities.
- Light rail vehicles and facilities must meet all Buy America requirements.
- All aspects of the light rail transit system must be designed to be cost-effective, both with respect to initial procurement and long-term operations and maintenance.

Rolling Stock (Light Rail Vehicles)

General

Light rail vehicles must be equipped with or have:

- A minimum service life of 25 years, preferably 30 years, if kept in a good state of repair.
- An attractive appearance with streamlined ends, i.e. "looking like an elongated shoebox" is to be avoided during industrial design.
- Articulated car bodies capable of negotiating curves with a minimum horizontal radius of 59 feet or less.
- A length over anti-climbers of no less than 90 feet and no more than 125 feet.
- Car bodies of a modular design, constructed initially as three-section, six-axle vehicles with two double-articulations approximately 90 feet-long, designed to be lengthened into four-section, eight axle vehicles with three double-articulations approximately 120 feet-long.
- Car body exterior width of no less than 8 feet, 8 and $\frac{3}{4}$ inches (2.65 meters) and no greater than 9 feet, zero inches (2.74 meters).
- Four doorways per vehicle side providing entry to and egress from the passenger compartment when in a configuration approximately 90 feet-long; five doorways per vehicle side when in a configuration approximately 120 feet-long.
- One exterior doorway for access to and egress from the driver's cab located on the right-side (facing direction of travel) of each car body end.
- Low-floor car bodies with at least seventy percent (70%) of their length having a floor level and doorway thresholds 13.8 inches (350mm) above top-of-rail.
- ADA compliant throughout, including level boarding from or alighting to station platforms meeting three-inch maximum gap width and plus or minus fifth-eighths of an inch allowable variation in height between car body door thresholds and station platforms.

- Capable of being operated either under full automatic train operation (ATO) or manually by light rail vehicle drivers.
- With air-conditioning capable of providing a comfortable temperature and humidity ambience inside the passenger compartment under crowded conditions (AW3 loading). Separate provisions required for the driver's cabs that must be capable of dealing with the additional heat generated by summer-season sun loads.
- Electrical propulsion system capable of operating from 750 VDC and 1500 VDC power sources.
- Traction power collection from overhead contact system (catenary or trolley wire) using pantographs capable of being raised or lowered on command of light rail vehicle drivers.
- Traction power collection from a third rail contact system using retractable shoes. Third rails shall be either centrally-located between running rails (preferred) or of the side-mounted under-running (bottom contact) type.
- When pantographs are raised, third rail shoes shall be retracted automatically and de-energized; when pantographs are lowered, third rail shoes shall be deployed automatically and energized. Provision is required to permit a driver to retract pantographs and third rail shoes simultaneously to shut down a light rail vehicle or consist for storage, re-activation or due to an incident.
- Regeneration capability shall be provided for use whenever the traction power distribution system is receptive; on-board resistors shall be provided to permit dynamic braking whenever the traction power distribution system is not receptive.
- Crash worthiness design compliant with the latest code and standards applicable in the United States, including those of the Federal Government, the State of California (unless the State of Hawai'i has adopted a different code), and the recommendations of the American Public Transportation Association (APTA) whichever has force of law or in the absence of codification provides greater safety for passengers and transit system employees.
- Fire safety performance in accordance with the latest edition of National Fire Protection Association (NFPA) Code 1030 applicable to Fixed Guideway Transit Systems.
- Emergency evacuation provisions.
- Video monitoring and recording, both within car body interiors and of the guideway in front of the lead car of a light rail vehicle or consist.
- Automatic vehicle location / vehicle management systems.
- Maintenance and diagnostic systems.
- High reliability / availability / maintainability.
- Low mean time to repair including modular systems designed for easy removal of a unit and replacement with another permitting off-vehicle repairs.
- Resilient wheels and other noise mitigations measures.
- Automatic passenger counting system.
- Ergonomic design to accommodate the 5th percentile female to the 95th percentile male.

Performance

- Maximum operating speed: sixty-five miles per hour (65 mph) minimum on level tangent track with AW3 loading, with a demonstrable ten percent over-speed capability (not to be used in revenue service) required to ensure safe, maintainable and reliable characteristics of the propulsion, braking and vehicle suspension sub-systems.
- Acceleration rate: three miles per hour per second (3.0 mphps), held to at least 35 miles per hour tapering to zero 5 mph above maximum operating speed.
- Service braking rate: three miles per hour per second (3.0 mphps) using regenerative, dynamic or friction braking.
- Emergency braking rate: six miles per hour per second (6.0 mphps), using regenerative, dynamic or friction braking supplemented by magnetic track brakes.
- Minimum main line horizontal radius (in-street trackage): 59 feet.
- Minimum yard and shop horizontal radius: 59 feet, less if achievable.
- Maximum grade capability: no less than eight percent (8%), nine percent (9%) being preferable.

Passenger Accommodations

- Predominately transverse seating in pairs (two-and-two) on both sides of a central aisle required.
- Seats in high-floor areas at car body ends must face forward (in direction of travel) to permit passengers to see through cab and observe the progress of the light rail vehicle along the alignment. Non-reflective glass shall be used in the partition and door separating the passenger compartment from the cab.
- Seats in low-floor areas of the passenger compartment should face towards door vestibules.
- Pitch between seats no less than 30 inches. Seats facing bulkheads or partitions having minimum of 17½ inches between bulkheads or partitions and edge of seat cushion to provide adequate foot room for seated passengers.
- Seats padded but vandal-resistance materials comparable to those used on suburban buses; molded plastic seats covered with carpet-like materials are not acceptable. Individual seat width of 18 inches minimum, up to 20 inches if permitted by overall car body width providing that an ADA-compliant aisle width of 32 inches is maintained.
- Minimum seated ratio: fifty percent (50%) of the passenger compartment floor area.
- A minimum of two wheelchair spaces per vehicle; tip-up seats or standing body rests required in these areas.
- Dedicated space for luggage and four bicycles and/or surfboards provided in each light rail vehicle.
- A Public Address system with auto-announcer, as well permitting announcements to be made by either the driver or the OCC.
- Dynamic destination and passenger information displays in the passenger compartment.
- Passenger-to-driver or OCC emergency communications.
- Exterior route / destination signs at each vehicle end.
- Exterior and interior route / destinations signs on each side of the vehicle in each car body section (minimum four per car).

Train Sets (Consists)

Light rail vehicles shall be:

- Capable of running in both single-unit and multiple-unit coupled consists of up to three cars.
- Equipped at each end with a service-proven retractable coupler, comparable to the Scharfenburg design, capable of fully-automatic coupling of mechanical, electrical and pneumatic components.
- Capable of failed train retrieval, including being able to push or pull a failed train with a full passenger load on the steepest main line grade.

Transportation Research Board Report 1607 – Dual Mode Traction Power Distribution for Light Rail Transit:
A Design Option, by Jack W. Boorse, Parsons, Brinckerhoff, Quade and Douglas, Inc., January 1999

Dual-Mode Traction Power Distribution for Light Rail Transit A Design Option

JACK W. BOORSE

As light rail transit (LRT) systems continue to develop throughout the United States, the newer extensions tend to have a significant proportion of their alignments physically separated from all street traffic. Where those sections are lengthy, this presents the potential opportunity to use third rail instead of overhead catenary, generally more costly, as a traction power distribution medium. The implications, both positive and negative, of site-selective use of third rail on future systems and extensions are explored. The designs and procedures that allow LRT cars and trains to draw power from both media alternately are discussed, and a method for accomplishing the transition when they remain in motion is described in some detail. Descriptions of some historical and contemporary practices related to the concept are also included. Encouragement is provided for considering the concept as a design alternative for new LRT lines and extensions of existing systems.

The new generation of light rail transit (LRT) systems in the United States began to emerge early in the final quarter of the 20th century. The systems were developed largely because of a desire to provide the benefits of rail transit to more of the nation's cities without incurring the long construction times and high capital costs associated with traditional subway or elevated lines. In pursuing that goal, planners and designers of these LRT systems often made extensive use of railroad and street rights-of-way as hosts for the trackways of the new lines. This significantly minimized the need to acquire private property, or to build long sections of costly aerial or subterranean structures, or both, to provide a passage for the tracks.

In retrospect, this has proved to be a wise start up strategy. It allowed quality rail transit to be introduced (or re-introduced) to cities sooner and at a lower cost than previously had been considered feasible. Advancing these projects from concept to actual operation then resulted in a broader public understanding and awareness of the virtues of the LRT mode.

In many cases, once it was established, the rail transit service was subsequently augmented with extensions into other locations in the region. Those extensions were often developed to fulfill the identified needs for a rail solution, but were thought to be unattainable until the pioneer LRT segment became a reality.

However, those needs were sometimes in corridors without an uninterrupted link of street or railroad rights of way as suitable hosts for an LRT trackway. Consequently, the planners of the expanding systems sometimes found it necessary to choose other types of trackway configurations to piece together a continuous alignment to reach the new locations.

These choices included placing some sections of the line on above-grade structures or in medians of limited-access highways, or

both. The latter almost invariably also involved aerial structures to carry the trackway through the transitions into and out of the median.

The primary negative consequences of selecting this type of alignment were an increase in trackway construction costs and diminished convenience of access to stations. The major positive effects were the reduced delays that resulted from the absence of all conflict of rail operations with vehicle and pedestrian movements. The counter balancing of these effects has been, and will continue to be, a subject for discussion and debate within the LRT professional community. It will doubtless be the subject of numerous papers yet to be written. However, this paper focuses on a new design opportunity that has emerged because these types of alignments have no interface with roadway traffic.

All of today's LRT systems have some interface with vehicle and pedestrian traffic. This interface ranges from extensive (exemplified by some streetcar-style operations in Philadelphia, Pittsburgh, Sacramento, San Francisco, and Toronto) to minimal, with only a few at-grade street crossings (in Edmonton, Newark, and St. Louis). Actually, the trains operating on one particular line of the Los Angeles system, the Green Line, currently have no roadway interface at all. But even on that line, trains are designed with the ability to operate feasibly across, along, and, if necessary, within vehicle traffic lanes.

Indeed, the requirement that LRT cars and trains possess this ability is embodied in the very definition of the mode. The TRB's Urban Transportation Glossary defines LRT as "A metropolitan electric highway system characterized by its ability to operate single cars or short trains along exclusive rights-of-way at ground level, on aerial structures, in subways, or occasionally, in streets, and to board and discharge passengers at track or car floor level." It is this fundamental characteristic that sets LRT apart from all other rail modes.

HISTORICAL AND CONTEMPORARY POWER DISTRIBUTION METHODS

In developing new LRT systems and extending existing systems, the need to satisfy the roadway interfacing requirement has resulted in a general assumption on the part of the designers that the traction power can be delivered to the trains or cars only by means of an overhead wire. The obvious reasoning that led to that assumption is, because this type of conductor is suspended above any traffic that may operate in or across the track (thereby creating no physical impediment to vehicle or pedestrian movements), it is the only power distribution method suitable to LRT. Consequently, the corollary that every millimeter of electrified track in the system must

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have a wire over it is unnecessarily rigid, particularly when the practices of earlier generations of LRT (street and interurban railways) are considered.

For the record, it is technically possible to operate LRT cars in virtually any roadway environment without an aerial power feed. The most severe challenge would be an operation mixed with street traffic. However, during the first half of this century this was done in two North American cities. Within the central districts of New York City and Washington, D.C., streetcars operated in general traffic lanes without depending on any type of overhead wire.

The eschewing of the then-common overhead trolley wire was the result of a possibly overzealous desire by these cities to eliminate all exposed wiring, including utility lines, in the downtown districts. It resulted in an installation that was not only much more problem-prone than overhead wire distribution, but it also was more costly to construct, maintain, and operate.

Traction power was distributed through insulated rails mounted in a conduit beneath the street. The current was collected by a plow-like device hanging beneath each car and reaching down into the conduit through a slot in the street surface between the two running rails of each track. This method of power distribution and collection was never widely adopted. No examples survive today.

A far more successful version of power distribution by rail is the electrified third rail. In this version, the energized rail is set next to the two running rails of each track (creating the configuration that gives the system its name) and supported by electrical insulators that raise it about nine cm higher than the other two rails. It delivers power to third-rail shoes. They are current collectors that protrude horizontally from the truck frames on the motorized cars of a train and slide along the top or bottom of the energized rail. This current collection method is by far the most common on rapid transit metro systems. It can also be found on various regional and urban railways around the world.

Because of its above-ground location, this type of power distribution is far less problematic than the below-ground version once used in New York and Washington. However, the physical location of this third rail, with respect to the running rails, severely restricts its use on line sections in a street environment.

This system's unsuitability for traditional streetcar-type trackage is obvious but, at present, it also is generally considered inappropriate for other LRT configurations, including exclusive backways within, or adjacent to, a street right-of-way.

This perception of unsuitability also applies to line sections on independent rights-of-way that include at-grade vehicle crossings, no matter how few. This was not always so. Many of the interurban lines and electrified railroads of the early 20th century did use third-rail traction power distribution on sections of surface trackage that crossed public streets at grade. To provide an unobstructed path for vehicle and pedestrian traffic movements across the trackway, a short section of third rail was omitted in the immediate vicinity of each crossing. The resulting gap in the third rail was relatively short. Where its length exceeded the distance between the two third-rail shoes on a single car, it simply coasted across it. As a safety measure, signs were often posted near the edge of the road to warn pedestrians of the presence of high voltage. Although a few crossings of this type do survive, it does not appear to be advisable in today's litigious society to create any new crossings of this type. However, the concept remains technically feasible.

Similar liability concerns have been expressed regarding situations where the trackage would have no interface with roadway traffic. That trackage would be at ground level and not physically iso-

lated from pedestrians who might trespass on the trackway. Such conditions were not uncommon in the early part of this century. But, as with at-grade crossings, few examples remain today.

COMPARISON OF POWER DISTRIBUTION METHODS

Considering that overhead wire distribution avoids all of these problems and is also suitable for virtually all other situations, including those where third-rail distribution would be clearly feasible, it would appear reasonable to question why third rail should be used instead of overhead wire for any new electric railway.

There are several reasons. The primary one being that third rail is measurably less expensive. Individual examples vary but, on average, the capital cost of a third-rail installation is significantly less than for overhead wire distribution of the same voltage. For a two-track railway on a straight alignment, overhead catenary for 1,609 m (1 mi) of line would cost approximately \$600,000 compared with \$475,000 for third rail. For curved alignments, the disparity is even greater. The cost differential stems from how each type of conductor is supported.

Overhead catenary requires a series of relatively elaborate structures to support it. Each of these structures comprises, at a minimum, a concrete foundation, a steel column, and a lateral arm. The distance between support points can be as great as 80 m, provided that the track alignment is flat (not necessarily level) and straight. However, any substantial vertical or horizontal curvature in the alignment necessitates a closer spacing of support structures in order to keep the wire properly positioned with respect to the track. This results in an increase in the number of these costly structures that must be built within a given track length. Also, for the shorter radius horizontal curves are often necessary to provide "pull-offs," cables that provide no vertical support, but pull the catenary outward horizontally to keep it positioned over the track. To anchor these cables, additional poles must be constructed at points between the main support structures.

Conversely, third-rail electrification requires no elaborate structures. Each conductor rail is merely attached to the ties or slabs that support the running rails. The attachment hardware is a simple metal bracket that supports an electrical insulator where the third rail is placed and a cover board positioned about 7 cm above the top of the third rail. A cross section of a typical installation is shown in Figure 1.

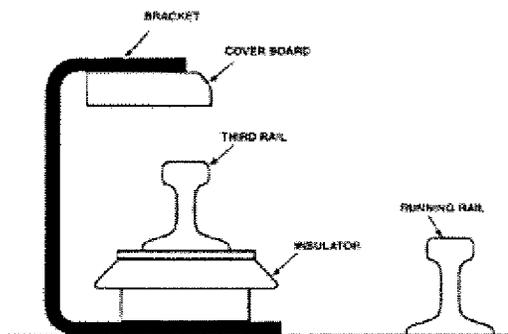


FIGURE 1 Typical third rail installation.

The rail itself can be easily formed by bending it to match the vertical or horizontal alignment, or both, of the running rails and, because it is rigid, the distance between support points (about 3 m) need not be reduced to accommodate either vertical or horizontal curvature, as is necessary with flexible overhead wire.

These physical characteristics not only minimize the initial cost of the third-rail electrification itself, but also lead to other construction economies as compared with catenary. With third rail, the trackway width need be no greater than what is required to accommodate the dynamic envelope of the trains and to provide the necessary safety clearances. It does not have to be increased to provide clearance for the catenary poles alongside or between the tracks. This is particularly significant for an aerial alignment where a requirement to provide additional width of structure, beyond that needed for the basic trackway, could measurably increase the construction cost.

Maintenance cost differences between the two distribution modes are more difficult to quantify because of the variables. If catenary is designed for fixed anchoring it may require seasonal attention that would not be needed with constant tension design. This may be more pronounced in the more severe climates. The presence of third rail can measurably increase the cost of servicing or replacing running rails and ties, even when the third rail itself is not in need of work. These factors influence the life cycle costs of both modes.

Less significant than the cost differences, but not to be dismissed, are aesthetic considerations. Catenary wires and their support structures are particularly noticeable where they protrude above a trackway that is built on an embankment or an aerial structure and are viewed against the background of only the sky. Unlike the situation of a surface alignment, in these elevated configurations there is little or no opportunity to mask the support poles with trees or to eliminate them by attaching cross spans to nearby buildings. In contrast, third rail on an above-grade structure is virtually invisible from the ground.

Unfortunately, neither overhead wire or third rail is invulnerable to severe weather. Overhead wire is jeopardized by extreme temperatures, high winds, and broken tree branches. The third rail is relatively immune to those conditions. On the other hand, a third rail is sometimes vulnerable to deep, wet snow. Both distribution media can be adversely affected by ice storms.

For regions with severe winter weather, it is difficult to demonstrate that the reliability of one medium is clearly superior to the other. In the more moderate climates, third-rail distribution is generally less problematic than overhead wire.

The points discussed above have been presented to set the stage for the further consideration of the concept that is the core subject of this paper. In summary, these points are

- Traction power distribution by third rail has some distinct advantages as compared with overhead wire, but it is suitable only in non-street environments.
- Many current and planned LRT systems comprise line sections of substantial length that are completely separated from all vehicle and pedestrian traffic.

Some meaningful savings in construction costs for systems built in the past 15 years might have been achieved had third rail been used on some of the exclusive sections. For example, in Los Angeles there are extensive lengths of aerial structure on the Long Beach Blue Line. Also in Los Angeles, as noted previously, the crosstown Green Line is currently separated from roadway traffic throughout its length, although it may be extended in the future to include interfaces with vehicle traffic. A substantial section of the San Jose sys-

tem, south of the city's downtown, runs in the median of a freeway, and Portland's East Line runs beside one. Recent extensions of the San Diego system include lengthy grade-separated sections as does the St. Louis system.

However, at this point in time any construction cost savings for those segments that might have been achieved through the use of third rail are academic. These lines are already completed and the additional construction cost of overhead electrification has already been incurred. Nevertheless, as the growth of LRT systems continues throughout the country, it appears that new exclusive rights-of-way will be developed. Those segments may be candidates for third-rail electrification.

DUAL MODE POWER DISTRIBUTION AND COLLECTION TECHNOLOGY

Implementing the concept of substituting third rail for overhead wire only on selected portions of a system would obviously require the trains to have dual mode current collection (DMCC) capability. In practical terms, they would have to carry both third-rail shoes and pantographs. Although this may be considered by some as revolutionary or impractical, or both, it is neither.

A number of interurban railways, some with the characteristics of today's LRT lines, used this concept during the first half of the 20th century. Trains of the Chicago, North Shore and Milwaukee, as well as the Chicago, Aurora and Elgin, collected traction power from a third rail when operating on the Chicago "L," and from overhead wire at some outlying locations. Trains of the Shore Fast Line ran on overhead wire in the streets of Atlantic City; but when crossing the Absecon Bay when entering or leaving the city, they used the tracks and the third rail of the West Jersey and Seashore Railroad. The West Jersey and Seashore itself, with basic third-rail electrification, used overhead wire within the city of Gloucester. Cars of the Lehigh Valley Transit system carried third-rail shoes for operation on the trackage of the Philadelphia and Western south of Norristown, Pennsylvania. Numerous other interurban railways also had a mixture of overhead wire and third rail traction power distribution. Although these particular systems have all expired, the concept has survived.

Although they are not LRT lines, there are to this day three metropolitan electric railway systems in the United States where trains make use of both types of traction power distribution on a single trip. Trains operating on the Blue Line of Boston's rapid transit system run with collapsed pantographs through a downtown subway, where they collect traction current from a third rail. After they cross under the Inner Harbor, the pantographs are raised (during a station stop) and they continue to the outer end of the line drawing power from overhead catenary. On the New Haven and New Canaan lines of New York's Metro North commuter rail system, the trains utilize third rail inside the city and catenary from a point just beyond the city limits to the current extremities of the electrification in Connecticut. Cars operating on the Skokie Swift line of the Chicago "L" system, draw power from a third rail on the south end of the line and from overhead wire on the north end.

APPLYING THE DMCC CONCEPT

Any consideration of using third-rail distribution in concert with overhead wire in the design of new LRT lines, or for extensions of

existing systems, would have to take into account the potential physical and operational requirements. The most critical would be the transition from one collection mode to the other. In today's fast-paced environment this transition would have to be essentially seamless. It would also have to be accomplished without requiring the installation of ungainly or extremely costly equipment. These goals are achievable, if correct design techniques and operating practices are used.

This design would include a section of track at the transition points where the two distribution systems are overlapped. The length of that overlap would have to be sufficient to accomplish the change without delaying the trains. Thus, the length of this overlap is a function of the time required to perform the transition at the chosen operating speed. The procedures that would be used to accomplish the transitions are described below.

As a train operating under wire approaches the entrance to a third-rail line section, the collector shoes would be deployed. Then, after they have come into electrical contact with the energized rail, an on-board switching mechanism would disconnect the traction motors and other electrical equipment from the pantographs and connect them to the third-rail shoes. With today's electronic switching technology, the flow of current to these devices could be virtually continuous during that transition. After the electrical switching is accomplished, and before the end of the wire is reached, the pantograph(s) would be lowered.

In the reverse direction, after a train operating on third rail enters the overlap section and the contact wire is present overhead, the pantographs would be raised. Once they were in contact with the wire, all electrical equipment would be disconnected from the third-rail shoes and connected to them. After the shoes have ridden off the end of the third rail, they would be retracted.

Powered pantograph operation is already a standard feature on many modern LRT cars. Raising and lowering the pantograph(s) at the transition point would require only manipulation of a device on the train operator's console at the appropriate time. (This action would be comparable to that taken by LRT train operators in San Francisco to raise and lower powered steps when entering and leaving line sections with high platforms.) If desired, on-board and line-side equipment could be designed to actuate this function automatically, without operator involvement, although the need for this additional feature is questionable.

The deployment and retraction of the third-rail shoes is the other element of this procedure. It could be argued that as long as they are deenergized there is no reason to retract them. However, it would not be desirable to operate LRT trains in a street environment with protruding shoes. Although they would be deenergized, they could be damaged or even broken off as a result of striking road debris. In addition, with the combination of some body designs, track gauges and truck frame configurations, the shoes could extend beyond the side of the car. This could present a potential hazard to any pedestrians standing close to a passing train. Finally, a likely assumption by the public that shoes are energized whenever they are deployed, although incorrect, would create an impression of safety irresponsibility on the part of the operating agency. Consequently, the shoes should be retracted whenever the trains are running in a street environment.

Deployment and retraction of the collector shoes can be completely automated. Although it is technically feasible to equip each of the shoes on every car with a powered device to raise and lower it on the command of the train operator, there is a simpler and lower cost method.

By fitting the basic shoe with an appropriately oriented spring and adding a tail piece inside the pivot, it could be deployed (lowered) and retracted (raised) by the motion of the car as it passes over a simple passive track-side device. A key to avoiding the need for any powered device to manipulate the shoe is the spring. To perform this necessary task its mounted position, with respect to the pivot of the shoe, must be such that two things will occur successively. When the shoe is first rotated it will compress the spring. Then, when it has been rotated past the center of its travel arc, in either direction, the stored energy of the compressed spring will complete the motion.

The trackside device, that might be referred to as a "rotator," would be mounted on the ties (or track slab) outside the running rails at a point on the line just outside of each third-rail zone. It would comprise two steel plates, each shaped in the form of a very broad inverted V. They would be set in vertical planes about 15 cm apart, parallel to the track and to each other. The two plates would be positioned laterally so that the one closer to track would engage the tail piece of a retracted shoe and the other one would be able to engage the main arm of a deployed shoe. The plates would be staggered longitudinally with the outer plate closer to the overhead wire zone. Figure 2 illustrates the positioning of the plates.

Each shoe on a car or train traveling toward the third-rail zone would first pass the rotator's outer plate. The plate would not engage its main arm because it would still be retracted in that circumstance. The shoe would then reach the rotator's inner plate, and the plate would engage its tail piece and push it upward. This would rotate the shoe around the pivot, causing the main arm to descend.

In the reverse direction, a shoe on a train traveling away from the third-rail zone would pass the inner plate first. There would be no engagement with the tail piece since, in that situation, the shoe would still be deployed. Then the main arm would engage the outer plate, moving it upward.

In both scenarios, the spring, by virtue of its angle of attachment, would complete the motion initiated by the engagement with a rotator plate.

The deployment sequence is illustrated in Figure 3 and the retraction sequence in Figure 4.

THIRD RAIL WITHIN PASSENGER STATIONS

Another matter related to third-rail power distribution that would have to be addressed is its interface with passenger activity at

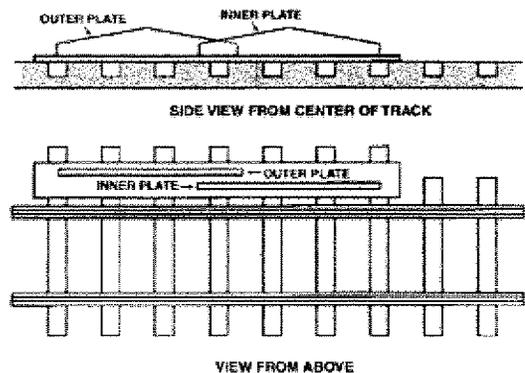


FIGURE 2 Third rail shoe "rotator."

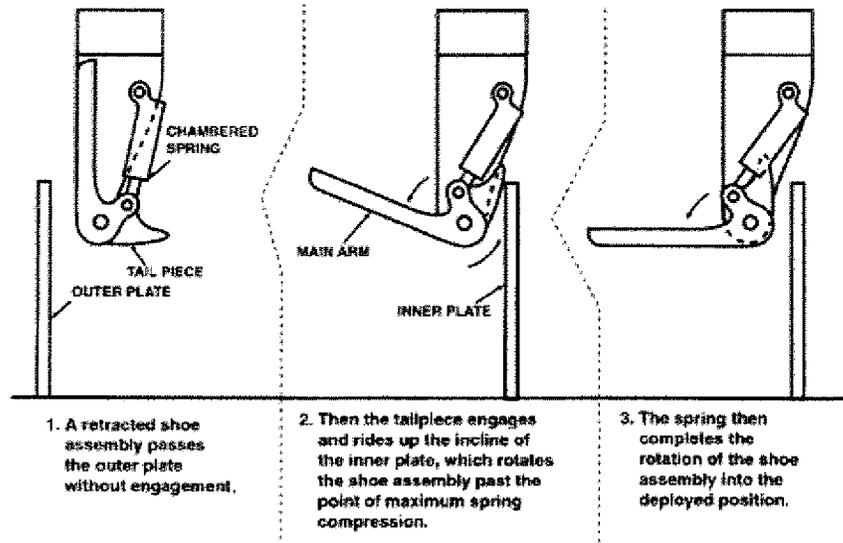


FIGURE 3 Shoe deployment procedure.

stations. Light rail cars are generally narrower than metro cars and in some cases the third-rail shoes, when deployed, would protrude beyond the side face of the car body. In that position, they would present an unacceptable hazard if they intruded into a space where passengers could be standing. Furthermore, the energized third rail itself could not occupy any part of that space.

These conditions would be potentially possible in stations having "low" platforms. These are platforms with an elevation lower than

that of the car floor, at or very close to the elevation of the track. Any line segments that include stations with this type of platform, no matter how exclusive from roadway and pedestrian traffic they might be, are not likely candidates for third-rail power distribution.

However, few new stations are being designed with this type of platform because of accessibility concerns. To comply with the Americans with Disabilities Act (ADA), new stations must now include provisions for the boarding and alighting of mobility-

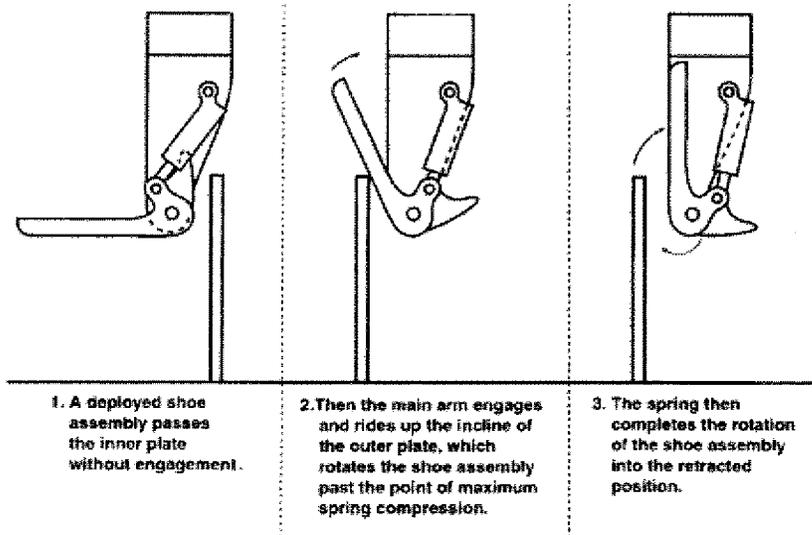


FIGURE 4 Shoe retraction procedure.

impaired passengers. This is sometimes accomplished with high blocks or mechanical lifts, or both. Sometimes called a mini-high platform, this is a raised landing connected at the downstream end of the main platform by means of ramp or lift. It provides level boarding and alighting at one door of a high-floor car.

These facilities serve only the front door of a train and generally require the operator to leave the driving seat to participate in the boarding and alighting process. The trend on new systems is to provide for same-level boarding at all doors by matching the platform height to that of the car floor. The actual platform heights depend on the basic car design. These designs can be divided into two basic categories.

High-floor cars have conventional four-wheel trucks that require a clearance in the range of 1 m between the top of the rails and the underside of the car floor. North American examples of LRT operations with high-floor cars (and platforms) can be found in Buffalo, Calgary, Edmonton, Los Angeles, Pittsburgh, St. Louis, and San Francisco.

Low-floor cars use various types of low-profile running gear (such as two-part axles and small diameter wheels) to reduce under-floor clearance requirements. This allows the walking surface of the car floor to be lowered to a height of about 35 cm above the top of the running rails. The majority of the new systems now being designed will operate this type of car. Also, at least three existing systems in Boston, Newark, and Portland are in various stages of implementing programs to reconstruct their original track-level station platforms to provide for level boarding of new low-floor cars.

At stations that are served by high-floor cars the juxtaposition of the track and the passengers standing on the platform is essentially the same as it is at traditional metro ("T" or subway) stations. The third rail could be put below the edge of this type of platform, it generally cantilevers out beyond its support structure, or on the other side of the track. The deployed shoes would be well separated from any walking locations. Introducing a third rail at stations of this type would not present a significant hazard to passengers on the platform.

The situation at stations serving low-floor cars differs only in that the vertical distance between the platform and the live rail and shoes would be shorter. As with the high-floor platform, the trackside vertical support could be set back from the edge of the platform, thereby providing lateral clearance for passage of deployed third-rail shoes. The nominal 35-cm height of the platform surface above the top of the running rails would leave a comfortable vertical clearance beneath its bottom face for passage of the shoes. Because the elevation of a top-contact third rail must necessarily be below that of deployed shoes, it too could be fitted beneath the platform extension. This concept is illustrated in Figure 5.

As an alternative design, the third rail could be located on the non-platform side of the track in station sites. The shoes on the platform side of the train could either remain deployed and pass beneath the platform, or be retracted when the train is in the station zone. The latter option would require the installation of rotators just beyond each end of the platform to retract and then re-deploy the platform-side shoes. This procedure was used at the low platforms in the San Francisco terminal to accommodate trains operated by the Key System that collected power from a third rail when operating on and west of the Bay Bridge.

In evaluating the potential use of third rail in this type of station, it should be realized that it is not revolutionary. In addition to the

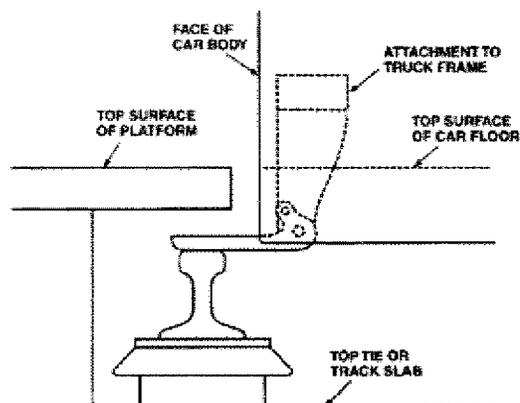


FIGURE 5 Third rail at low-floor car station platform.

San Francisco example just cited, historic precedent can be found on a number of commuter railroads. In the past, there were numerous stations along trackage with third-rail electrification that had platforms that were significantly below car floor level, in the range of 35 cm above the top of the running rails.

With either high- or low-floor cars, passenger access to the platform might include an at-grade walkway across the tracks at the end of the station. If so, it would be necessary to leave a gap in the third rail in the immediate vicinity of the passenger crossing. The length of that gap should be sufficient to keep the ends of the energized rails at least 3 m beyond the nearest edge of the walkway. This separation would prevent any contact with persons legitimately using the crossing. To avoid an undesirable interruption of propulsion power to any car of a train as it traverses the walkway, the total length of the gap in the third rail should not exceed the distance between the shoes on an individual car. For a six-axle articulated LRT car, this dimension would be about 21 m.

Analysis to date appears to indicate that, with some adaptation, level-boarding platforms for both high-floor and low-floor LRT cars should be able to accommodate third-rail power distribution. Designs that are safe for responsible passengers are achievable. Nevertheless, liability issues relating to trespassing and other irresponsible acts will require further consideration.

CONCLUSION

It would appear that the concept of utilizing third-rail traction power distribution on selected portions of LRT lines is physically and operationally feasible. It also appears that there will be an increasing number of line segments where its use might be appropriate. Because of the potential cost savings and other advantages, this option should be considered in the planning of future LRT lines and extensions.

Publication of this paper sponsored by Committee on Light Rail Transit.

American Public Transportation Association (APTA) Trackway Infrastructure Guidelines for Light Rail Circulator Systems, April 2007

Trackway Infrastructure Guidelines for Light Rail Circulator Systems

A Report Prepared by

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April 2007

FOREWORD

In the array of land, water and air transport methods, a major position is occupied by railway technology that is based upon the proven and time-tested concept of flanged metal wheels rolling on a pair of metal rails. The provenance and first major application of this excellent (some might say, ingenious) technology occurred during the latter half of the 19th century when the majority of intercity and transcontinental railroads were constructed. As the 20th century dawned its most popular use shifted to the development of urban streetcar lines. In the larger cities, it was also used by the designers of rapid transit elevated and underground rail lines. Toward the end of the last century the same technology was utilized in the design of light rail transit (LRT) systems that are still growing in number worldwide. Through all of the evolution of these somewhat diverse railway modes, the fundamental technology has endured and it promises to do so for the foreseeable future.

However, as railways in their various versions matured the technology evolved and was adapted. New design skills, products and applications emerged while some of the older ones faded. The application that declined the most steeply was the street railway. By the beginning of the last quarter of the 20th century, outside of Europe, streetcar lines had largely vanished.

Now, as we move into the 21st century and many urban cores are experiencing revitalization, new streetcar lines are being developed to provide circulator service in these dense and often constricted districts. In the course of planning and developing these railways it has become apparent that some of the needed manufacturing skills and design expertise, which were once readily available to the street railway industry, have eroded and that some of them need to be recaptured and updated.

With that purpose in mind, an assemblage of rail transit professionals with skills and practical experience in street railway practices began researching this matter to identify areas where issues with current technologies and practices exist and to recommend measures to address those issues. One of the issues identified was the need for trackway infrastructure designs and materials specifically related to the environments in which circulators often operate. The findings of that research are set forth in the following guideline document.

LIGHT RAIL CIRCULATOR SYSTEMS
TRACKWAY INFRASTRUCTURE GUIDELINES

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1. Introduction

Light Rail Transit (LRT) is a well established mode, with many representative systems in operation in North America. The Light Rail mode is essentially distinguished by providing rail transport between urban centers and suburban communities at distances sometimes exceeding 32 kilometers (20 miles) or more at speeds of up to 110 kilometers (68 miles) per hour. Typically light rail follows a basically linear corridor into or through the urban center, usually utilizing paved track in the central business area, but located in reservations free of motor vehicle traffic where possible. When not on reservations, as much as possible the paved tracks are segregated from vehicular traffic lanes to enhance service regularity. Light Rail Circulator systems, while utilizing basically the same technology, are designed to provide a transport function within a single urban district, connecting activity centers of all types that produce a flow of passengers worthy of the rail transit mode. Light Rail Circulator Systems may connect with other transport nodes and stations, including those of a light rail transit system. Providing this function may not always require the speed, capacity and multiple-unit capability required of line-haul light rail transit systems, but may impose two other requirements, which are the ability to negotiate the urban center street pattern and to "fit in" with the scale of peripheral residential areas that may be contiguous with the urban center. Meeting the first requirement may result in the Light Rail Circulator System track and cars needing to have the ability to negotiate smaller radius curves than present light rail standards recommend, while the second may be achieved by the use of shorter, single car, rather than multi-car, trains. Portland, Tacoma, Little Rock, and Tampa have examples of recently constructed Light Rail Circulator type systems.

The description of the Light Rail Circulator System service described above will be recognized as describing to a great degree the characteristics of what has historically been known as the streetcar. This is not to be unexpected as the technology employed is basically the same. There remain in North America three cities operating "classic" streetcar-type transit operations, Philadelphia, Toronto, and San Francisco. Each has at least one operating section that could be considered a Light Rail Circulator type in that it does not function solely to transport passengers from outlying areas to the city center, and the overall system utilizes paved track in streets for the majority of its operations. Boston and New Orleans also operate streetcar type vehicles suitable for Light Rail Circulator System operation, although Boston has no lengthy sections of track in general traffic lanes and the New Orleans cars are historic and primarily on reserved track. The cars used on all these systems could be used in Light Rail Circulator-type operations, whereas most light rail transit cars could not. Of the new systems in Portland, Tacoma, and Tampa, the last has been designed to be a modern "Heritage" (tourist-oriented) type of system, although its geometry, as with other heritage lines constructed in Little Rock, Galveston, Memphis, Kenosha, and Charlotte, is such that it functions like a Light Rail Circulator System. To date, Portland and Tacoma are the only new Light Rail Circulator Systems employing modern low floor rolling stock.

The intent of this document is to be supplementary to TRB TCRC Report 57, Track Design Handbook for Light Rail Transit, and it is therefore focused on the important differences between "line-haul" light rail systems and Circulator light rail systems as they relate to trackway infrastructure. The guidelines, narrative, and illustrations provided in this report are intended to highlight many of the principal issues and concerns that should receive attention when designing a Light Rail Circulator System's trackway infrastructure. Past experience of a number of transit agencies with wheel-rail incompatibilities requiring extra effort and cost to resolve have indicated that the attention to detail required to achieve the successful construction of such infrastructure is not to be underestimated.

2. Vehicle Size and Curving Considerations

De facto standards have been informally established for LRT in the US for minimum curve radius (25 m./82 ft.) and car width (2.65 m./8.7 ft.), based on general European practices. These informal standards have been adhered to even in cases where the vehicles acquired were a brand new design and there were no alignment constraints on either dimension. An analysis of European vehicles finds widths varying from 2.2 to 2.65 m. and with curving capabilities having a similarly wide variance. Streetcar widths in the US varied from 2.53 m. (8.3 ft.) to 2.74 m. (9 feet).

Guideline – Do not unnecessarily constrain vehicle width in specifications. While recognizing and respecting the physical constraints of the operating environment, allow for the range of widths judged to be the maximum and minimum that are desired and feasible for the system. This allows for the possibility of a wholly new design to be supplied with the maximum width, which enhances the passenger comfort aspect of a rail car.

Examples of curving capability currently existing are found below.

a. Existing transit agencies with minimum center line track radius below 25 m. (82 ft)

- Philadelphia – 10.8 m (35.4 ft)
- Toronto – 11 m (36.1 ft)
- Boston – 12.8 m (42 ft)
- San Francisco – 12.8 m (42 ft)
- Portland & Tacoma - car capability 18 meters (59 ft)
- Newark – 19 m. (62 ft)
- Melbourne – 16.8 m. (55 ft)
- Sydney – 20 m (65 ft)

b. Some existing low floor cars with minimum radius capability below 25 m. (82 ft)

- Brussels Bombardier Flexity – 14.5 m. (47.5 ft)
- Boston Type 8 – 12.8 m (42 ft)
- Nordhausen Combino – 15 m (49.2 ft)
- AnsaldoBreda "Sirio" – 15 m (49.2 ft)
- Portland Skoda "Astra" – 18 m (59 ft)
- Alstom Citadis – 18 m (59 ft)
- NJT Kinki Sharyo car – 18 m (59 ft)
- Melbourne - Combino and Citadis – 16.8 m (55 ft)

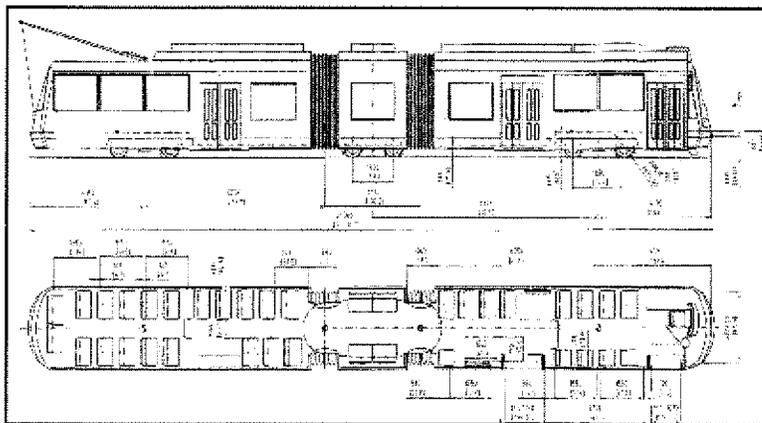


Figure 1 - Low floor car design capable of small radius curves.

From the above, it can be seen that there are a number of current vehicle designs that are suitable for Light Rail Circulator Systems in which the use of a smaller curve radius can be of benefit. Figure 1 shows a low floor car design that was proposed by a prospective bidder for one of the major US transit systems, and Figure 2 illustrates its ability to negotiate a worst case curve of 10.8 meters (35.4 feet).

(82 feet) that has often been the de facto Light Rail Transit standard. As has been indicated above, there are available on the world market low floor rail vehicles with better curving capability than most contemporary LRT vehicles. The evolution into low-floor vehicles has resulted in designs with smaller body sections and a greater number of articulations than are found on traditional LRT vehicles. This has provided a synergy with curving capabilities in that it allows the angle between body sections at the articulations to be kept within reasonable limits.

Guideline – *A key word in the title “Light Rail Circulator System” is the word “system”. Preliminary system engineering and meetings with potential vehicle suppliers should take place simultaneously to ensure that the resulting minimum radius car capability is such that a maximum number of leading car suppliers can participate. Re-engineering a vehicle to meet a slightly smaller radius entails supplier cost and can result in a supplier not bidding if the procurement is for a small number of vehicles. Optimizing the trackway infrastructure/vehicle relationship may thus be an iterative process.*

While the ability of a Light Rail Circulator vehicle to negotiate smaller curves may be beneficial to constructing such a system in an urban area, another not insignificant benefit can arise with regard to the storage and maintenance facility. LRT systems are typically able to find land for yards and shops in outlying areas or in old industrial zones adjacent to the right-of-way being used. A Light Rail Circulator System may find itself in a much more constrained situation. Historically, urban streetcar systems have had to use very small radius curves in order to provide the needed space and functionality in relatively small parcels of land. The Light Rail Circulator System vehicle ability to traverse small radius curves will provide greater flexibility in locating a site in a more urbanized area.

Guideline – *In optimizing the trackway/vehicle relationship ensure that the chosen vehicle curving capabilities do not excessively constrain site selection for the maintenance facilities and storage yards. Evaluate the trade-offs of a reduced number of vehicle suppliers and possibly higher vehicle prices versus greater costs for the fixed facilities if the site location is constrained by the vehicle capabilities.*

5. Track Design Considerations for Light Rail Circulator Systems

While seemingly simple, wheel-rail relationships can be highly complex and sophisticated. This is especially true when curves of very small radius, and site-constrained, compact special work arrangements are employed. Both of these characteristics are likely to be found on Light Rail Circulator Systems. Wheel and rail must function as a system, and when that is not adequately addressed, problems can arise that result in increased rates of wear and even derailments. At least five transit agencies have experienced significant problems with rail-wheel interactions that required engineering attention and expense to resolve. Causes have related to both the design and construction aspects of the project.

Guideline – *Ensure that those parties responsible for wheels and rails are working in concert to produce optimum compatibility between the two subsystems. Wheel gauge, track gauge, check gauge, and all new and worn dimensions should all be mutually agreed to and initial drawings documenting all parameters should be developed before any serious design work takes place.*

5.1 Preliminary Design Considerations

A review of industry experience indicates that LRT systems that have had the least difficulties relating to the wheel/rail interface are those that have employed purely railroad standards for wheels and rails. In such a case, all the critical dimensions have been long established and, if track is properly constructed, the likelihood of problems arising is small. However, constructing to railroad standards requires that there be ample room along the line and in yards and shops, as curve radii are larger. These standards may not be compatible with Light Rail Circulator environments. Further, those operations using railroad standards have either used T-rail in their paved track, or have no paved track except at crossings.

Where agencies have encountered problems with the wheel-rail interface, either design or construction details have typically been the cause. When an agency employs an outside firm to design the Light Rail Circulator track there are a number of considerations that should weigh heavily in the selection of the firm. Problems typically found on track of questionable design and/or construction are:

Improper gauging of track and guard rails.

Use of apparently railroad-based designs not suitable for Light Rail Circulator System rolling stock with street railway wheels and/or the curvature employed on the system. (See Figure 3.)

Failure to understand the criticality of certain crucial track dimensions and tolerances under small radius circumstances.

Employment of design details that increase the cost and complexity but have no payback in terms of performance or utility. (See Figure 4.)

Guideline – When choosing a track designer, it is of great importance that the one chosen has demonstrable knowledge of streetcar track and successful design experience. Many track designers have primarily a railroad background, which by itself is not qualification for design of Light Rail Circulator System track with small radius curves and possibly complex and compact shop and yard layout.

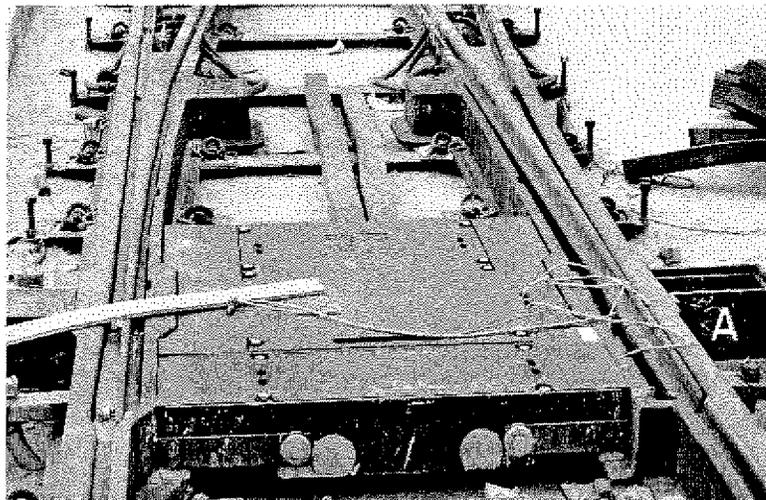


Figure 3. - Switch points apparently based on railroad designs and used on a light rail system in conjunction with grooved rail. The jog in the rail gauge face at A could cause the trailing axle flange to climb onto the railhead in situations where the curve radii are small. Correct design for a Circulator will provide a guiding surface for the back of the wheel that is opposite A which will hold the trailing axle wheel flange away from the guidance surface jog at A.

5.2 Rail Options

Very often, streetcar and light rail lines that use public streets are constructed using girder rail rather than conventional T-rail. Modern girder rails provide a groove in the head of the rail for the rail car wheel flange. The

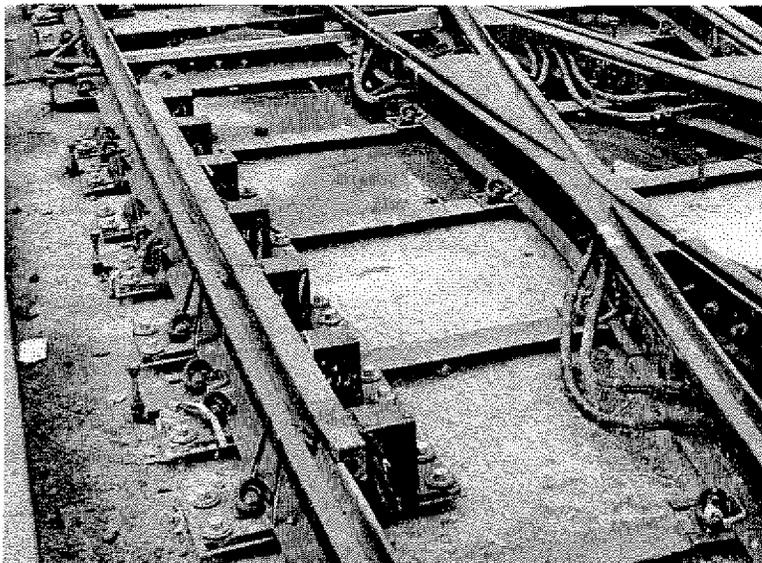


Figure 4 - The complex and expensive guard rail construction on tangent rail opposite the frog appears to provide no more useful guarding than the grooved rail itself would provide. Noteworthy is that in this instance the axles taking the diverging path through the frog are in fact guided by the grooved rail opposite the frog.

decision as to whether to use T-rail or girder rail can be site-specific. Historically, large municipalities sometimes required that street railway track be constructed using girder rail, while some smaller towns had no such regulation. Grooved girder rail has several advantages that have made it almost universally used in paved track world-wide:

It provides a minimum width of flangeway which produces the least hazard to small-wheeled vehicles (such as baby carriages and wheel chairs) and bicycles. While it is possible to form flangeways in paving material adjacent to T-rail, it is necessary to make them wider than optimum so as to avoid damage to the paving due to abrasion by the back faces of the rail car wheels. Also, paving materials other than stone or concrete will eventually collapse into the flangeway under the impact of rubber-tired traffic.

Its use in curves for the guard rail function requires less labor for both fabrication and installation than the use of T-rail and a separate restraining rail. Restraining rails can take many forms but will always require additional fabrication work such as drilled holes in the running rail. The large number of fittings will require many labor-hours for assembly. Grooved girder guard rail is one integral piece that can just be laid in place. Figures 5 and 6 illustrate this difference.

Grooved rail provides a steel flangeway that is not easily damaged by the impact of steel wheel flanges on foreign material in the flangeway, or by the effects of salt, traffic, etc., that over time can cause even concrete to disintegrate. On tangent track, grooved rail effectively provides a continuous guard rail with maximum protection against possible derailment resulting from non-crushable objects lying in one of the flangeways. Because of the near-universal use of grooved rail for street railways and light rail lines outside of North America, all the designs and dimensions found on small radius curves and special work used in compact yard and shop situations are long-developed, and so can be delivered almost fully engineered with little chance of error. Thus design engineering and installation costs can be lower if the designers have appropriate experience.

Circulators that are part of a larger LRT system that employs railroad track standards may find that readily available rails and special trackwork that is based on the use of grooved rails is incompatible with the railroad type wheels used on the vehicle fleet. Customized special trackwork designs and/or wheel designs may be necessary.

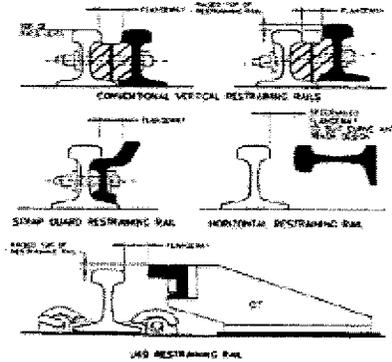


Figure 5. - T-rail guard rails.

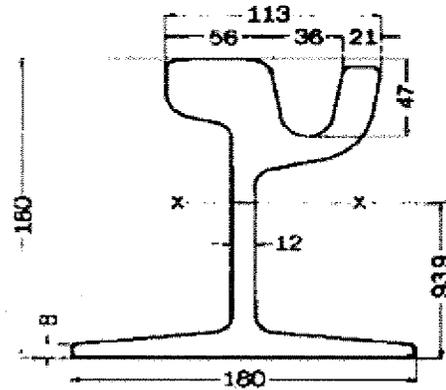


Figure 6. - R1 60 grooved girder guard rail.

In the North American context, because there is no domestic source of supply, the use of grooved rail track and special work has some disadvantages in that:

- Lead times for procurement of material may be longer.
- With the existing unfavorable exchange rate and the shipping involved, material cost may be higher.
- Buy-America regulation waivers may be needed.

The rails used in paved track on legacy streetcar lines were usually – but not always – grooved or not-grooved girder rails. The exceptions were largely driven by economics, girder rails always having been more expensive than common T-rails. In the early 20th century, it was common that lower-capitalized trolley lines would use T-rail when local regulations permitted. In such installations, the required flangeway was often formed with a specially-shaped paving brick, re-pressed so as to both fit into the web of the rail and form the flangeway. In the mid-20th century, with the number of US producers reduced to two and then one, many street railway companies began to use T-rail. Typically, this involved formation of a flangeway in a concrete or asphalt pavement surface.

There were only two major types of girder rails produced in North America after about 1930. Grooved girder rails with a sloped self-cleaning flangeway provided wheel guidance on only one side of that groove, as shown in Figure 8. Girder guard rails had the outer edge of the groove rotated vertically, and were thus able to provide guidance to both the front and the back of the wheel flange as shown in Figure 9. Thickness was increased to improve service life. Girder guard rails are used on sharp curves where two point guidance provides superior steering of the streetcar wheels as well as reduced levels of rail and wheel wear, thereby resulting in longer service lives for both. Today, there are no North American producers of girder rails. "Grooved Rails" (as they are termed in the rest of the world) are manufactured by several European rolling mills, although not to the designs last produced in North America.

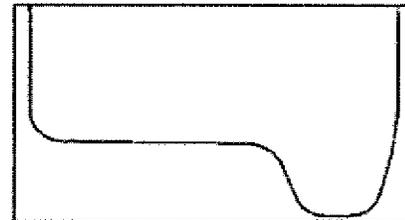


Figure 7. - Streetcar wheel profile.

(See Figures 6, 8, and 9) In general, the grooved rail sections that are available from Europe come in two varieties – those with flangeways that are too small for North American railroad wheel flange profiles and those with flangeways that are too large to satisfy guidelines of the Americans with Disabilities Act (ADA) for walking surfaces. Use of these European rails will usually require adoption of a European type of flange profile as is

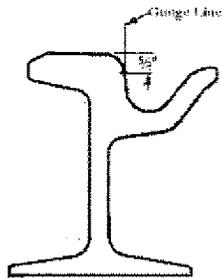


Figure 8 – US Grooved Girder Rail

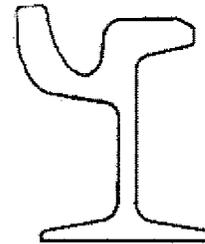


Figure 9 – US Grooved Girder Guard Rail

currently in use on a US transit system and illustrated in Figure 7. Grooved rails are sometimes made of softer steel than common T-rails. This is because the more complex shape of the grooved rail requires more passes through the rolls compared to T-rail. The temperature of the nascent rail is reduced with each pass and if the rail steel chemistry isn't soft enough, it may not be possible to make the last few passes without fracturing the rail. Some European suppliers can provide surface weldments to increase the durability of grooved rails, but results have been mixed. One manufacturer had just recently begun offering a heat treatment process for grooved rails, but the product has not been on the market long enough to be considered proven.

Most North American LRT projects have used T-rail for paved track installations, usually because railroad flange profiles were adopted. Methods for providing the requisite flangeway have varied, as have results. Similarly, methods and results for providing a guard rail in curves have varied by project. One method consists of a vertically-mounted restraining rail that is bolted to the running rail every two to three feet. A few projects have used a special rolled shape – strap guard – that mates with common 115RE T-rail and provides a flangeway that mimics that once provided by North American girder guard rails as is shown in Figure 5.

Guideline – *If grooved rail is used, then a wheel flange profile optimized for the girder guard rail should be adopted. Both the gauge and guard side flange angles from vertical and the tip radii on both the running rail and guard side of the flange should be analyzed for use on curve radii below 15 meters (49 feet) and adjusted for perfect compatibility if found necessary. Alternatively, a flange profile in use on a European property with curve radii equal to that to be used on the Light Rail Circulator System can be adopted. The flange should include the typical flat tip that works best with flange-bearing frogs, crossings, and switch points mates. (See Figure 7.) Such flanges are used at speeds of up to 100 km/h (62 mph) in Europe, so pose no constraints on system expansion. If grooved rail is used, attention should be given to its carbon content to ensure procurement of rail that is no softer than is necessary.*

5.3 Use of Bolted Connections

Light Rail Circulator System track embedded in concrete is not very maintenance-friendly. Access is only by jackhammer. Therefore, a goal of the track designer should be to design potential maintenance out of the system. One key component of the design should be to minimize bolted rail connections. Figure 10 illustrates a design in which bolted connections predominate. When alloy castings are used in special work (not a universal approach), it is still possible to electrically weld them if the right welding rod is used and the welder is skilled. The transit agency

should have its track designer evaluate the best techniques and locations for use of bolted and welded joints. Figures 11 and 12 illustrate two different approaches to this task. Thermit welding can also be used if frogs and points are made with carbon steel.

Guideline – Bolted joints should be minimized as much as possible. Any decisions regarding welding to castings should be contingent upon conversations with the potential casting supplier to confirm that the material composition being used lends itself to being welded without risk of thermal damage. The welding rod used should be recommended or approved by the casting supplier.

5.4 Control of Gauge

A common cause of difficulty in construction of Light Rail Circulator System track can arise from inadequate control of gauge during track construction. In small radius track arrangements the track must be very accurately gauged. Traditional railroad tolerances will often not suffice, particularly in maximally compacted arrangements featuring doubly-curved frogs, a technique which offers increased tangent track lengths for car storage and increased land for

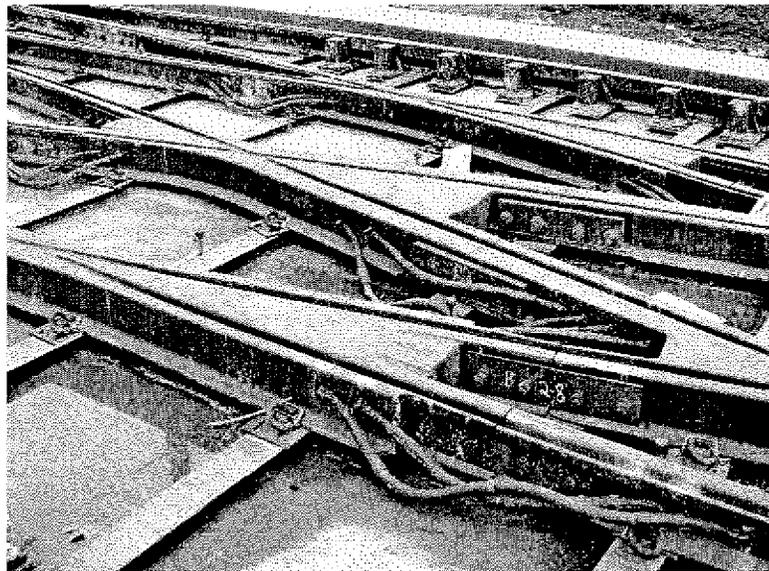


Figure 10. - Crossover consisting of grooved rail sections and castings, all bolted together.

storage buildings. Excessive gauge play increases the angle of attack of the flanges on the rails and results in increased wear. Figure 13 illustrates an extreme example of excessive gauge play, as can be deduced by the wide spacing of the flange paths on the diagonal rail. Figure 14 illustrates a typical compact storage yard layout. In construction of this type, without gauging devices, aggressive contractor monitoring is critical to achieving accurate gauging. Even greater compactness and land-use efficiency can be achieved by reversing the locations of switch point and mate and achieving a greater degree of interlace. Figure 15 illustrates this technique. The potential for gauge-related problems can be minimized by application of gauge bars, gauge rods, or steel ties, which remove the workmanship element from the track installation site and shift it to the gauging device manufacturing process. With any of these methods, fabrication errors made up to that point in the process can be detected at the pre-assembly checks. However, the use of gauge bars or rods significantly complicates the process of insulating the rails so as to deter stray currents. Attempts to insulate gauge rods with sleeves have had mixed results. Steel ties have fewer



Figure 11. - Cast crossing frog electrically welded to carbon steel grooved rail.



Figure 12. - Electrically welded connections between grooved rail sections and frog castings.

problems in this regard. In addition, when T-rail is used, steel ties are usually preferred as they can better accommodate the guard rails, as Figure 5 illustrates. Figure 16 illustrates a typical application of gauge bars. When coupled with careful shop bending of rails, gauge bars or rods can provide assurance that the as-built gauge is correct. However, bars or rods typically cannot correct a tight gauge situation since they have insufficient strength against buckling under compressive loads. Sharp radius curves, typically anything under 91.5 m (300 ft) radius, will usually require that the rails be pre-bent in a fabrication shop. Such bending is done with the rail "cold", using either a gag press or a roller bender. Rail bending is somewhat of an art form and careful measurements must be made during the process to verify whether the correct radius is being achieved. Due to their non-symmetric cross section, grooved rails, when bent horizontally, will usually twist about their longitudinal axis. The result is that the rail base will not lay flat. To counteract that, grooved rails must be cambered vertically before horizontal bending is

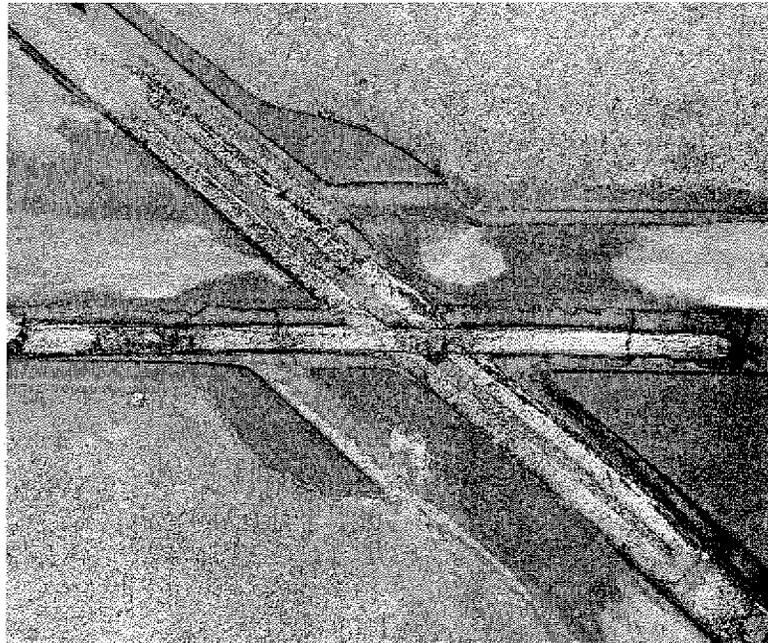


Figure 13. - Example of excessive gauge play.



Figure 14. - Typical compact track fan at a storage facility but without gauging devices.

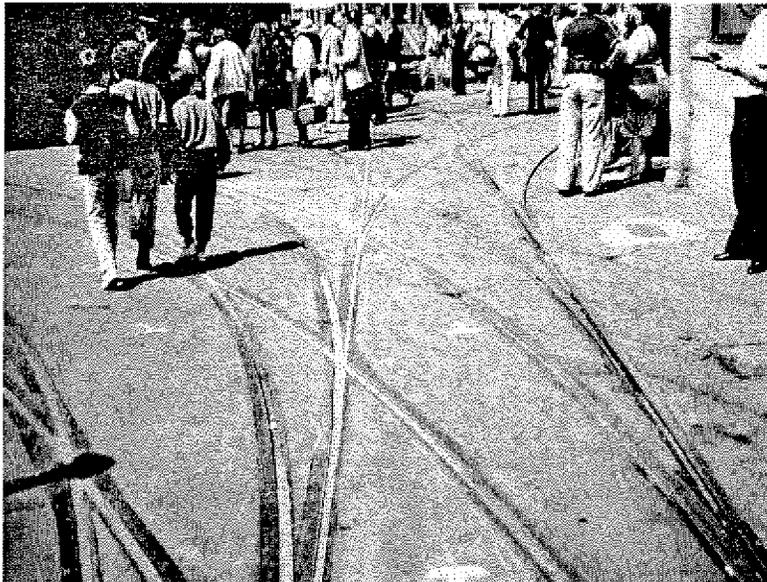


Figure 15. - Example of a maximally-compacted depot track fan. Noteworthy is the reversal of the point and mate locations for some of the turnouts to minimize the use of space.

done, with the amount and direction of the camber being dependent on the horizontal radius and whether the finished rail is on the inside or outside of the curve. Cambering is also necessary when it is desired to maintain a specific cant

in the rail. Extreme vertical curvature – generally any curve sharper than the natural sag of the rail when supported only at its ends – will also require shop fabrication.

Guideline – To avoid potential problems due to gauge inaccuracies, all special work containing turnouts and small radius curves should be designed and constructed with a positive means of maintaining the gauge. Full assembly including the gauging devices should be accomplished before they are embedded or are fastened to a concrete slab or invert. All gauging should be carefully checked during pre-installation assembly so as to detect any gauge device dimensional errors. Consideration should be given to constructing wheel-pair templates that will accurately simulate both new and worn wheel conditions. Supply of these can be made a part of the track supply contract. Alternatively, a Circulator vehicle truck (if available) can be pushed around through the track layout to determine if appropriate rail/wheel interaction is occurring, but it should be recognized that the worn wheel condition will not be present without modification. If it is decided to build plain curves without gauging devices, the templates or a truck can be used to check gauging of running and guard rail surfaces. With new wheels, both flanges should be in contact with their respective guidance surfaces. Regardless of the verification method employed, these checks should be done prior to the time when placement of embedding paving makes corrective actions extremely difficult and costly.

5.5 Special Work and Gauging Considerations

As can be seen in Figures 3, 14, and 15, LRT and Light Rail Circulator System turnouts can be found with both double points and with "point and mate" (single point) arrangements. Generally, double points are preferred for



Figure 16. - Typical gauge bar application in a turnout.

main track use, while single point designs are usually used in yards. Compact yard track layouts are sometimes only possible with single point turnouts. Mates are typically a casting, and flange-running through the mate compensates for the inability of the wheel tread to bridge the running surface gap that exists where the two flangeways join. Point and mate construction typically puts the point on the inside of the curve, as can be seen in Figure 14. From a ground vibration standpoint, the use of a mate is inferior to the use of a double-pointed turnout. Although the flangeway depth of the mate can be made to perfectly match the new wheel flange depth, wheel wear can result in a flange becoming deeper. Ramping the flangeway largely compensates for this at low speeds. In addition, transfer from the normal running radius of the wheel tread to the larger flange tip radius produces slippage since the two wheels of the

axle are running with different radii. It has not been uncommon in Europe to insert flange-bearing running rail opposite a flange-bearing frog to alleviate this. With the passage of time, these factors tend to result in the flange-bearing running surface of the mate having a rougher surface than a railhead would. Therefore, use of mates in other than low speed track is not common and they are best suited to use in low speed turnouts at junctions and yards.

Wheel tread widths on Light Rail Circulator System vehicles typically are smaller than railroad standard. Seventy six mm. (3 inches) is typical for paved track use, although historically many properties used 63 mm. (2 ½ inches). A typical profile is shown in Figure 7. The purpose of this reduced width is to minimize overhang of the wheel beyond the railhead and over the paving, as it is undesirable for the steel wheels to be crushing street debris into the paving. As a result, frogs used in turnouts and crossings are typically flange-bearing to minimize ground vibration caused when wheels drop into a gap when crossing an intersecting flangeway. At the point of intersection of the flangeways, cold rolling and wear will in time produce a "dimple" at that location. Where minimum ground vibration is desired, consideration should be given to having frogs made of weldable material. This allows fill-in of the "dimple" with welding followed by grinding to restore a smooth flange running surface. The turnout shown in Figure 16 contains such a frog. As with mates, frog decisions should be based on location and operating speed.

Where small radius curves and compact yard layouts are concerned, track gauging is very important. Likewise, girder rail flangeways are small and allow only limited lateral motion to occur before the flange contacts either the gauge face of the rail or the guard face. Typically, lateral motion of a streetcar wheel set is restricted to 3-6 mm. (1/8 to 1/4 inch), i.e., the wheelset gauge is 6-13 mm. (1/4 to ½ inch) less than the nominal track gauge. This value is known as the "Gauge Play". It increases with flange wear, and must be considered in designing the track. It should be noted that railroad Gauge Play is 17 mm. (11/16 inch), and if this is applied to paved track wider flangeways must be provided, or the track gauge can be reduced. It is important to note that while girder rails that accommodate railroad wheel flanges without requiring track gauge reduction are available, they come with flangeways wider than are appropriate in a street environment.

Guideline – *In locations where ground vibration is a concern and turnouts are installed solely for operational flexibility under abnormal conditions, a design in which the frog has no flangeway for the abnormal traffic path should be considered. In such a design the flangeways of the abnormal path are ramped up on either side so that the diverging movement flange is lifted to the height of the normal path railhead so that it may roll across it. Alternately, if a shallow angle frog is used and the flangeway width is minimized, it may be possible for the chosen wheel profile to bridge the flangeway and make flange bearing unnecessary. Single point turnouts, which are used to minimize cost and maintenance requirements, are best restricted to low speed locations.*

5.6 Trackway Paving

5.6.1 Purpose of the Paving

A light rail transit track might be embedded in paving for one or more purposes.

Roadway driving surfaces for general traffic - If the Circulator lane is shared with rubber tired traffic (either along the track in a shared lane or transverse to the tracks at an intersecting street) paving provides a generally smooth riding surface for the general traffic, concealing all but the top horizontal surfaces of the rails.

Pedestrian crosswalks - Providing a safe path for pedestrians across tracks requires careful attention not only when they are in private right-of-way but also when the trackway is in an urban street. Because of safety considerations, including compliance with the Americans with Disabilities Act (ADA) guidelines in the US, or similar legislation in other countries, the physical location of crosswalks relative to track hardware, as well as the pavement surface provided for pedestrians, must be carefully considered. It is desirable to avoid placing crosswalks in areas of special trackwork and vice versa. In particular movable switch points (either power or manually operated) should not be installed in pedestrian paths. Because steel surfaces can be slippery when wet, large special trackwork fabrications should also be segregated from crosswalks. When T-rail is used, fitting metal edging to the flangeways at pedestrian crossings should be considered. This serves to minimize the flangeway width and ensures

that the width will not widen with age-related wear. Figure 17 illustrates excessive flangeway width in a pedestrian crossing zone.

Trackway housekeeping - Sometimes it is desirable to embed a light rail track in paving even if rubber tired or pedestrian traffic is not a consideration. Most often this is done for housekeeping purposes in urban environments where an open track structure – such as tie and ballast track or direct fixation track – would tend to collect trash or



Figure 17 - Flangeway with excessive width that is incompatible with small wheels in a pedestrian crossing area.

present problems for street drainage. If rubber tired traffic is not a consideration in such areas, the paving structure can sometimes be less robust than a shared traffic area although this could inhibit both the ability of public safety vehicles (e.g. police, fire and ambulance) to use the trackway in an emergency. It could also restrict railway maintenance forces from driving rubber tired equipment along the trackway while performing inspection and maintenance on the overhead contact wire systems.

5.6.2 Types of Paving Materials

Reinforced Concrete - Concrete is arguably the most structurally durable type of trackway paving and has been used for LRT and Circulator tracks in many cities. It is particularly well-adapted to use with the popular rubber rail boot method for electrical insulation and vibration isolation of the rail. However, concrete paving can have problems related to improper design and construction. Cracking is common unless concrete control joints are carefully positioned on the plans and similarly constructed in the field. Disintegration of the surface of the concrete – particularly in corners of slabs and at control joints – is a common problem that is directly related to poor construction controls. In northern climates, these problems are abetted by freeze thaw conditions and the use of de-icing chemicals in the street. If a concrete trackway surface is desired, the responsible agency needs to make certain that the construction specifications are rigorous and that sufficient construction inspection resources are budgeted to make certain that those specifications are followed to the letter. In urban districts, where there are numerous utility lines within the street right-of-way, there are drawbacks to concrete as compared with other paving materials. Repaving following excavations for utility maintenance/repair work not only leaves a noticeable blemish, but also can allow seepage of water leading to erosion and (in colder climates) mechanical damage from freezing and thawing. Cosmetic issues can be addressed to some extent by adding color pigmentation to the concrete.

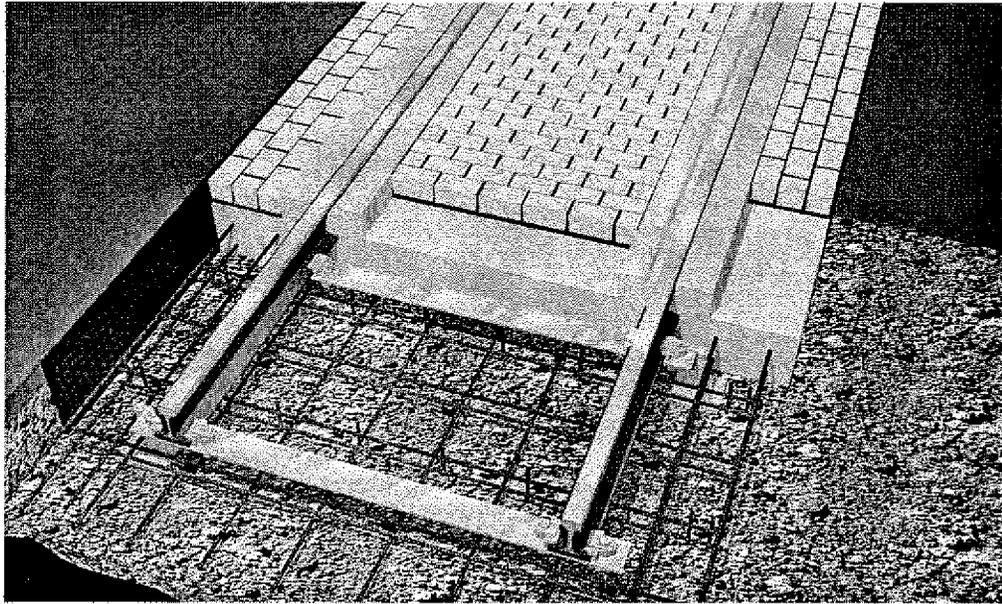


Figure 18. - Track design with T-rail and block pavers.

Bituminous Concrete/Hot-Mix Asphalt/Blacktop - Known by various names, asphalt was often a paving choice on legacy streetcar systems. Many systems used full-depth asphalt directly over ballasted track of conventional construction although such expedient construction generally had a short service life. A more durable variation on this placed plain cement concrete up to within about five centimeters (two inches) of the top of rail, and then placed an asphalt overlay up to the top of rail. That type of construction generally works well, provided that all concerned recognize that the asphalt is a sacrificial layer that will have a much faster rate of wear than the steel rail and will usually need to be removed and replaced periodically – possibly as often as every five years. This type of construction could be adapted to the use of the rubber rail boot, although extreme care would need to be taken to avoid damage to the top edges of the boot during placement of the hot asphalt and during later milling of adjacent deteriorated asphalt.

Pavers - Various type of pavers (e.g. granite blocks, cobblestones, bricks, etc.) are popular choices for decorative paving in urban areas and such materials are thus often specified for paving of LRT tracks in sensitive zones. One such use is the preservation or restoration of historical street paving. Traditionally, brick or block pavers were often used as paving around tracks on legacy streetcar systems, often long after municipal authorities elected to use concrete or asphalt on street reconstructions. Various types of pavers have been employed on both legacy and modern light rail lines. These include granite blocks or slabs of various depths/heights, fired clay brick, and manufactured pavers made of concrete and other materials. Figure 18 illustrates a typical design using block pavers.

Designers who are interested in clay brick pavers should first understand that the type of brick used in street construction 60-plus years ago is no longer commercially available. That material was called re-pressed brick, had a formed and glazed finish on all six sides, and was manufactured in accordance with ASTM C-7. Modern clay paving brick does not go through the manual re-pressing process and hence has two wire-cut faces that are porous and less durable. Traditional pavers also had lugs extending out from the sides of the brick so as to provide a 3 mm. (1/8 inch) gap between each brick and its neighbors. This gap allowed relative movement between the bricks and saved them from mechanically damaging each other as heavy wheel loads pass down the street. The other major difference between the way brick streets were constructed 60 years ago and the methods now used has to do with construction details.

Contemporary paver streets are often laid on a bed of sand which in turn is directly above a compacted granular subbase. Such construction is seldom up to the rigors of heavy loading such as from trucks or buses. Seventy-five years ago, a typical brick street would have had a granular base, covered by a reinforced concrete slab. Above the concrete, a thin layer of asphalt would have been placed to provide a level setting bed for the brick pavers. Today, sand or a sand/mortar mixture is usually employed to fill the joints between the bricks. This kind of hard material makes it difficult to for the bricks to move relative to each other, particularly if the pavers do not have lugs to keep them apart. It also does not exclude moisture from penetrating the surface of the street. First class construction 75 years ago would have filled the joints between the lugged bricks with hot tar, which retains some flexibility even at low temperatures. It is also self-healing so that even if the tar cracks, it will flow back together and maintain a impermeable surface on the street. A lime whitewash was typically applied over the top surface of the bricks prior to spreading the hot tar so as to keep the tar from adhering to the visible surface.

While it may be possible that some manufacturer could be persuaded to tool up for making re-pressed paving brick, it is certain that they would be quite expensive compared to alternatives with less visual appeal. Small projects might be able to use recycled brick from old streets, but on larger projects it would likely be impossible to come up with enough brick that is both in good condition and all of the same color.

Stone pavers are subject to some of the same sorts of considerations as clay brick. The stone pavers used on legacy streetcar systems were usually close to the size of a loaf of bread, sometimes larger or smaller. Their vertical dimension was often between 18 and 20 cm. (7 and 8 inches), largely because of the 23 cm. (nine-inch) tall girder rails that were commonly used for city streetcar lines. Because of manufacturing tolerances at the quarry, these stone block pavers resulted in a street surface that was equally rugged to view and to drive upon. Many streetcar companies continued to use recycled stone block paving for years, possibly in part because the rugged surface discouraged timid motorists from driving in the trackway and getting in the way of the streetcars. Architectural paving stones that are less than 13 cm. (5 inches) thick are probably not suitable pavers for track areas that are subjected to any significant amount of roadway traffic. If track is installed in an area in which horse-drawn tourist carriages are used, consideration should be given to the use of granite block paving, as even concrete will not long survive the horse's steel shoes.

Stamped concrete and stamped asphalt -- This technology attempts to achieve the visual appeal of genuine pavers in track areas at relatively low cost. However, it is probably not suitable for areas with high levels of motor vehicle traffic.

Track in Grass - While strictly speaking, grass is not a paving material, it has an obvious appeal for areas where paving isn't needed for either rubber-tired or pedestrian traffic but an attractive appearance is desired. Like all designs, it has its place but it also has some shortcomings. The following issues are offered for thought by those who might be considering track in grass on some portion of a Circulator project:

It is probably best limited to temperate climates where snow and snow removal is not an issue. The usual snowplow truck would likely destroy the turf in the track area during a winter of frequent plowing. In addition, it would be very easy for snowplow drivers to absentmindedly activate their truck's salt spreader while plowing the tracks, doing even further damage to the trackway.

Achieving electrical isolation of the rails in grassed track is possible, but doing so correctly and in a manner that will prevail over the long term is expensive.

Grass should be kept at some distance from the rails in order to avoid lubricating the rail/wheel interface. Accordingly, contrary to what is the common impression, more than just the top of the rail surface will be visible. The grassed track area will often blend in so well with the urban fabric that the fact that it is NOT a public park area may be lost on a significant percentage of the population. Some grassed track areas in New Orleans have become popular jogging trails, much to the dismay of streetcar operators.

5.6.3 Flexible Materials

It is often pointed out that extruded rubber products are commercially available that can be inserted in a flangeway, leaving a level surface. These products deflect under the weight of the rail vehicle and then spring back up after passage. Such products are designed for use indoors and in outdoors in temperate climates. They are also intended for very slow rail movements – 8 km/hr (5 mph) maximum. They are not suitable for outdoor areas that are subject to freezing, nor are intended for areas where rail car velocity is higher than walking speed. They also are not likely to be durable under very frequent repeated use such as would be encountered on a Circulator rail line.

5.6.4 Drainage

The flangeways interrupt the normal flow of storm water across the surface of the street and act as gutters that convey water to a low point along the track. The flangeways must be drained at the low point of any sag vertical curve, particularly in northern climates where water could freeze in the flangeway and cause a derailment. Drains must also be provided immediately upstream of any switches in paved track so that the street detritus that accompanies the run-off isn't washed into the switch mechanism. Drains are also recommended immediately upstream of any point where embedded track changes to open track so that this residue does not foul the open track area and possibly become the origin of stray current leakage. Drains must connect with nearby drain lines for the adjacent pavement lanes, and the drain entrance ways must be sufficiently large so as to not be easily blocked by dirt and leaves. When grooved rails are used, a slot of appropriate length should be cut into the bottom of the flangeway and made as wide as the rail design allows so that the drains will not be easily blocked, as can happen with smaller drilled holes.

5.6.5 Climate Factors and Paving Durability

Designers of paved track systems have far more latitude in temperate climates than in frost belt cities. If the paving will be subject to freeze-thaw cycles and de-icing chemicals, the design must recognize those factors.

5.6.6 Paving Maintenance Responsibility

At the beginning of the 20th century, it was uncommon for city streets to be paved. In exchange for municipal permission to build and operate a streetcar line, legacy systems were therefore usually saddled with the responsibility of both constructing and maintaining the paving in the trackway. Some paving designs are far more expensive to construct and/or maintain than other. Designers of Circulator rail lines with paved track should consider who will be responsible for both the cost and the action of maintaining the paving in the track area before finalizing a design.

In situations where the transit agency is responsible for maintaining the paving in the track area, it is sometimes a good practice to have a visually-obvious line of demarcation between the transit agency's paving and paving that is maintained by the municipality or highway agency. That line should never be inboard of the dynamic envelope of the Circulator vehicle.

5.6.7 Paving Cross Slope and Track Superelevation

Ideally, the two rails of a tangent Circulator track will be at the same elevation. This is rarely possible when the track is embedded in a street since most pavements have cross-slopes so as to promote surface drainage. In the past, it was very common for streets to have a parabolic crown with the actual side slope of the pavement varying from near nothing at the center of the street to a significant figure at the curb lines. Since the tracks of legacy streetcar systems were usually located in the center of the street, there would be relatively little cross slope between the rails. Today, a straight percentage cross slope is the usual pavement design – 2% is common. That much cross slope across a track effectively introduces about 3 cm. (1 1/8 inch) of superelevation in the track, regardless of whether it is needed. Negative superelevation can result if the normal pavement crown is carried through a curved track area. The track and pavement designers must carefully coordinate their efforts to minimize any need for excessive cross

slope in the track areas. Their analysis should include recognition of how the flangeways intercept storm water runoff and hence change the paths for storm water compared to a street without rails.

Typically, it will not be possible to incorporate much superelevation in a track that is constructed in a public street and must conform to existing street pavement elevations. A common error is to presume that since no superelevation is used, that there is no reason for using spiraled transition curves. To the contrary, it is even more important to use a transition curve leading into very sharp radii so as to reduce the rate of change of lateral acceleration experienced by



Figure 19. - Turnout with housed point.

both the vehicle and its passengers. Aptly called "jerk rate", this factor can be controlled through use of transition curves of appropriate design. Usually, the transition curves used on street railway curves are not mathematical spirals, but rather a series of compound curves that decrease in radius and then increase following a set pattern. These transition curves can also be used to control the "end-overhang" of the circulator vehicle where it enters and exits curves so as to avoid or minimize clearance conflicts with trackside obstructions or general vehicular traffic in an adjacent lane.

6. Use Of Vehicles With Independent-Wheel Trucks

Some transit agencies have had incidents of derailments of the center truck of their low-floor LRT and Light Rail Circulator System type cars. In both cases the center truck is of the type in which the wheels are independent of each other, that is, not mounted on the same axle, but mounted on four short axles, two on each side of the truck. This design allows for the low floor to be continued through the short body section that is carried on the center truck. Figure 1 illustrates such a car design. It appears that forces on the flanges are greater on independent wheels when traversing curves than on conventional 2-wheel axle sets. At one agency this appears to be substantiated by a greater rate of wear of the flanges on the independent wheels. The Interface Journal paper "Flange Climb and Independently Rotating Wheels" is an examination of the factors involved. It is a fact that there are hundreds of Light Rail Circulator type cars with independently rotating wheels in successful operation in other parts of the world, which raises the question as to why such a design should be problematic in North America. A common thread might be that overseas they operate on track which possesses greater margins of safety against derailment by use of very high percentages of grooved rail. (As noted previously, European grooved rail provides the equivalent of double-

guarding at all points in the track structure.) Further, in Europe, where T-rail is used on open track, curves are typically gentle and well guarded where needed. If cars of this type are to be used on a Light Rail Circulator System, it will prudent to carefully consider the track design in all aspects to ensure its suitability. An area to be given strong consideration is rate of change in track cross-level, typically encountered in the build up or run-off of superelevation. Modern multi-truck light rail cars are less tolerant in this area than earlier double-trucked cars. Track and vehicle design should be coordinated at an early stage to ensure that both parts of the system are fully compatible.

Guideline – *If T-rail track construction is used, sharp curves should be double-guarded. (See Figure 14.) Switches should have curved points and at least one should be housed. (See Figure 19.) Gauging should be such that it is impossible for a flange to climb on top of the running rail. If single point turnouts are used, points should be placed on the inside of the curve. If the point must be placed on the outside of the curve, the point should be recessed (See Figure 3.) and application of a friction modifier to the mate surfaces is desirable to reduce flange forces. The mate design should provide a guarding surface that ensures that the point-side flanges cannot travel into the recessed area. Ensure that the vehicle and track designs are fully compatible in the area of rate of change of cross-level.*

7. - Compatibility of LRT and Light Rail Circulator Systems

As noted previously, Light Rail Circulator Systems can be expanded into broader areas and function as line-haul LRT systems. If a Light Rail Circulator System is added to an existing LRT system it will be necessary to consider carefully the physical interfaces of the two. Primary areas of concern are the track interface and the platform interface. Some Light Rail Circulator System-suitable car floor heights now existing are:

- Portland Streetcar – 350 mm. (13.8 inches)
- Brussels Bombardier Flexity – 350 mm. (13.8 inches)
- Boston Type 8 – 355 mm. (14 inches)
- Nordhausen Combino – 300 mm. (11.8 inches)
- Ansaldobreda Sirio – 350 mm. (13.8 inches)
- Alstom Citadis – 350 mm. (13.8 inches)

Note - Some cars have the floor ramped downward at doorways to achieve a lower threshold height.

In addition to the need to match the height of the vehicle and the car floor, the relative width of the vehicles must be considered. For example, the Skoda-Inekon vehicles used by the Portland Streetcar line are 190 mm. (7.5 inches) narrower than the low floor light rail vehicles used in the same city. The light rail vehicles would not be able to fit past the streetcar route's platforms. The streetcar would easily pass the light rail platforms, but the resulting wide stepping gap between the door sill and the platform edge would require an on-demand bridge plate to be deployed to satisfy ADA requirements. This situation has not arisen thus far in Portland because the streetcar vehicles do not run on the light rail tracks in revenue service.

The wheel-rail interface compatibilities will also need to be considered. At present only one city, Portland, has both LRT and Circulator type systems in operation, however no joint track use occurs in revenue service, so the issue of platform compatibility has not arisen, and both wheel-rail and power supply compatibilities have been accomplished. Since Portland Streetcar has a relatively generous minimum radius of 18 m. (59 ft.), wheel-rail compatibility has been easily obtained by using the LRT wheel profile on the Light Rail Circulator System cars. Also, the Portland LRT cars can be considered as having a Light Rail Circulator System wheel profile, as grooved rail is used on paved track. In cases where the existing LRT has been built to railroad standards of wheel and track, existing tangent track will not present any problems, but curves and special work may need careful analysis to determine if any problem areas exist, followed by deciding how to deal with them.