

# UC Berkeley

## Earlier Faculty Research

### Title

Investigating the Possibility of Using BART for Air Freight Movement

### Permalink

<https://escholarship.org/uc/item/8067t840>

### Authors

Lu, Xiao-Yun  
Hanson, Matt  
Graham, Michael  
et al.

### Publication Date

2008-12-01

# Investigating the Possibility of Using BART for Air Freight Movement

*2<sup>nd</sup> National Urban Freight Conference, Dec. 5-7, 2007, Long Beach California*

**Xiao-Yun Lu (Corresponding Author)**  
PATH, Institute of Transportation Studies  
University of California, Berkeley  
Richmond Field Station, Bldg 452  
1357 S. 46th Street  
Richmond, CA 94804-4648  
Tel: 1-510-665 3644, Fax: 1-510-665 3537  
Email: [xylu@path.berkeley.edu](mailto:xylu@path.berkeley.edu)

**Matt Hanson**  
Division of Research and Innovation, Caltrans  
1127 O Street  
Sacramento, CA 94273  
Email: [matt\\_hanson@dot.ca.gov](mailto:matt_hanson@dot.ca.gov)

**Michael Graham**  
Manger - Regional Sort Operation, Planning and Engineering  
FedEx Western Regional Hub  
1 Sally Ride Way, Oakland, CA 94621-002  
Email: [mkgraham@fedex.com](mailto:mkgraham@fedex.com)

**Eugene Nishinaga**  
Manager – Research and Development  
San Francisco Bay Area Rapid Transit District (BART)  
300 Lakeside Drive, Oakland, CA 94612  
Email: [Enishin@bart.gov](mailto:Enishin@bart.gov)

**Richard Lu**  
San Francisco Bay Area Rapid Transit District (BART)  
300 Lakeside Drive, Oakland, CA 94612  
Email: [Rlu@bart.gov](mailto:Rlu@bart.gov)

**Key Words:** San Francisco Bay Area, BART, air freight movement, feasibility

**Total Number of Words:** 5796 + 250x5 (figure) = **7046**

## **1. Introduction**

The San Francisco Bay Area has one of the most congested metropolitan corridors in both California and nationwide, with very high demand for both passenger and air-freight transport. It is also a main entrance to the United States for the huge Asia market, and thus critical for the United States to play a leading role in the global economy. On one hand, traffic congestion in the main corridors through the Bay Area is severe and is becoming worse with the rapid increase of population and the development of the local economy, in which a substantial impact is created by truck-related activities such as the ever increasing air freight business (performed by companies such as Federal Express, UPS, DHL, and CNF). On the other hand, the San Francisco Bay Area Rapid Transit District (BART) operates a regional environmentally-green transit system has excess capacity during non-commute periods and during the commute on some lines in some reverse-commute direction. If the BART system were to be used by the air-freight delivery service providers, BART could probably provide reliable service to integrated air freight carriers to meet their limited-time window delivery service needs. This would lead to additional revenue generation for BART. For the traveling public as well as local, regional, and state government it would reduce truck activity, and its corresponding negative impacts on traffic, environment, safety, land use and the economy. Using BART for air freight movement as a model for combined goods and passenger movement can be generalized to other critical corridors nationwide to effectively relieve corridor congestion problem. Improving movement through these critical metropolitan corridors could yield significant benefits in terms of reduced travel time and delays and increased reliability and predictability of both passenger and freight movement.

### **1.1 Characteristics of Air-Freight Delivery**

Air freight delivery in the US has been dominated by a few integrated carriers such as FedEx, UPS, and DHL (Lu et al, 2006a, 2006b). The services are not just restricted to air-freight in practice, as most land delivery services utilize trucks for the final leg(s) of the journey. A primary interest of the air-freight transportation industry is to develop intermodal transportation chains to provide seamless door-to-door service. The main

characteristics of these integrated carriers are: (a) package/goods size/amount are relatively small but of much higher value than those of land/sea goods movement; (b) the packages/goods need to be delivered to end-users within a limited time window (a narrow period, especially with regards to express services); and (c) the ground transportation in the air-freight door-to-door service chain usually involves trucks traveling from: airport ⇔ airport/off-airport sorting site(s) ⇔ local distribution/collection center(s) ⇔ end-users. The features of the door-to-door service chain are:

- Sorting sites and local dispatch centers are generally located near airports along a hub-and-spoke network configuration, so goods movement is closely tied to airport ground traffic patterns;
- Trucks/vans are tracked and monitored in real-time by a centralized dispatch control;
- Carriers employ an aircraft fleet for moving freight between airports, generally at night;
- Long-haul truck fleets are used for moving freight between terminals, and may be used also for sorting and processing freight;
- A fleet of trucks/vans are used for local pickup and deliveries;
- Trucks are used for long distance haul.

Each respective integrated carrier operates hundreds of trucks daily to stations for all day operation, and retains empty containers, which generates large amounts of Vehicle Miles Traveled or Vehicle Hours Traveled (VMT or VHT respectively).

Limited-time Window Delivery and Traffic Congestion: More trucks need to be on the road during peak periods to meet delivery commitments, particularly in the evenings in the West Coast according to FedEx. Truck movements experience significant roadway congestion on the way to/from, and in the vicinity of, major airports as well as moving back and forth across the San Francisco-Oakland Bay Bridge. Time-sensitive intermodal delivery service operating under congested traffic conditions faces two challenges:

- Overall time limitations in delivery – re-dispatching is necessary if it has been subjected to time delay of air cargo’s arrival (subject to the impact of air cargo

- operation), which results in more trucks on the roads and further impacts general traffic;
- Limited time window at each step along the delivery chain: missing one window may cause the missing of the following windows in the chain, which will create an adverse domino effect for the carrier.
  - Delivery delays will directly affect the service quality and cause a loss of revenue. Using the BART system away from the congested traffic will significantly improve the service.

## **1.2. Characteristics of BART**

San Francisco Bay Area Rapid Transit (BART) is a mass rapid transit system built for passenger movement in the San Francisco Bay Area. It is an inter-regional railway system crossing 26 cities and 4 counties, but the impact it has on congestion relief benefits a far greater number of adjoining communities throughout the region. In 2004, BART was recognized by the American Public Transit Association as the best transit system in the US in its class. Its function and importance can never be underestimated. This is witnessed by the serious accident at the "MacArthur Maze" cloverleaf freeway interchange in Oakland - resulting in a horrendous fire that destroyed one of the busiest commuters and trucking routes in the nation. State and local officials warned about traffic delays and nightmare gridlock scenarios until the freeway was fixed. During this period, BART played an excellent and critical role for linking between San Francisco and the East Bay.

This year also marks the 35th year that BART has provided service to a growing and diverse Bay Area. And in those more than three decades, BART has not only continued to provide an alternative to driving on congested freeways, but it has also greatly benefited the region by reducing the reliance on imported oil, spurring the local economy, encouraging infill development and housing, reducing air pollution and greenhouse gases and helping to connect diverse neighborhoods and communities. Recent media sources cite that without BART, there would be 15.2 million additional pounds per day of pollutants released into the air, and commute times would increase dramatically (the Bay

Bridge commute would increase from 40 minutes to 2.2 hours, and the Caldecott route would go from 24 minutes to 3.25 hours).

BART system is primarily designed for inter-regional passenger transport. Due to main freeway traffic congestion, particularly, the peak hour congestion at the Bay Bridge, the BART system becomes more and more important for timely transport within the Bay Area. However, one fundamental problem for the BART system to be used to its full capacity is the link of the BART station to work places in those areas with less population density. In these outlying areas, bus service is not as frequent due to low demand. Other factors may be due to the habit: most commuters prefer to drive instead of using transit, which can be perceived by some to be slow and inconvenient to use. Due to those problems, the demand for BART system is about 30% of its capacity on-average. More specifically, some lines in peak hours may have higher passenger demand such as the line towards San Francisco in the morning, and from San Francisco in the afternoon. But in other times, the passenger demand is lower than that. Thus BART needs to run shorter consists for operational and fiscal economy. This means that some capacity of the BART system exists, for example, lines in the East Bay and line to San Francisco off AM peak and from it off PM peak, which could be used in a more judicious way.

## **2. Potential Benefits for Combined Passenger and Freight Movement**

Although, passenger movement and freight movement are quite different in nature, chances still exist for them to share some transportation facilities. This is particularly true for air freight movement. This is because air freight movement is usually conducted under seamlessly security control: collection, sorting, containerizing, air shipment, and distribution. Those tightly and securely controlled containers or similar products could possible be inserted in the green type transit system such as BART for local shipment whenever possible. To put into reality, many issues need to be investigated, but the primary concern would be business case: the benefit to both air freight carriers and BART for doing so.

### **2.1 Air Freight Carriers**

A primary interest of the air-freight transportation industry is to develop seamless transportation chains to provide intermodal door-to-door service (Lu et al, 2006a, 2006b; Tsao and Rizwan, 2000). The characteristics of the air-freight business dominated by a few carriers (FedEx, UPS and DHL) are: (a) package/goods size/amount are relatively smaller but of much higher value than those of land/sea goods movement; (b) the packages/goods need to be delivered to end users within a limited time window (a narrow period, especially with regards to express services); and (c) the ground transportation in the air-freight door-to-door service chain usually involves trucks traveling from: airport ⇔ airport/off-airport sorting site(s) ⇔ local distribution/collection center(s) ⇔ end user. The characteristics of the door-to-door service chain are:

- (1) Sorting sites and local dispatch centers are generally located near airports along a hub-and-spoke network configuration, so goods movement is closely tied to airport ground traffic patterns. As an example, FedEx Western Regional Hub is located at Port of Oakland. All the packages from/to the states within the western region of the US will first be shipped to the hub, then sorted and send to the destination by airplane.
- (2) Trucks/vans are responsible for local ground transport for dispatching and collection, which are tracked and monitored in real-time by a centralized dispatch control;
- (3) Carriers employ an aircraft fleet for moving freight between most airports, and the Hub generally at night;
- (4) Long-haul truck fleets are used for moving freight between terminals, and cities within certain range in place of airplane, and may be used also for sorting and processing freight;

As an international leading company, FedEx business is increasing rapidly in recent years. At the same time, FedEx is actively searching new technologies and transportation alternatives which could potentially improve the delivering service, and at the same time, to reduce truck trip for the interest of the public. The view of the FedEx is an efficient and integrated intermodal transportation system which combines both passenger

movement and freight movement. In general, air freight carriers would choose freight delivery alternatives based on the following factors:

- Current demand and area demand (the amount of products the air freight carriers to be transported through the alternative system)
- Business expansion of air freight carriers implies more product types and large demand on each product
- Capacity and development of alternative system
- Service types
- Reliability for dispatching/collection
- Operation frequency
- Empty container returning
- Travel time
- Cost for shipment in dollars and time
- Trans-shipment cost in dollars and time

In summary, integrated carriers need more reliable, frequent, and congestion-free transport modes to improve their ever-expanding, limited-time window services.

## **2.2 More Efficient Use of BART Facility**

BART is a regional rail transit system that serves approximately 340,000 passenger trips per weekday. Despite BART's excellent track record in moving people, system utilization was at 29.3% in 2004 of its mainline capacity. This statistic indicates that although many passengers use BART, they do so during periods of peak demand in certain directions, leaving much unused capacity during off-peak hours and in some reverse-commute directions during peak hours. BART continues to aim for increased usage of the remaining 70.7% of its overall capacity through marketing and other strategies to bring in more riders.



In a broader sense, BART capacity can be looked at from two viewpoints: The primary viewpoint is the capacity of mainline, or track, which can be measured by the number of consist can run and the maximum number of trains in each consist. The second viewpoint involves Yard, vehicle (seating) and station (platform access and egress) capacity for transport but not restricted to passengers only, which is related to the dynamics of tail-track and storage track capacity. In either case, the total capacity minus the passenger demand produces the *extra capacity*. To understand where and when the extra capacity exists is critical to primary service, revenue service staging and scheduled maintenance procedures. Here the revenue service staging means other possible services beside the primary passenger service.

Looking into the future, the BART's new vision (Cabanatuan, 2007) for development has been blueprinted by the Committee Board and transportation experts as including: (a) adding extra tracks to allow direct service to pass; (b) build more light rails to link with BART main lines to improve connectivity in densely populated areas; (c) add I-680 corridor line; (d) link to Warm Springs and San Jose; (e) add connections with high speed rail and other rail services; and (f) start to think about the second Trans-Bay tube with four bores. It is expected that future development according to the blueprint will significantly increase BART capacity and service quality in near future.

### **2.3 Local Communities and the State**

It is also necessary to look at the problem from the viewpoint of local community and the State. It is the local community and the state's interest to develop a transportation system with high efficiency, mobility, sustainability, safety with minimum pollution and land use. This is required by the expectation that the transportation system is the backbone for globalized economy and high quality of social life with the rapid development of population in the Greater Bay Area.

#### **2.3.1 To Reduce the Number of Trucks**

As indicated in the research results of MTC's Regional Goods Movement Study (2004), air cargo business in the Bay Area at 1998 levels will double by 2010 and triple by 2020, due to the increase of the U. S. economy and global economy. Trucks are the primary ground mode for air-freight door-to-door service delivery for all the integrated/non-integrated carriers connecting airport/sorting and customers. However, trucks have significant impacts on four areas of public interest: safety, traffic congestion, air pollution and security.

**Safety:** As reported in previous research, 80% of the victims killed in crashes involving trucks are occupants of smaller vehicles. Reducing trucks on busy highways can reduce such fatalities.

**Security:** Due to its size and potential destruction capability, terrorist might use trucks as weapons to attack. To reduce truck activities to/from the airport is to improve the security of airports and bridges across the Bay.

**Air Pollution:** Truck activities have a great impact on the environment. Ground level ozone, the main ingredient smog, is formed by complex chemical reactions of Volatile Organic Compounds (VOC) and Nitrogen Oxides (NOx) in the presence of heat and sunlight. Particulate Matter (PM), a diesel engine pollutant, is easily inhaled and disposed in lungs. Goods movement generates emissions both during on-roads activity (truck driving) and non-roads activity (cargo loading/unloading and idling). The reduction of pollution is proportional to the reduction of truck activities.

It is anticipated that in a long run, using excess BART capacity for freight delivery to reduce truck transport will improve traffic congestion, reduce air pollution, and improve economic land use, driver safety and public security. Although, some baby steps have to be taken at the beginning, the potential benefit for combining passenger and goods movement on the rail transit systems should not be underestimated.

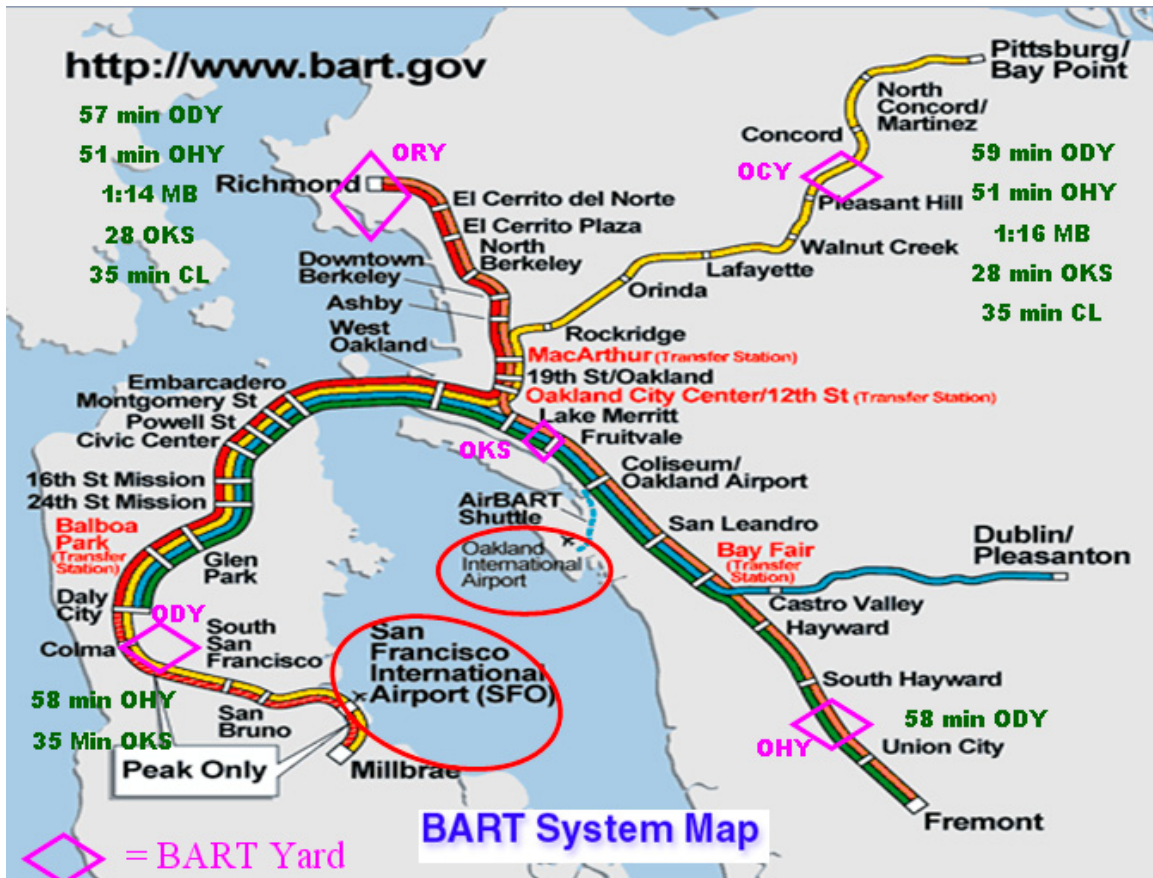


Figure 1: BART System Map, with yards and travel times between strategic facilities

### 3. Necessity of Feasibility Consideration

The feasibility consideration of using the BART system for air freight movement is necessarily the first step. It is to investigate the main challenges and opportunities from a systems approach. The consideration will involve both technical and institutional issues which can be classified as follows.

(1) Business case:

- Business Opportunity for BART:
  - Revenue analysis - All expenses related to the freight role should be identified and weighed against all revenue generating scenarios to see if the idea can be profitable.
  - Liability issues should be identified and ownership for them outlined.

- Benefit to the community as a public entity;
- Business opportunities for FedEx:
  - Cost for using BART: container, loading/unloading, security scanning, etc.
  - Benefit for using BART in terms of service quality: reliability for limited time window delivery, simplification in operation logistics, etc. to meet the ever increasing in demand and heavily congested traffic
  - Benefit to the community

(2) Infrastructure Feasibility: It is recognized that the main problem related to infrastructure feasibility and container transshipment time/cost from the BART system. Infrastructure involves: (a) stations, platforms, yards accessibility and location for conveniently loading/unloading containers/goods; (b) vehicles and container compatibility, mainly container size; and (c) trans-shipment equipments from/to rail cars.

(3) Operation and logistics feasibility for both BART and FedEx:

- Using freight car with passenger train or using dedicated freight train
- loading/unloading /routing of dedicated air-freight train
- Scheduling – Dedicated freight car traveling through the BART System without affecting scheduled revenue service
- Qualified Personnel available to plan and perform cargo operations

(4) Safety and Security Issues in Operations: It is a coincidence that BART system and FedEx products naturally satisfy the security requirement: BART system operates in a closed environment. Screened FedEx products suitable for BART system, required by BART system and without loss of any security through BART system. However, trans-shipment protocols need to be designed to guarantee seamless connection between FedEx and BART system.

(5) Institutional Issues: We will study the institutional issues for using BART in air freight delivery from several aspects. BART system belongs to public while integrated air freight carriers such as FedEx is private entity. There will naturally legal issues to do so.

Besides, most FedEx products are ensured. How such insurance can be continued through BART system (public acceptance, legal and constitutional issues if any).

- Synergy of Private Business and Public service
- Liability issues

Screening of cargo is already a nominal function performed by private delivery companies. The ideal and most cost effective scenario would be if cargo could be screened prior to arriving at BART while ensuring that access to cargo is restricted the whole time it is in transit to and within the BART System.

(6) Performance Evaluation: Quantitative methods will be used to evaluate the performance of using BART in air freight delivery. This evaluation will be conducted from three aspects: Integrated air freight carrier FedEx, BART, the society and the state.

- FedEx: Improvement on current and future service quality, profit, and business expansion
- BART: Improvement on Current and future revenue, capacity use, and service quality
- Society and California State:
  - How much trucks can be taken out of the road if most air freight carriers are to use BART
  - Traffic impact reduction by doing so
  - Pollution reduction by doing so
  - Land use efficiency How this approach can be generalized to other areas and to other systems

#### **4. Preliminary Considerations on Possible Alternatives**

Some discussions have been conducted between FedEx, BART and PATH for two years. All the idea listed here are just some preliminary thought which will not make sense unless some potential business case exists. Business cases can be looked for current situation, in the near future and in a long run.

#### **4.1 Establishing the Business Case: Demand and Capacity**

The mission of BART as a public transit system operator is to transport passengers in a safe, reliable and timely manner; if this same infrastructure can be used, without a net increase in cost, to create further benefit for the public by providing additional services, it would be of interest to the District to learn more about such opportunities.

The (area) demand of FedEx and system capacity of BART are the two primary elements driving the business case. To establish the business case, the first thing to look at will be the existing demand and area demand of a locally-based air freight carrier. If the current market conditions remain profitable by using BART, further market analysis could be applied to explore how the business model can be made even more profitable by refining or enhancing the FedEx/BART service model to decide if it is worth doing so. BART needs to investigate the system capacity with regards to existing revenue service and non-revenue track activities (for maintenance, training, etc.). BART and FedEx need to exchange information to understand the planning and operation of the other for present, in the near future, and in a long run.

(b) Business Opportunity for BART: Positive cash flow is the primary incentive for BART to provide freight movement service. A profitable business plan must identify all potential costs and outline a means to implement an operating plan such that revenues can outpace expenses. Given the economic success of the private shipping industry, BART can capitalize on that industry's needs in the following ways:

- Provide reliable, timely service during off-peak hours when BART has extra mainline capacity.
- Provide reliable, timely service during peak hours, arguably with peak hour congestion-based pricing.
- Derive additional advertising revenue, specifically through car wrapping of dedicated cargo-cars (if applicable) with advertising media. Car wrapping would serve a dual purpose: for BART, the wrapped car would make it clear to passengers that the car is being used for cargo only, and not for passenger

access; for the customers and the community in general, the wrapping could be used to advertise and/or promote the freight company.

- Revenue analysis - All expenses related to the freight transport role should be identified and weighed against all revenue generating scenarios to see if the idea can be profitable in practice.
- Liability issues should be identified and ownership for them outlined.

Regarding service, BART operates nearly 20 hrs a day and seven day a week. BART system can provide reliable service in travel time between stations and yards regardless on peak hours or off-peak hours. This is a rather charming advantage for BART to provide express services to air freight carriers.

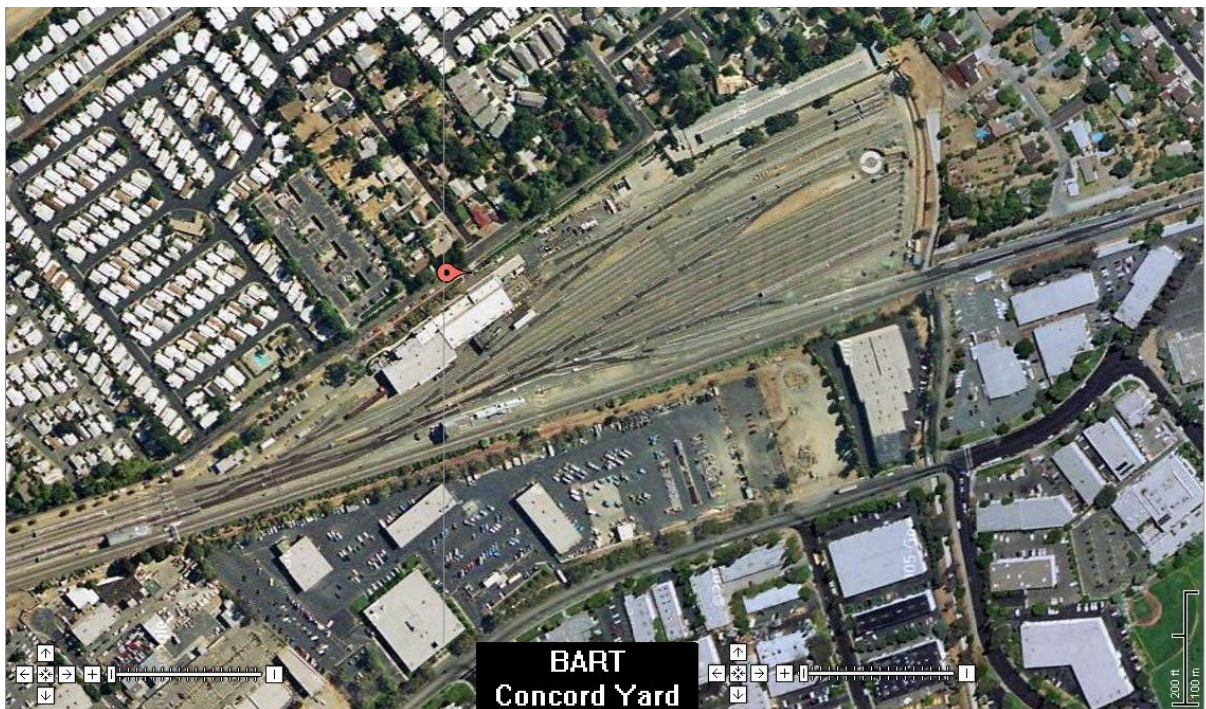
(c) Business opportunities for FedEx:

FedEx side may need to study the strategic plan, the forecasted cost for operation, reliability issues, service quality expectation, traffic situation, business expansion and other possible challenging issues. The benefit analysis from FedEx side would include the following factors:

- Comparing costs for using BART system and trucks dispatching including: capital cost for purchasing trucks; and operational cost for container returning, trans-shipment, loading/unloading, staffing, operation logistics, etc.;
- Benefit for using BART in terms of service quality: reliability for limited time window delivery, reliable and frequent services of BART system, simplification in operation logistics, BART system expansion etc. to meet the ever increasing in demand and heavily congested road traffic;
- Benefit to the future development and business expansion: FedEx business is continuously expanding rapidly in recent years. This expansion is not only in size, it also includes service types. An immediate implication is that FedEx will have more products to be transported.

## **4.2 Yard Accessibility and Trans-shipment**

In the overall picture of BART system in Figure 1, all the BART yards could be used for load/unload containers. The access of the BART yards by trucks is also not a problem. Figure 2 shows the bird's view of the BART Concord Yard. The multiple tracks in the yard could be used for freight movement. Some stations such as that in San Francisco international airport, still have spare platforms, which could potentially be used for air freight movement. Beside BART yard and stations, there are several service points in BART system, which have multiple tracks used for rail system services. Those service points could also be potential candidates for access points. However, from those service points to the main track may only run in one direction, not the other. To access two directions, a short track may need to be built.



**Figure 2:** Bird-view of the Concord Yard: Its layout allows for truck to access

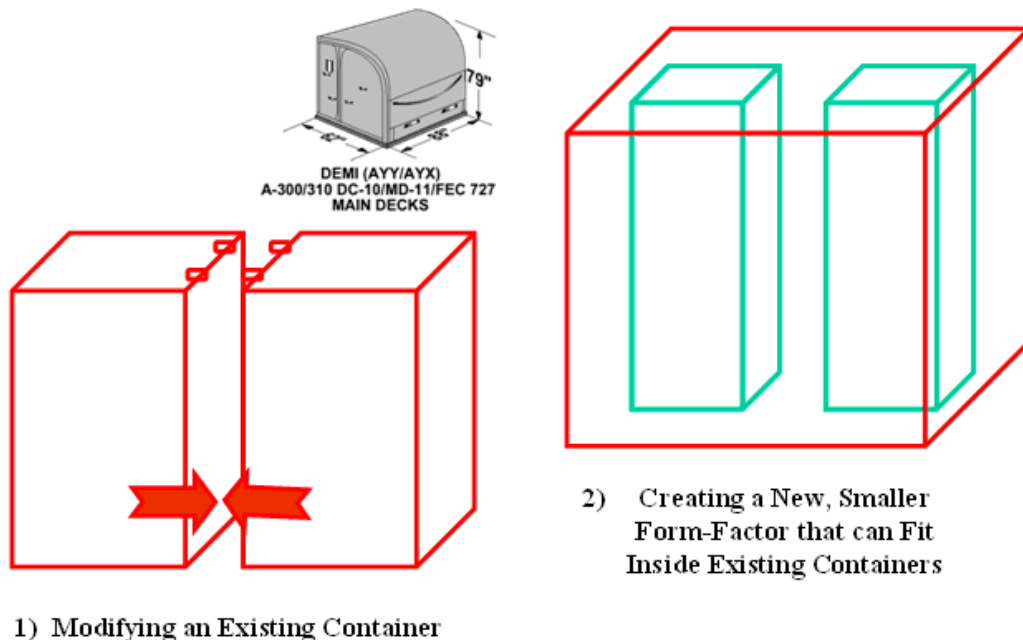
### 4.3 Container Size and BART Car

Those constraints may be divided into soft constraints and hard constraints. Soft constraints include the size compatibility FedEx containers and BART cars. It turns out that the three types of containers FedEx uses currently would not fit into the BART



car due to the door size. Several possible approaches of overcoming the soft constraints have been discussed among BART, FedEx and PATH, which include:

- One idea was for FedEx to specify the container size so that the container size fit BART car;
- Using smaller container for transport on BART system and FedEx the combines the smaller containers into larger ones for air shipment as shown in Figure 3;
- Different alternatives for consist configuration Figure 5;
- Modification of BART train for air-freight movement is another possibility or specification of the door size of BART train for new purchases to accommodate goods movement, as indicated in Figure 4a; For this purpose, older BART car can be recycled with all the electronic system and seats removed;
- Possibility for BART and FedEx to jointly purchase cars/trains suitable for goods movement such as flat board chase like cars for dedicated freight movement.



**Figure 3:** Combinations of small containers which can fit in BART cars

Hard constraints would be the access point and link. We do not expect to build any links for goods movement through BART. However, to have convenient access points for FedEx loading/unloading is very important. The critical access point would be the closest point to FedEx Western Regional Hub at Oakland Airport.

- Potential access point in BART system: yards, shops and maintenance access points in the BART system;
- Possibility of build some platform and or a short rail track (such as 100-150m) for FedEx easily to access BART system for loading/unloading;
- How the BART stations are to be designed for future development (extension) for multiple purposes including goods movement, for example, built by-pass tracks at each station to allow other trains passing and extra docking point for goods/container loading/unloading;
- How the BART system is going to evolve, for example, to adopt Advanced Direct Transit Systems. The impact of such evolvement will potentially leads to significant increase in BART system capacity and service quality and reduction in operation cost. All those factors will improve BART system's competitiveness in both passenger and goods movement.



(a)



(b)

**Figure 4:** (a) Modified BART car by removing seats for goods movement; (b) Flat car for air freight container movement

#### 4.4 Preliminary Consideration on Operation Scenarios

BART can potentially provide freight transport service between any of its yards, shops or access points. Current, there are four BART yards and a shop, each located geographically in four different parts of the Bay Area, with the shop being closest to Oakland International Airport. Beside yards and shops, BART service access points, where extra tracks exist originally for short service, could also be potential point for loading and unloading. The Yard locations are strategically ideal for freight hauling: two are in relatively close proximity to SFO and OAK airports (Daly City and Hayward Yards, respectively), and two are near existing UPS and Federal Express sorting centers (Richmond and Hayward Yards, respectively). Even though, some loading/unloading point may needs further construction for convenient platform or even a short section of track, its cost is almost nothing compared to building a new local rail line covering the area as BART or add another lane to a freeway. The use of train yards, instead of train stations, greatly increases accessibility options for cargo to enter/exit the BART System, provides a more controlled environment for security requirements, and facilitates cargo handling activities without risk of affecting passenger service because such activities are performed off the main line(s).



1) Modified BART Cars



2) Flatcar used as a Control Car



3) Flatcar without Control Elements

**Figure 5:** Consist configurations for combined passenger and freight movement

Operation and logistics feasibility for BART and FedEx: For practical operation, it is necessary to reduce the impact on passenger transport while shipping freight. If the loading/unloading is to be conducted in BART yards, shops and maintenance access points, it would not affect current BART system schedule. This also makes it easier for FedEx send/collect products according to a flexible time table. To achieve this, the operation logistics in BART side needs to be designed such that the following requirement to be satisfied:

- To move freight car and hook with passenger train without affecting scheduled revenue service
- To schedule dedicated freight train traveling through the BART System without affecting scheduled revenue service
- Qualified Personnel available to plan and perform cargo operations

Air freight carriers may have different products: High, medium and low priority. If it is proved to use BART system to deliver, then some low priority products would be put on BART system first. If this scenario proves to be successful and reliable, medium and high priority products could then be delivered through the BART system. It is expected that this is a progressively from low level to high level and from some special case (between special yards and stations) to more lines. For example, BART lines between Lake Merritt Station (Oakland) and Concord, and between OAK and San Francisco International Airport could be the first candidate lines for trial.

Cargo handling could be performed in Yards without dwell time pressure because the activities would take place away from mainline revenue service trains. The cargo could then be transported either in 1) a dedicated freight consist that could be inserted between regularly scheduled passenger service runs, and/or 2) one or more cargo-carrying rail vehicles that could be set up for a make/break with a passenger consist that would enter revenue service from the Yard.

In the first scenario above, a freight consist could be made of up to 10 cars. The dedicated consist could travel from Yard to Yard without the need for a make/break with a passenger consist.

In the second scenario, one or more cargo-only cars would be linked with a passenger consist that could then enter revenue service. The newly formed freight/passenger consist could then perform its passenger service run, and afterward, return to the destination yard as an out-of-service train to disconnect its cargo vehicle(s).

Scenario 1 is logistically simpler and has minimal impact on passenger service. However, it does require a dedicated consist and train operator, and offers no economies of scale with normal passenger service. This scenario could work well during off-peak times, when there is ample mainline capacity. Scenario 2 requires more logistical planning and operational involvement, but the operational cost to provide this type of run might be significantly less because the expense of the operator is already covered to provide passenger service. Further, this type of configuration could work well during peak hour commute times, when the mainline is more congested and headways are shorter.

## **5. Concluding Remarks**

With the rapid growth of population in the Bay Area, economic land use and sustainability in development must be taken as the first priority in transportation planning. Using BART for air freight movement is an out-of-box idea. The objective of this consideration is to fully use current transportation facilities to its maximum capacity since building a new system or even add a lane to current freeway is prohibitively costly. It thus makes sense to use all possible capacity of rail system such as BART for freight movement. This idea is just a special case of more general idea: combining freight movement with passenger movement. This though requires people look at the transportation system from integrated and seamless intermodal transportation system. It is believed that only such a system can provide the public an efficient and sustainable

transportation system with high mobility, safety, sustainability, less pollution, while satisfying the require from the rapidly expanding and globalized economy.

However, such system as BART is not naturally designed for this purpose, many aspects need to be investigated systematically before declaration the feasibility on not. Those aspects include: business cases, infrastructure, operation scenarios, safety and security, and institutional issues. Some preliminary thoughts and findings shows that it is worth considering in more details in the future feasibility study. Above all, the business case would be the first to be considered quantitatively.

The experiences and lessons learned in the investigation will include:

- (a) How to combine passenger movement with freight movement for efficient use of current facilities;
- (b) How to establish dynamic cooperation between public transportation systems and private entities;
- (c) How to practically move towards a integrated an seamless transportation system for high efficiency, mobility, safety, and optimal in land use with minimal environment impact.

These experiences and lessons could be applied to other transit systems in Bay Area, in Southern California where freight movement from seaport and airport have caused significant impact on general traffic, environment and social life, and in other cities states such as Chicago, New York, Boston, end etc, where similar transit systems exist. It is also valuable as reference to those states and cities where new transit systems are to be built. It is time to think ahead how to optimally plan such an advanced transportation system for the future.

**Acknowledgement:**

All the ideas presented here are for research purposes. Neither BART nor FedEx has any commitment or liability for any content of this paper.

The project is sponsored by UCTC (University of California Transportation Center), which is gratefully acknowledged.

## **References**

Lu, X. Y., Gosling G. D. and Xiong, J., (2006a), Opportunities for Improved Intermodal Connectivity at California Airports, California PATH Working Paper, **UCB-ITS-PWP-2006-1**, Univ. of California, Berkeley

Lu, X. Y., Gosling, G. D. Shladover, S. Xiong, J., and Ceder, A., (2006b), Development of a Modeling Framework for Analyzing Improvements in Intermodal Connectivity at California Airports, California PATH Working Paper, **UCB-ITS-PWP-2006-14**, Univ. of California, Berkeley

Tsao, H.-S.J., and Asim Rizwan, (2000), The Role of Intelligent Transportation Systems (ITS) in Intermodal Air Cargo Operation, Research Report UCB-ITS-RR-2000-5, Institute of Transportation Studies, University of California, Berkeley, 2000.

Cabanatuan, M., (2007), BART's new vision: more, bigger, faster, *San Francisco Chronicle*, A1, June 22<sup>nd</sup>