COMMUTER CARS AND CONGESTION: THE IMPACT OF THE TANGO F ON FREEWAY PERFORMANCE CHARACTERISTICS AND PARKING CAPACITY

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ABSTRACT

This report documents the findings of an analysis conducted by the Pacific Northwest National Laboratory, exploring the impact of Commuter Car's Tango f on roadway performance characteristics – level of service, flow rates, and average speeds – for a hypothetical basic freeway segment and on a segment of Interstate 5 located north of Seattle, Washington. The report also examines the parking benefits associated with the Tango f, as applied to parking in Downtown Seattle. The study presents a methodology for calculating passenger-car equivalents for the smaller vehicles and presents modifications to standard equations for estimating vehicle flow rates to account for the introduction of the Tango f into the traffic stream.

The report demonstrates the impact of the Tango f on flow rates, average speeds, and levels of service as the proportion of Tango f's in the traffic stream grows under two scenarios. First, as the Tango f is simply introduced into the traffic stream. The second alternative explores the enhanced impacts of the Tango f as a dedicated lane is built or the vehicle is granted access to existing high occupancy vehicle (HOV) lanes or shoulders.

INTRODUCTION

From 1981 to 2000, total vehicle miles of travel in the U.S. grew from roughly 1.6 trillion to 2.8 trillion, an increase of nearly 77 percent. As the growing demands of the motoring public and an expanding economy that has become increasingly reliant on just-in-time delivery systems has continued to strain the capacity of the existing roadway network, congestion and the costs associated with congestion have increased significantly.

The impacts of congestion include wasted time, lost fuel, maintenance, pollution, and quality of life. These costs have increased significantly in recent years. A recent study published by the Texas Transportation Institute (TTI) estimates that congestion costs in 75 urban areas exceeded $67.5 billion in 2000.[1] Furthermore, the measured congestion was estimated to translate into 3.6 billion hours stuck in traffic and 5.7 billion gallons of wasted fuel. To meet the increasing demands placed on the transportation system, the TTI study estimates that the nation would have been required to construct an additional 2,590 new lane-miles or streets to fully accommodate the additional traffic. Though spending on roads has continued to grow in recent years – particularly at the federal level – investment has not kept pace with demand and congestion has continued to grow.

Washington State, and particularly Seattle, has not been immune to the growing problems associated with congestion. Quite the opposite, in fact, as Seattle has consistently climbed the ranks of the most congested cities in America and now stands as the fifth most congested city in America according to TTI's Travel Time Index. In 2000, Seattle area motorists spent 67.5 million hours delayed in traffic, incurring roughly $1.3 billion in costs.[2]

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[1] Texas Transportation Institute. 2002 Urban Mobility Study. 2002. College Station, TX.
[2] IBID.

As the costs associated with being stuck in traffic continue to mount and limited resources are stretched thin, transportation planners have increasingly turned to alternative measures to combat congestion, including urban growth boundaries, smart growth, congestion or value pricing, high occupancy vehicle (HOV) lanes, and investment in public transportation.

The focus of this report, however, reviews another solution to the congestion problem: build smaller, more environmentally responsible automobiles. The Commuter Car Corporation has constructed two prototype cars that are ultra-narrow, short in length, extraordinarily agile with great acceleration, and completely battery powered. The specifications for Commuter Car's first prototype – the Tango f – are presented in Table 1. As shown, the vehicle is extremely narrow at 39", narrower than the Honda Gold Wing motorcycle. The vehicle is roughly 8'5" in length. It is extremely quick, capable of accelerating from 0 to 60 miles per hour in under four seconds. The size and agility of the vehicle enhance its ability to reduce vehicle spacing on congested roadways, thus increasing flow rates and reducing congestion.

Table 1
Tango f Specifications

Item	Specification
Width	39"
Length	8'5"
Height	60"
Ground Clearance	4"
Weight	3,050 lbs.
Power Source	25 Optima Yellow Tops with nominal voltage of 300 VDC
Range	80 miles
Acceleration	1 to 60 mph in under 4 seconds
Top Speed	130 mph

Source: Commuter Car Corporation www.commutercars.com

This report analyzes the impact of the Commuter Car on traffic congestion on a hypothetical basic freeway segment and on a segment of Interstate 5 located in the Seattle Metropolitan area. The report also assesses the parking benefits associated with the Commuter Car. The report is divided into four sections, with the first being this introduction. The second section provides an overview of the study methodology. The third section presents study findings. The fourth, and final, section of the report details study conclusions.

METHODOLOGY AND DATA

The Highway Capacity Manual, and the equations and methods presented therein, was primarily used to construct the methodology for this study.[3] Modifications and enhancements were made to equations presented in the manual in order to integrate Commuter Cars into the traffic stream and measure their impact on the performance of basic freeway segments (i.e., flow, speed, and levels of service). This section details how these calculations were made and briefly identifies the data collected from the Washington State Department of Transportation and Downtown Seattle Association to support the analysis of traffic and parking impacts of the Commuter Car.

[3] Transportation Research Board, National Research Council. *Highway Capacity Manual.* Washington, D.C. 2000.

Congestion Impacts

Equation 1 represents a modification to the flow rate equation identified in the Highway Capacity Manual.[4] Flow rate measures the equivalent number of passenger cars – passenger car equivalents or PCEs – traversing a lane per hour. The flow rate equation shown below can be used, in conjunction with estimates of density and speeds, to estimate levels of service (LOS) for basic freeway segments. The LOS measure is a common measure for assessing the performance of a roadway segment. In this case, the equation is used to analyze flow rates along basic freeway segments, where the flow rate (Vp) is a function of hourly volume, a peak hour factor used to account for fluctuations in flow rates during peak periods, the number of lanes of a highway segment, an adjustment for heavy vehicle travel used to account for the impact of heavy vehicles in the traffic stream, and a driver factor used to account for drivers who are less familiar with the given roadway segment such as vacationers in recreational areas. The heavy vehicle adjustment factor has been modified to account for the impact that Commuter Cars in the traffic steam has on the freeway segment flow rate.

Equation 1: $Vp = v / PHF*N*Fhv,cc*fp$

where

Vp =	15-min passenger-car equivalent flow rate (passenger cars / hour / lane)
v =	hourly traffic volume
PHF =	peak hour factor
N =	number of lanes
Fhv,cc =	heavy-vehicle and Commuter Car adjustment factor
fp =	driver population factor

The aforementioned term LOS represents a method for traffic analysts to assess the performance of freeway segments, with grades ranging from A to F. The Traffic Capacity Manual has established LOS criteria for basic freeway segment, with measures varying due to the free flow speed of the facility. The criteria used to establish the LOS for each freeway segment include maximum density, minimum speed, maximum volume to capacity ratio, and maximum service flow rate. For example, a freeway segment with a free flow speed of 70 miles per hour and a flow rate of between 2,170 and 2,400 passenger cars per hour per lane would be assigned an LOS of E. Effectively, the LOS is designed to measure how well traffic flow is accommodated by a freeway segment.[5]

The heavy vehicle/Commuter Car adjustment factor is highlighted in Equation 2. The heavy vehicle adjustment factor presented in the Highway Capacity Manual accounts for the additional physical space, braking, and acceleration requirements for heavy vehicles. These factors impact the spacing requirements for heavy vehicles by increasing the gap between vehicles traveling on basic freeway segments. That is, heavy vehicles in the traffic stream are effectively treated as 1.5 passenger cars on level terrain when calculating the flow rate. PCEs for heavy trucks/buses and recreational vehicles are shown in Table 2. Note that the heavy truck PCE factors also apply to passenger buses due to similarities in size and acceleration/deceleration characteristics.

[4] Transportation Research Board, Chapter 23.
[5] Transportation Research Board, Chapter 23, Page 23-4.

Equation 2 – $F_{hv,cc} = 1 / (1 + P_t(E_t-1) + P_r(E_r-1) + P_{cc}(E_{cc}-1))$

where

Fhv,cc =	heavy vehicle, Commuter Car adjustment factor
Pt, Pr, Pcc =	proportion of trucks/buses, RVs, and Commuter Cars in traffic stream, respectively
Et, Er, Ecc =	passenger-car equivalents for trucks/buses, recreational vehicles, and Commuter Cars in traffic stream, respectively

Table 2
PCEs for Heavy Trucks and Recreational Vehicles on Varying Terrains

	Level	**Rolling**	**Mtn**
Heavy Trucks / Buses	1.50	2.50	4.50
Recreational Vehicles	1.20	2.00	4.00
Passenger Cars	1.00	1.00	1.00
Commuter Cars	0.85	0.85	0.85

Source: Highway Capacity Manual

As opposed to the impact of heavy vehicles and recreational vehicles on the traffic stream, Commuter Cars would be expected to effectively expand capacity by increasing the number of vehicles capable of flowing through a freeway lane on an hourly basis. To adequately add the Commuter Car to the flow rate calculation, however, a methodology was required to estimate its PCE rating.

The methodology used to estimate the PCE for the Commuter Car is based on the impact of the Commuter Car on density, or the number of vehicles per lane per mile. The standard passenger car at 18 feet is roughly twice the length of the Commuter Car, which is nearly 9 feet in length. Density can be calculated based on Equation 3. Vehicle spacing is the distance measured from a single point on vehicles traveling in a lane (e.g., front bumper to front bumper). Vehicle spacing is then a function of the size of the vehicle and the space between each vehicle.

Equation 3 – $D = 5280 / S_p$

Where

D = density, and
Sp = spacing (feet per vehicle)

Headway is measured in Equation 4. A standard headway required for safety is 1.0, and at 60 miles per hour that translates to spacing of 88 feet.

Equation 4 – H = Sp / Spd

Where

H = Headway
Sp = Spacing (feet per vehicle)
Spd = Speed (feet per second)

The impact of the Commuter Car on spacing, and hence density, as measured under two scenarios is illustrated in Figures 1a and 1b. Under the first scenario, the only consideration is the impact of the shorter vehicle length on spacing. Scenario 2 assumes that the gap between vehicles could be reduced by 25 percent due to the enhanced agility and lower weights associated with the Commuter Car.

Figure 1a – Spacing variance between passenger cars and Commuter Cars based solely on differences in vehicle length.

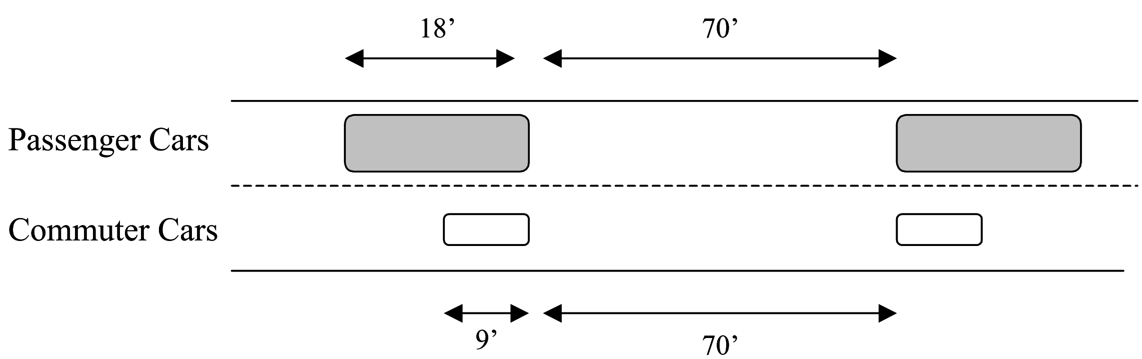
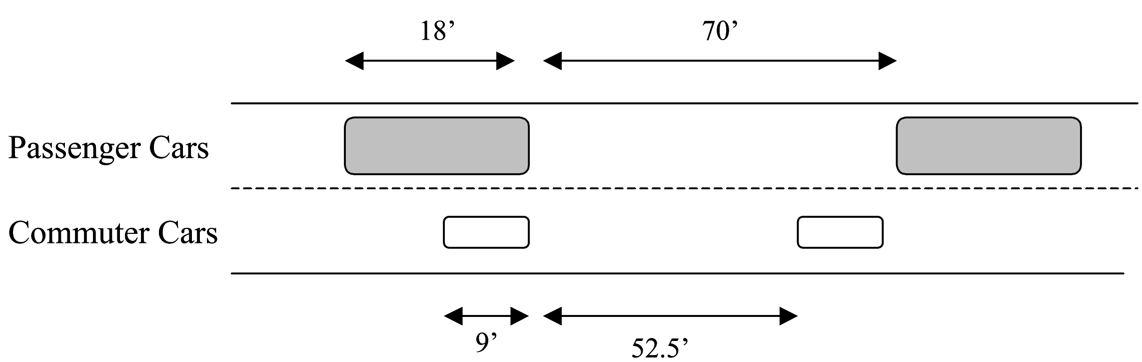


Figure 1b – Spacing variance between passenger cars and Commuter Cars based on differences in vehicle length and assuming 0.75 gap.



The spacing requirements for both passenger cars and Commuter Cars outlined above were input into the density equation (Equation 3) and compared to determine their impact on the flow rate. These spacing requirements were calculated for vehicles assuming the full gap requirement and the 25 percent gap reduction for Commuter Cars traveling at 40, 50, and 60 miles per hour. As shown in Table 2, closing the gap requirements significantly affects the PCE calculation for the Commuter Car, demonstrating that the Commuter Car could potentially significantly enhance capacity.

Table 3
Commuter Car PCEs Under Full Gap and .75 Gap Scenarios

	60MPH	50MPH	40MPH	Mid-Point
Full Gap	0.898	0.877	0.845	0.871
0.75 Gap	0.699	0.688	0.672	0.686

In addition to analyzing the impact of Commuter Cars operating within the traffic stream, an analysis was also conducted concerning their impact when removed from the traffic stream altogether. This could be achieved by constructing a dedicated lane – with far lower design requirements for width and pavement thickness – or by granting Commuter Cars access to HOV lanes or roadway shoulders. The provision of access to HOV lanes is justified because the Commuter Car is battery-powered and, thus, complies with federal requirements relating to HOV lane accessibility.[6] The Commuter Car could also easily operate within the standard freeway shoulder due to its reduced width. Note, however, that consideration would need to be given to traffic conflicts where gaps in shoulders exist to accommodate interchanges and other freeway features.

The flow rate was used to estimate average travel speed according to Equation 5. The average travel speeds were calculated for scenarios varying based on market penetration and the gap required between vehicles. The free flow speed for a basic freeway segment is assumed to be 70 miles per hour. Free flow speed would, of course, decline under all passenger and Commuter Car scenarios if interchanges and additional lanes were considered.

Equation 5 - S= FFS - [1/9(7FFS-340)(Vp+30FFS-3400/40FFS-1700)^2.6

Where

S = average speed
FFS = free flow speed
Vp = flow rate

This methodology was applied to an example basic freeway segment highlighted in the Highway Capacity Manual and to a segment of Interstate 5 located in the Seattle Metropolitan Area. Thus, the study is designed to examine the concept both in the abstract and using actual monitored data.

Parking Impacts

The benefits of the Commuter Car in terms of parking capacity are significant. Because the Commuter Car is less than 9 feet in length, it can actually park perpendicularly to other vehicles on streets. Furthermore, published reports estimate that between two and three Commuter Cars can fit in the space currently provided for standard passenger cars.[7] Generally, two Commuter Cars could fit within a standard passenger car parking space, but additional capacity could be

[6] Transportation Equity Act for the 21st Century (TEA-21 Public Law 105-178), as amended by the TEA-21 Restoration Act (Title IX of Public Law 105-206).
[7] Booz-Allen & Hamilton, Benefit and Cost Impacts of Implementing Commuter Cars in California. Prepared for the Institute of Transportation Studies, University of California, Berkeley. August 30, 1993. Los Angeles, CA.

realized by re-striping parking spaces in existing garages and along streets to allow for ultra-narrow spaces and slanted parking along Downtown Seattle streets.

Based on the findings of the study referenced below, parking impacts in the Seattle area were estimated based on several scenarios, which vary based on the number of Commuter Cars parking in Downtown Seattle and the number of Commuter Cars (i.e., two or three) occupying the space formerly occupied by a single passenger car. Data to support this analysis were provided by the Downtown Seattle Association.[8]

FINDINGS

The methodology discussed in the previous section of this report was used to assess the impact of the Commuter Car on traffic flow, LOS, and average vehicle speeds for a typical yet hypothetical freeway segment highlighted in the Highway Capacity Manual and a segment of Interstate 5 located in the Seattle Metropolitan area. This section of the report details the findings of the analysis.

Congestion Findings

Table 4 demonstrates the output of the first analysis, where a six-lane freeway with a free flow speed of 70 miles per hour and 10 percent truck volume is analyzed. In this case, the capacity of the facility is 6,512 vehicles and the current traffic volume is 6,000. As shown, speeds increase slightly when Commuter Cars are added to the traffic stream, and increase further as Commuter Car market penetration grows. For example, 10 percent market penetration fails to increase the LOS but would improve the average speed by roughly 1 mile per hour. Note, however, that this initial analysis assumes the full gap requirement, and congestion is not significant. When Commuter Cars operate in an HOV lane or a designated lane, they significantly enhance the flow rate of the facility, increase the LOS, and improve speeds. For example, 10 percent market penetration would increase the average speed by up to 5 miles per hour.

Table 5 presents the second scenario under analysis. Under this scenario, all the initial assumptions remain unchanged; however, the traffic volume is increased to 6,700 vehicles per hour and congestion is evident. The service levels have dropped to F, and speeds under the base case alternative (with no Commuter Cars in the traffic stream) have fallen to 50 miles per hour. This LOS is still superior to many evident in congested major urban freeway segments during peak hours. The impact of the Commuter Car is more significant under this scenario with speeds increasing by 1.3 mph, 2.5 mph, and 3.7 mph when Commuter Cars are 10, 20, and 30 percent of the traffic stream, respectively. Once again, the dedicated lane scenario yields more promising reductions in congestion, improving speeds by roughly 8.5 miles per hour at 10 percent market penetration.

Table 6 presents the third, and final scenario, under analysis. In this scenario, volumes are increased to 7,250 vehicles per hour, and significant congestion is evident. Speeds under the base case have dropped to 40 miles per hour and a service level of F is in place. Assuming the full gap is evident, the impact of the Commuter Car in the traffic stream is slight, enhancing speeds by roughly 2 miles per hour. Assuming that a dedicated lane is provided, an improved LOS of E is achieved at a 12 percent rate of market penetration and speeds are increased significantly (roughly 14 mph).

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[8]www.downtownseattle.com

Table 4

Impact of Commuter Cars on Flow Rate and Level of Service

Six-Lane Urban Freeway with Traffic Volume = 6,000 (1)

Base Case	LOS	Speed	Commuter Car as Percent of Traffic Stream	Commuter Cars in Traffic Stream	LOS	Speed	Commuter Cars in Dedicated Lane	LOS	Speed
2211	E	59.80	2.0%	2205	E	60.0	2168	E	61.0
2211	E	59.80	4.0%	2200	E	60.1	2126	D	62.1
2211	E	59.80	6.0%	2194	E	60.3	2084	D	63.1
2211	E	59.80	8.0%	2189	E	60.4	2042	D	64.0
2211	E	59.80	10.0%	2183	E	60.6	2000	D	64.9
2211	E	59.80	12.0%	2178	E	60.7	1958	D	65.6
2211	E	59.80	14.0%	2172	E	60.9	1916	D	66.3
2211	E	59.80	16.0%	2167	E	61.0	1874	D	66.9
2211	E	59.80	18.0%	2161	E	61.2	1832	D	67.5
2211	E	59.80	20.0%	2156	E	61.3	1789	D	68.0
2211	E	59.80	22.0%	2150	D	61.5	1747	C	68.4
2211	E	59.80	24.0%	2145	D	61.6	1705	C	68.8
2211	E	59.80	26.0%	2139	D	61.7	1663	C	69.1
2211	E	59.80	28.0%	2134	D	61.9	1621	C	69.3
2211	E	59.80	30.0%	2128	D	62.0	1579	C	69.5

(1) Assumptions include: six-line urban freeway, free flow speed = 70, capacity = 6,512 vehicles/hour
10% truck volume, .95 peak hour factor, traffic volume = 6,000

Table 5

Impact of Commuter Cars on Flow Rate and Level of Service

Six-Lane Urban Freeway with Traffic Volume = 6,700 (1)

Base Case	LOS	Speed	Commuter Car as Percent of Traffic Stream	Commuter Cars in Traffic Stream	LOS	Speed	Commuter Cars in Dedicated Lane	LOS	Speed
2468	F	50.5	2.0%	2462	F	50.8	2421	F	52.5
2468	F	50.5	4.0%	2456	F	51.0	2374	E	54.3
2468	F	50.5	6.0%	2450	F	51.3	2327	E	56.0
2468	F	50.5	8.0%	2444	F	51.5	2280	E	57.6
2468	F	50.5	10.0%	2438	F	51.8	2233	E	59.1
2468	F	50.5	12.0%	2432	F	52.1	2186	E	60.5
2468	F	50.5	14.0%	2426	F	52.3	2139	D	61.8
2468	F	50.5	16.0%	2420	F	52.6	2092	D	62.9
2468	F	50.5	18.0%	2413	F	52.8	2045	D	63.9
2468	F	50.5	20.0%	2407	F	53.0	1998	D	64.9
2468	F	50.5	22.0%	2401	F	53.3	1951	D	65.7
2468	F	50.5	24.0%	2395	E	53.5	1904	D	66.5
2468	F	50.5	26.0%	2389	E	53.8	1857	D	67.2
2468	F	50.5	28.0%	2383	E	54.0	1810	D	67.7
2468	F	50.5	30.0%	2377	E	54.2	1763	C	68.2

(1) Assumptions include: six-line urban freeway, base free flow speed = 70, capacity = 6,512 vehicles/hour
10% truck volume, .95 peak hour factor, traffic volume = 6,700

Table 6

Impact of Commuter Cars on Flow Rate and Level of Service

Six-Lane Urban Freeway with Traffic Volume = 7,250, Full Gap (1)

Base Case	LOS	Speed	Commuter Car as Percent of Traffic Stream	Commuter Cars in Traffic Stream	LOS	Speed	Commuter Cars in Dedicated Lane	LOS	Speed
2671	F	40.4	2.0%	2,664	F	40.8	2620	F	43.2
2671	F	40.4	4.0%	2,658	F	41.2	2569	F	45.8
2671	F	40.4	6.0%	2,651	F	41.5	2518	F	48.3
2671	F	40.4	8.0%	2,645	F	41.9	2468	F	50.5
2671	F	40.4	10.0%	2,638	F	42.3	2417	F	52.7
2671	F	40.4	12.0%	2,631	F	42.6	2366	E	54.6
2671	F	40.4	14.0%	2,625	F	43.0	2315	E	56.5
2671	F	40.4	16.0%	2,618	F	43.3	2264	E	58.2
2671	F	40.4	18.0%	2,612	F	43.7	2213	E	59.7
2671	F	40.4	20.0%	2,605	F	44.0	2162	E	61.2
2671	F	40.4	22.0%	2,598	F	44.4	2111	D	62.4
2671	F	40.4	24.0%	2,592	F	44.7	2061	D	63.6
2671	F	40.4	26.0%	2,585	F	45.0	2010	D	64.7
2671	F	40.4	28.0%	2,578	F	45.4	1959	D	65.6
2671	F	40.4	30.0%	2,572	F	45.7	1908	D	66.4

(1) Assumptions include: six-line urban freeway, base free flow speed = 70, capacity = 6,512 vehicles/hour
10% truck volume, .95 peak hour factor, traffic volume = 7,250

Table 7

Impact of Commuter Cars on Flow Rate and Level of Service

Six-Lane Urban Freeway with Traffic Volume = 7,250, Reduced Gap (1)

Base Case	LOS	Speed	Commuter Car as Percent of Traffic Stream	Commuter Cars in Traffic Stream	LOS	Speed	Commuter Cars in Dedicated Lane	LOS	Speed
2,671	F	40.4	2.0%	2,655	F	41.3	2,620	F	43
2,671	F	40.4	4.0%	2,639	F	42.2	2,569	F	46
2,671	F	40.4	6.0%	2,623	F	43.1	2,518	F	48
2,671	F	40.4	8.0%	2,607	F	43.9	2,468	F	51
2,671	F	40.4	10.0%	2,591	F	44.7	2,417	F	53
2,671	F	40.4	12.0%	2,575	F	45.5	2,366	E	55
2,671	F	40.4	14.0%	2,559	F	46.3	2,315	E	56
2,671	F	40.4	16.0%	2,543	F	47.1	2,264	E	58
2,671	F	40.4	18.0%	2,527	F	47.9	2,213	E	60
2,671	F	40.4	20.0%	2,511	F	48.6	2,162	E	61
2,671	F	40.4	22.0%	2,495	F	49.3	2,111	D	62
2,671	F	40.4	24.0%	2,479	F	50.1	2,061	D	64
2,671	F	40.4	26.0%	2,463	F	50.7	2,010	D	65
2,671	F	40.4	28.0%	2,447	F	51.4	1,959	D	66
2,671	F	40.4	30.0%	2,431	F	52.1	1,908	D	66

(1) Assumptions include: six-line urban freeway, base free flow speed = 70, capacity = 6,512 vehicles/hour
10% truck volume, .95 peak hour factor, traffic volume = 7,250

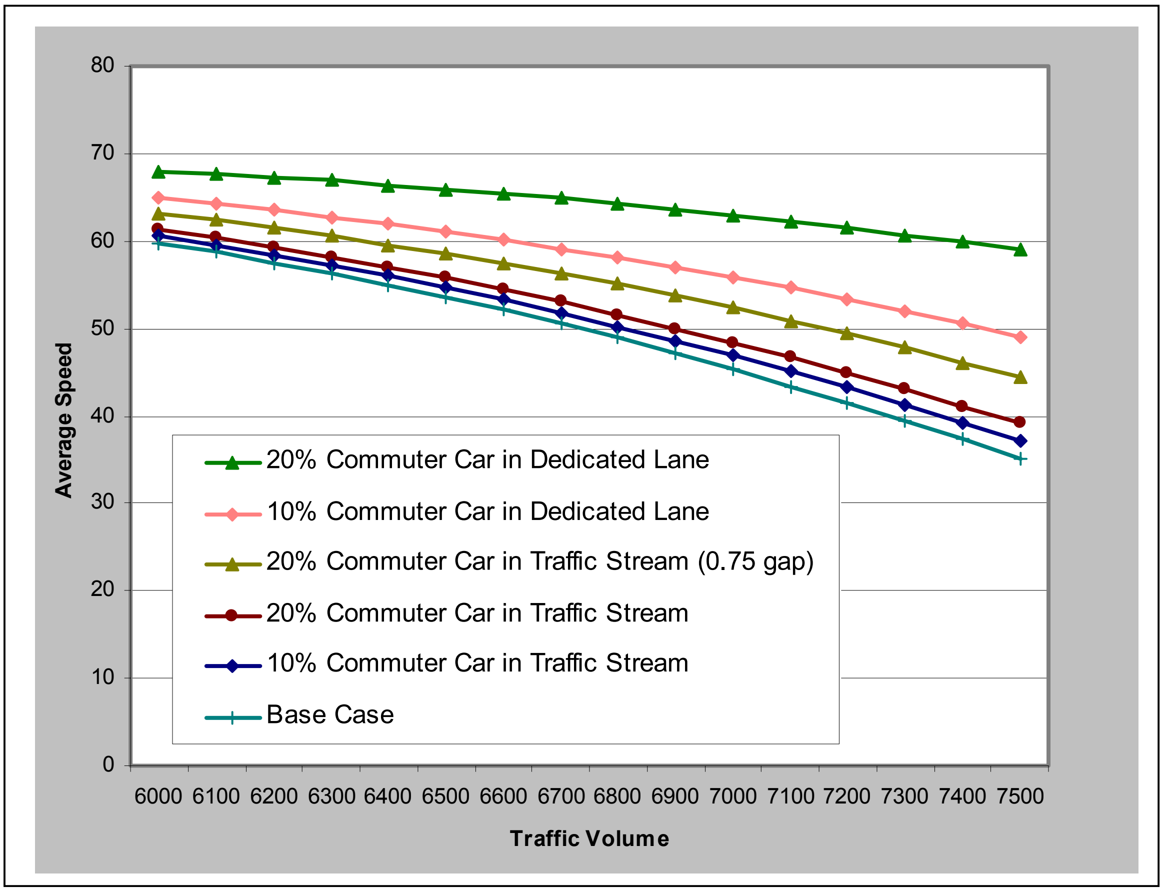
Table 8
Estimated Speeds as Traffic Volumes Vary under Six Alternative Scenarios

Traffic Volume	Base Case	10% CC in Traffic Stream (1.0 Gap)	20% CC in Traffic Stream (1.0 Gap)	10% CC in Traffic Stream (0.75 Gap)	20% CC in Traffic Stream (0.75 Gap)	10% CC in Dedicated Lane	20% CC in Dedicated Lane
6000	59.8	60.6	61.3	61.6	63.2	64.9	68.0
6100	58.7	59.5	60.3	60.7	62.4	64.2	67.6
6200	57.5	58.4	59.3	59.7	61.5	63.5	67.3
6300	56.3	57.2	58.2	58.6	60.6	62.7	66.9
6400	54.9	56.0	57.0	57.4	59.6	61.9	66.4
6500	53.5	54.7	55.8	56.2	58.6	61.0	65.9
6600	52.1	53.3	54.4	54.9	57.5	60.1	65.4
6700	50.5	51.8	53.0	53.6	56.3	59.1	64.9
6800	48.9	50.2	51.6	52.1	55.1	58.1	64.3
6900	47.1	48.6	50.0	50.6	53.7	57.0	63.7
7000	45.3	46.9	48.4	49.0	52.4	55.8	63.0
7100	43.4	45.1	46.7	47.4	50.9	54.6	62.3
7200	41.5	43.2	44.9	45.6	49.4	53.3	61.5
7300	39.4	41.3	43.1	43.8	47.8	52.0	60.7
7400	37.3	39.2	41.1	41.9	46.1	50.6	59.9
7500	35.0	37.1	39.1	39.9	44.4	49.1	59.0

Table 7 presents the findings of an analysis where all the assumptions remain unchanged at the 7,250 traffic volumes but the reduced 0.75 gap is used. Reducing the gap yields more significant results, showing gains of roughly 4.3 miles per hour at 10 percent market penetration. At 20 percent market penetration, speeds increase by just over 8 miles per hour. This is a significant increase over the full gap scenarios.

Table 8 and Figure 2 present the findings of an analysis of average speeds under six scenarios: base case (no Commuter Cars), 10 percent Commuter Cars in traffic stream at full gap, 20 percent Commuter Cars in traffic stream at full gap, 10 percent Commuter Car in traffic stream at 0.75 gap, 10 percent Commuter Cars in a dedicated lane, and 20 percent Commuter Cars in a dedicated lane. For each scenario, speeds were estimated for traffic volumes ranging from 6,000 to 7,500 per hour, in 100 vehicle increments.

Figure 2
Estimated Speeds as Traffic Volumes Vary under Five Alternative Scenarios



The most significant gains are made through the dedicated lane scenarios, with speeds increasing significantly as traffic volumes grow. For example, 10 percent Commuter Car market penetration in a dedicated lane enhances speeds by roughly 12 miles per hour when traffic volumes reach 7500, and 20 percent Commuter Cars in the traffic stream would enhance speeds by up to an additional 10 miles per hour. Even the reduced gap scenario yields significant improvements to speeds as traffic volumes reach 7500, as roughly 5 miles per hour are achieved when market penetration reaches 10 percent. Note that market analysis performed in a previous study estimates the potential market of the Commuter Car at between 4 and 13 percent of the number of vehicles produced for sale in the State of California.[9] This study makes no assumptions about the expected level of market saturation, but rather analyzes the impact of adding Commuter Cars to the traffic stream.

To test the impact of the Commuter Car on a segment of Interstate 5, located in the Seattle Metropolitan Area, data were collected from the Washington State Department of Transportation.[10] For the segment of Interstate 5 examined in this study, the 30th highest hour of the year, in terms of traffic volumes, was used. Data were collected from Automated Data Collection devices that are permanently located at the site. The examined site is located on Interstate 5 at mile post 176.72 between Seattle and Everett, Washington. It is an urban Interstate freeway segment south of the King/Snohomish County line with a posted speed limit of 60 miles per hour. The segment has three general purpose lanes and one HOV lane. It is located approximately four miles north of a major mall and supports commuter traffic to Everett. For this segment, a northbound directional volume of 8,549 was measured, with 6991 vehicles traveling in the general purpose lanes and an additional 1,558 vehicles in the HOV lane. Heavy truck traffic is 4.84 percent, and the terrain is rolling. The peak hour was measured at 5pm on April 16, 2001.

Based on the methodology outlined in the previous section, calculated speeds were roughly 43 miles per hour for the base case scenario. This estimate is very close to the 41 miles per hour actually recorded at the site. The LOS under the conditions evident at the time of measure was F. As shown in Table 9, 10 percent Commuter Cars in the traffic stream would have a marginal 4 miles per hour increase on speeds; however, enabling the Commuter Car to access the existing, free-flowing HOV lane would enable speeds to increase more significantly. Note that the 25 percent gap reduction is assumed for this analysis. Even at 6 percent market penetration, the influence of Commuter Cars would increase the average speeds by more than 6 miles per hour, bringing them up to 49.0 miles per hour. At 10 percent market penetration, the LOS is improved to E and the average speed is increase by nearly 10 miles per hour.

Parking Findings

Parking statistics collected from the Downtown Seattle Association are presented in Table 10. As shown, there are roughly 5,400 on-street spaces and 58,567 other spaces (primarily in lots and garages) in the downtown area.[11] Downtown Seattle, as defined for this study, stretches from Puget Sound to Interstate 5 and from Denny Way to South Royal Brougham Way**.**

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[9] Booz-Allen & Hamilton, Benefit and Cost Impacts of Implementing Commuter Cars in California. Prepared for the Institute of Transportation Studies, University of California, Berkeley. August 30, 1993. Los Angeles, CA.
[10] E-mail. Ruth Decker, Washington State Department of Transportation. July, 2003.
[11] www.downtownseattle.com

Table 9
Impact of Commuter Cars on Flow Rate and Level of Service
Interstate 5 Mile Post 176

Base Case	LOS	Speed	Commuter Car as Percent of Traffic Stream	Commuter Cars in Traffic Steam	LOS	Speed	Commuter Cars in Dedicated Lane	LOS	Speed
2500	F	42.94	2.0%	2485	F	43.7	2453	F	45.1
2500	F	42.94	4.0%	2470	F	44.3	2406	F	47.2
2500	F	42.94	6.0%	2456	F	45.0	2360	F	49.0
2500	F	42.94	8.0%	2441	F	45.7	2313	F	50.7
2500	F	42.94	10.0%	2426	F	46.3	2266	E	52.2
2500	F	42.94	12.0%	2412	F	46.9	2220	E	53.5
2500	F	42.94	14.0%	2397	F	47.5	2173	E	54.7
2500	F	42.94	16.0%	2382	F	48.1	2127	E	55.8
2500	F	42.94	18.0%	2368	F	48.7	2080	E	56.7
2500	F	42.94	20.0%	2353	F	49.3	2033	E	57.4
2500	F	42.94	22.0%	2338	F	49.8	1987	D	58.1
2500	F	42.94	24.0%	2324	F	50.3	1940	D	58.6
2500	F	42.94	26.0%	2309	F	50.8	1894	D	59.1
2500	F	42.94	28.0%	2294	E	51.3	1847	D	59.4
2500	F	42.94	30.0%	2280	E	51.8	1800	D	59.7

Table 10
2002 Parking Summary Downtown Seattle

Area	1989	1999	2002
Pioneer Square	4,731	5,591	6,866
International District	992	1,501	1,658
Retail Core (CBD)	22,156	28,724	30,129
Denny Regrade/Belltown	12,813	13,237	14,673
Denny Triangle	4,697	5,010	5,241
Subtotals	45,389	54,063	58,567
On-Street Spaces		5,817	5,438
TOTALS		59,880	64,005

Source: Downtown Seattle Association

The analysis of parking benefits is presented in Tables 11 and 12. As shown, the benefits were assessed assuming that two to three Commuter Cars could fit into a single standard parking space. The analysis demonstrates that as the proportion of Commuter Cars relative to the total vehicle population grows, the number of vehicles parking within Downtown Seattle grows significantly. At a market penetration of 6 percent, an additional 3,840 vehicles would be accommodated under the 2:1 ratio scenario, while an additional 7,681 would be accommodated under the 3:1 ratio scenario. At a market penetration of 10 percent, the 2:1 ratio scenario yields a total of 6,401 additional spaces (an increase of roughly 10 percent over existing conditions), and the 3:1 ratio scenario yields a total of 12,801 additional spaces (a 20 percent increase over current conditions). Note that current parking configurations would not yield the estimated capacity enhancements; however, the introduction of Commuter Car only metered parking and re-striped garages/lots would generate the benefits presented in this section of the report.

Table 11
Impact of Commuter Cars on Parking Capacity in Downtown Seattle Based on 2:1 Ratio

		2.0%	4.0%	6.0%	8.0%	10.0%	20.0%	30.0%
Street	5,438	5,547	5,656	5,764	5,873	5,982	6,526	7,069
Other	58,567	59,738	60,910	62,081	63,252	64,424	70,280	76,137
Total	64,005	65,285	66,565	67,845	69,125	70,406	76,806	83,207

Table 12
Impact of Commuter Cars on Parking Capacity in Downtown Seattle Based on 3:1 Ratio

		2.0%	4.0%	6.0%	8.0%	10.0%	20.0%	30.0%
Street	5,438	5,656	5,873	6,091	6,308	6,526	7,613	8,701
Other	58,567	60,910	63,252	65,595	67,938	70,280	81,994	93,707
Total	64,005	66,565	69,125	71,686	74,246	76,806	89,607	102,408

These findings suggest that the Commuter Car has the potential to generate significant additional capacity in Downtown Seattle, thus reducing pressure to expand the existing parking network and enabling additional development of the Downtown area without a significant increase in Downtown parking.

CONCLUSIONS

This report examines the traffic and parking benefits associated with Commuter Car's Tango f, an ultra-narrow environmentally responsible vehicle. The report documents the findings of essentially three traffic scenarios – Commuter Cars in the traffic stream with full gap requirements, Commuter Cars in the traffic stream with reduced gap requirements, and Commuter Cars in a dedicated lane – for an illustrative basic freeway segment and a segment of Interstate 5 located north of Seattle, Washington. The findings of the analysis suggest the following:

1. The examination of the illustrative freeway segment suggests that during periods of light congestion where average speeds are approaching free flow speeds, the benefits associated with the Commuter Car are negligible.

2. Even when congestion is evident, the benefits of the Commuter Car are slight under the full gap scenarios, requiring significant market penetration of 20 percent to generate an additional 4 miles per hour.

3. The congestion benefits are more robust under the reduced gap scenario, where even a market penetration of 10 percent yields an additional 4.3 miles per hour. The reduced gap was also used for the Interstate 5 case, and showed similar improvements. Note that reducing the gap additionally would further enhance the congestion benefits of the Tango f. There are, however, safety concerns that must be considered before allowing smaller gap requirements.

4. The most significant benefits accrue when the Commuter Cars are given access to a dedicated lane, an HOV lane, or a freeway shoulder. In congested conditions – both in the abstract and using actual data from the Seattle segment – even a market penetration of 6 percent can yield significantly improved speeds on the general purpose lanes (6.6 miles per hour). At a market penetration of 10 percent, the findings of this study suggest that allowing Commuter Cars into the HOV lane on Interstate 5 would improve average speeds for the general purpose lanes by roughly 9.3 miles per hour, and would improve the LOS for the facility from F to E. This study does not analyze the impact of the Commuter Car on HOV lanes. HOV lanes are, however, typically flowing at or near free flow speeds, even when general purpose lanes are congested.

5. The parking benefits associated with the Commuter Car are clear and measurable. Assuming that two to three Tango f's can fit into the space formerly provided for one passenger car and a market penetration of 6 percent, an additional 3,840 or 7,681 vehicles could be accommodated in Downtown Seattle based on the 2:1 and 3:1 ratio, respectively.

The methodology developed for this study is straightforward and readily adaptable for use in analyzing additional scenarios with varying assumptions. The methodology presents an alternative PCE rating for the Commuter Car and integrates the rating into standard traffic engineering equations to examine the capacity benefits associated with Commuter Car's Tango f. Additional scenarios potentially worthy of examination are the impacts of the Commuter Car on freeway segments in various California communities experiencing stifling congestion. Further, gap requirements could be changed to support additional scenarios.