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# The Nanocar: A Consumer Driven Solution for a More Sustainable California

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## Introduction

Population growth in metropolitan America has been steadily increasing. Since 1969, the population of the United States has increased by approximately 40% with 75% of the population living in urban areas by 1990.[i,ii] This trend was matched with a proportional increase in the number of drivers who use private vehicles as their primary means of commuting. Most urban transportation systems are currently not equipped to handle the increasing travel demands and consequently, peak hour congestion in major cities is increasing. This slowdown results in the loss of potential revenue and productivity, as more and more commuters sit idle in congestion for longer periods of time.[iii] Furthermore, even with the advent of more efficient engines, the continued rise in fuel consumption and congestion has deleterious effects on the air quality of these metropolitan areas and National Ambient Air Quality Standards (NAAQS) continue to be exceeded, particularly for ground level ozone.[iv]

**KEY PROBLEMS:**

1. **INCREASING URBAN POPULATIONS.**
2. **INCREASING CONGESTION DUE TO USE OF PRIVATE VEHICLES FOR DRIVE-ALONE COMMUTING.**
3. **CONTINUED NON-ATTAINMENT OF NAAQS**
4. **THE USE OF NON-INTEGRATED APPROACHES TO SOLVE ABOVE ISSUES.**
5. **CONSUMER PREFERENCES IGNORED**

Existing and emerging non-traditional solutions such as, High Occupancy Vehicle (HOV) lanes, Regional Transportation Plans (RTPs), state and federally implemented tax incentive programs, and California's Air Resources Board's (CARB) Zero Emission Vehicle (ZEV) Mandate, have begun to address these problems. However, there are several issues that hamper the effectiveness of these plans. Firstly, land-planning based solutions are developed mainly to increase the overall mobility of commuters in the region and does not specify the type of vehicle that will use the infrastructure. Second, vehicle-based solutions do not consider the infrastructure that will be required to ensure the proliferation of these vehicles on the road. Clearly there is a dichotomy between these two solutions when they are in fact attempting to achieve complementary objectives. Finally, a major factor that is ignored when implementing these plans is consumer preferences regarding mobility. Commuting statistics show that commuters overwhelmingly prefer to commute alone in their private vehicles (U.S. Census 2000). New solutions to the impending mobility crisis tend to view this behavior as an obstacle to overcome rather than a key to success. What is of great concern is that it is unclear whether sales forecasts for zero emission vehicles will be met and regional transportation plans be implemented, questioning whether or not the NAAQS will be attained and personal mobility be improved.

## The Nanocar Concept

The research presented in this paper focused on synthesizing existing commuter behavior and preferences with innovative technology to provide an alternative transportation solution that integrates both vehicle design and land-planning based incentives. The Nanocar is a unique vehicle that seats a maximum of two people in tandem, making it narrower and shorter than any mass-produced vehicle on the road today in the United States. It is designed primarily as a commuter vehicle that meets all recognized safety standards. It is also expected to meet or exceed the EPA's SULEV (Super Ultra Low Emission Vehicle) standard.[2] Advantages of the Nanocar include a lowered demand placed on transportation infrastructure and land due to its unique size, increases

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[2] The current SULEV standards for light duty vehicles (<8500lbs) are 1.0 g/mi and 0.02 g/mi for carbon monoxide and oxides of nitrogen (for 120,000/11 yrs)

in personal mobility due to various infrastructure incentives, and a reduction of total vehicle emissions.

The underlying research questions being addressed in this paper were *1) Is there a market for ultra compact environmentally friendly vehicles such as the Nanocar? 2) What transportation and policy incentives are necessary for consumers to purchase the Nanocar? 3) Do current programs in California that aim to increase purchases of environmentally friendly vehicles or reduce congestion observe consumer preferences? 4) Are consumers willing to trade-off automobile size for these incentives? and 5) Are there any quantifiable air quality benefits resulting from the gradual introduction of the Nanocar?*

**Survey Design and Administration**

Nine attributes of the Nanocar (vehicle price, tax incentives, preferential parking, parking fee reduction, annual fuel cost reductions, refueling advantages, price of gas, side-street infrastructure additions, and highway infrastructure additions) were included in the survey in the form of various inventive packages. The final survey took the form of a web-based stated preference survey where respondents were presented with five scenarios of which four were Nanocar packages with different incentives and a fifth "no-buy" scenario.[3] In total, 891 responses were returned from a wide range of urban and suburban localities in California with an estimated response rate of 8%.

**Respondent Demographics**

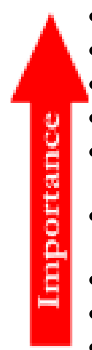
In general, the respondent set mirrored the demographics of the entire population of California. In total, approximately 75% of the respondents came from the largest Californian urban areas with the majority coming from the greater Los Angeles county area, including Orange County (36.7%). 199 respondents stated that they did not have a commute to work.

**Survey Results**

78% of respondents chose to purchase the Nanocar given a certain set of monetary and non-monetary incentives with the majority indicating that they would use the Nanocar as a primary vehicle. The most significant attributes in a respondent's purchasing decision were determined through logit and multinomial logit (MNL) regression analyses of the survey responses.

The results of the logit regression showed that the highest income-range had the greatest inclination towards purchasing the Nanocar.[4] Other lower income brackets also were inclined to purchase the Nanocar. The oldest respondent range indicated that they would not be likely to purchase the vehicle. No other demographic and commuting characteristics remained significant. A MNL regression was conducted for all respondents as well as two subsets of these respondents, commuters and non-commuters. The three variables that had the greatest utility for the entire respondent set were preferential parking at stores, and 50% and 100% reductions in parking fees. Preferential parking at work and stores, own-lane away from side-streets with an associated 50% reduction in commute time and own-lane on highways with an associated 25% reduction in commute time also had positive utilities. Similar utility factors were obtained for commuters. The analysis of non-commuters indicated that this subset mainly concentrated on price and preferential parking as purchasing factors, implying that this subset was more price sensitive than the commuting subset. Through these parameter estimates, the probabilities of choosing various Nanocar scenarios over other scenarios were subsequently calculated.

<u>**RANKING OF INCENTIVE IMPORTANCE**</u>




- Low Prices
- Preferential Parking at Stores
- 50% Parking Fee Reduction – **PF50**
- Preferential Parking at Work
- Own Lane Away from Side-Streets - **SSOLA** (50% Reduction in Commute Time)
- Own Lane on Highway – **HWOLO** (25% Reduction in Commute Time)
- 25% Parking Fee Reduction – **PF25**
- Refueling Capability at Work
- Tax Incentives

**Implications of Survey Results**

When the above factors are taken into account, the following conclusions can be drawn:

1. There is a market for the Nanocar.
2. Price will be the main determinant to whether or not the vehicle is purchased, but other monetary and non-monetary incentives will increase the purchase likelihood.

[3] This survey methodology, based on the economic model of utility maximization and random utility, allowed the researchers to determine the statistical significance of the specific attributes and predict the choice probability of specific scenarios through multinomial logit regression.

[4] A logit regression was conducted to determine whether or not a specific demographic characteristic of the respondent set was more inclined to purchase the Nanocar.

3. Non-commuters are more price-sensitive than commuters.
4. Most value is gained from parking advantages and infrastructure changes, while fuel cost reductions do not influence the purchasing decision.
5. Tax incentives are not likely to have a great impact on whether or not the Nanocar is purchased as compared to other incentives.
6. Fuel savings, tax breaks and refueling ability at home are incentives that reward consumers who purchase the Nanocar rather than factors that are included in a consumer's purchasing decision.

**Air Quality Benefits**

From the standpoint of the California Air Resources Board (CARB) and the individual air quality management districts of California, the goal of increasing the proportion of environmentally friendly vehicles on the road is to attain or exceed the NAAQS in California.

To determine the potential air quality benefits of the introduction of a Nanocar and the associated infrastructure, projections of the emissions reductions of carbon monoxide (CO) and oxides of nitrogen ($NO_x$), were calculated for the Los Angeles County Region.[5] For 10% sales of the Nanocar, the reductions in emissions achieved for CO and $NO_x$ in 2020 were 496 tons/yr and 25.55 tons/yr, respectively. For 20% sales, the emissions reductions were 1533 tons/yr and 62.05 tons/yr, respectively. The corresponding number of Nanocars on the road in the year 2020 was estimated to be 741,708 (10%) and 1,483,416 (20%).

**Recommendations**

Rather than develop incentive programs that target the entire population, we recommend a program tailored towards the specific needs of the commuting population. We believe from our analysis of the survey results and air quality model that this tailored program will have the greatest impact on improving personal mobility and air quality in urban California. Therefore, the following recommendations are based on the preferences of the commuting subset.

**Recommendations to Policymakers and Automakers**

- Timing: The vehicle and its associated incentives must come on-line simultaneously to meet the multiple policy objectives. If done properly, the collaboration between policymakers and automakers will achieve cleaner air, improve mobility and increase economic productivity; enable automakers to comply with regulations and remain profitable; and increase commuter convenience and employee productivity without altering consumer preferences drastically.
- Good faith marketing: For the successful introduction of environmentally preferable vehicles such as the Nanocar, companies must be willing to commit as much resources into advertising the vehicle and its incentives as any other vehicle in their fleet. Regulators must also increase consumer awareness of these incentives through marketing programs of their own. In addition, the involvement of non-governmental agencies (NGO's) may be beneficial in reaching advertising parity for the Nanocar and improve the dialogue between the various stakeholders.
- In order to receive 10%-15% sales on price alone, the price of the Nanocar should be set between $10,000 and $15,000.

**KEY RECOMMENDATIONS:**

1. **DEVELOP AREA-SPECIFIC INCENTIVE PROGRAMS FOR COMMUTERS WITH PARKING ADVANTAGES AND INFRASTRUCTURE CHANGES AS PRIMARY INCENTIVES**
2. **CREATE STRONG COLLABORATION BETWEEN ALL STAKEHOLDERS TO PROVIDE VEHICLE AND INCENTIVES CONCURRENTLY.**
3. **PROVIDE ADVERTISING PARITY FOR NANOCAR AND ASSOCIATED INCENTIVES WITH OTHER VEHICLES.**

**Infrastructure Recommendations**

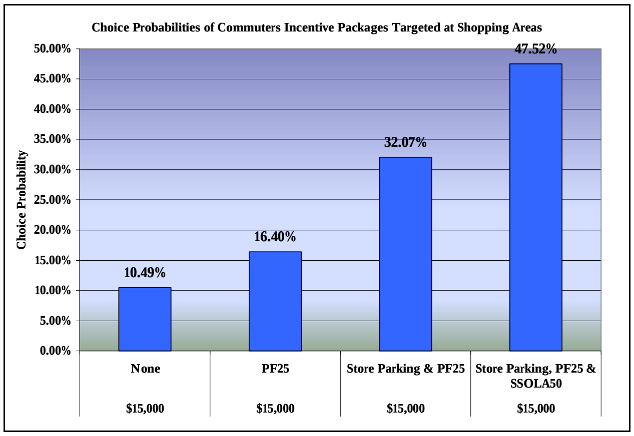
The political environment, geographic location, regional planning agendas and finances must be considered for efficient and safe incorporation of Nanocars into society. Infrastructure modifications could potentially come in a variety of forms to best suit Nanocars. These changes to current infrastructure include, but are not limited to, modifications to highways, side-streets and parking areas.

**Practical Applications**

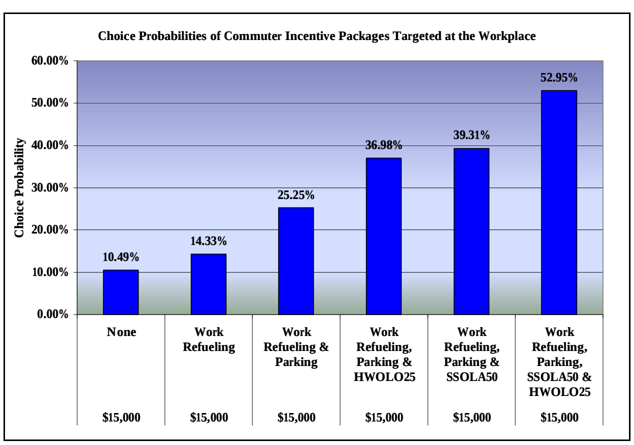
In an ideal situation where all incentives are provided the probability of commuters choosing to purchase a

[5] The Draft EMFAC2001 model produced by the California Air Resources Board was used to calculate the air quality benefits.

Nanocar package was 88.0%. In reality, however, all incentives would not be provided and therefore a combination of the incentives would have to suffice. The variables that had the most utility for commuters were 50% and 100% reductions parking fees and preferential parking at stores. Even at high amounts, tax incentives had the lowest utility among positive variables. Based on this information the following practical applications are recommended.




- Shopping areas can be the focus of incentive programs. A 25% or greater reduction in parking fees, while still maintaining revenues, can be achieved by modifying parking lots to fit more Nanocars. Both private and municipal parking lots should be modified in order to create preferential parking areas near to stores or lot exits. Side-street infrastructure should also be provided in order to increase the convenience of getting from home to stores and work. If all these incentives are implemented the choice probability is increased from 10.5% (Price and gas cost only) to 47.5%.




- Tax incentives can be given to businesses rather than consumers to promote the placement of preferential parking areas and refueling stations at work. New highway and side-street infrastructure built on existing highways and streets can be used to reduce commute times and thus increase mobility. If all of these incentives are provided, the choice probability is increased from 10.5% (Price and gas cost only) to 53.0%.

## Conclusions

The results from the survey indicated that there is a substantial market for an ultra-compact vehicle such as the Nanocar given that a certain set of incentives are provided at the time of purchase. In addition, commuters regarded parking advantages and specific infrastructure changes as the incentives that they believe are the most important to them in their purchasing decisions. Furthermore, the results indicated that in many cases, tax incentives and fuel-savings, which are traditionally utilized as incentives in statewide programs are not the most effective way of swaying the consumer towards purchasing an environmentally friendly vehicle or altering their commuting patterns.

The ideal package of incentives should be area-specific since commuter preferences and the political environment will differ across regions. Solutions such as the shopping area and workplace based incentive programs are examples of how incentive programs can be practically implemented.

It is important to note that the Nanocar concept is not the panacea that will solve all of California's congestion and air quality problems. It is meant to be an alternative transportation solution that can be incorporated into various regional transportations plans and other statewide plans. However, the concept does provide a different take on achieving reduced congestion, increased personal mobility and improved air quality since it is first, based on the consumer preferences towards a vehicle and its associated incentives and second, it attempts to tackle the problem in an integrated manner.

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[i] United States Census Bureau, "United States Census 2000", <http://www.census.gov>
[ii] United States Census Bureau, October 1995 <http://www.census.gov/population/censusdata/urpop0090.txt>
[iii] Texas Transportation Institute, "Urban Mobility Study," 2001, <http://mobility.tamu.edu>
[iv] Environmental Protection Agency, EPA Greenbook <http://www.epa.gov/oar/oaqps/greenbk/cncs.html> February 2002