What is "Induced Demand"?

- As expected, there is a range of opinions and definitions in the transportation planning community about how to define this phenomenon, in the context of travel demand analyses and forecasting. The key question for this discussion is – *In a congested urban highway network, if new capacities are introduced, will there be additional traffic growths above and beyond what would be generated from fixed trip generations?*

  Formal definitions:

- A widely used definition for induced demand for road travel can be summarized as ***'the increment in new vehicle traffic that would not have occurred without the improvement of the network capacity'***, where traffic is usually measured in vehicle-miles-travelled (VMT). This measure of induced travel means that there can be induced travel when the number of trips undertaken is fixed, for example if people travel longer distances (WSP/RAND-London).

- To better understand broadly the causes of such additional travels, following terms need to be defined (TRB-Caltrans):

  Latent Demand is the travel that would occur if the cost were lower (e.g., times were faster), or in other words, the travel that does not occur because costs are high (e.g. times are slow).

  Induced Travel is the additional travel that occurs when the cost is lower (e.g., as a result of a capacity expansion that reduces travel times), in other words, the additional travel that is induced by the lower costs that results from capacity expansion.

  Induced Vehicle Travel is additional vehicle travel that occurs when the cost is lower; this is a subset of all induced travel. In this paper, "additional vehicle travel" is measured using vehicle miles traveled (VMT).

So, there are two broad analysis basis – with a fixed trip pattern, and with a variable one (SACTRA-London). The following are examples with a fixed trip pattern (fixed O-D matrix):

1. **Mode shift** – Trips previously made by train, for example, to a given destination for a given purpose, when made by car instead, add traffic to the road network.
2. **Reassigned traffic –** Trips that have the same origin and destination, but which shift routes to use the new facility. Because travelers can travel at higher speed on the new road, they are prepared to incur extra travel distance for a saving in overall travel time - entirely consistent with their objective of minimizing the generalized cost to them of the trip.

With a variable, or semi-variable trip pattern (variable O-D matrix):

3. **Redistributed traffic** – Trips that alter destination because the new facility brings an alternative closer. More broadly, where either new destinations are chosen for given trips, or, through people moving to new houses, the same trips are made but from new origins.
4. **Generated traffic** – traffic from trips that are 'new' which were not being made at all without the facility (latent demand). This may also include trips from new land use that develops as a result of the new facility.

- In travel model community, there is a consensus that above items 1/2 are only shifts in trip-making patterns, while 3/4 can be identified as sources of new travel demands, which can be collectively identified as "Induced Demand" (FHWA-TMIP).
- Another way to look at these shifts is from temporal perspective (TRB-Caltrans):

Short-term responses

1. New vehicle trips that would otherwise would not be made.
2. Longer vehicle trips to more distant destinations.
3. Shifts from other modes to driving.
4. Shifts from one driving route to another.

Longer-term responses

5. Changes in land use development patterns (these are often more dispersed, low density patterns that are auto dependent).
6. Changes in overall growth.

- Some practitioners think there is nothing called "Latent Demand", on an economist's supply-demand curve, there is no special kind of demand called "latent demand" – it's all demand that will manifest if the price (generalized cost) is right (FHWA-TMIP).

Evidence of Induced Demands

- Some of these travel behavior phenomena are better understood with economic theories of 'consumers' surplus' and/or 'elasticity of demands' (SACTRA-London). These two terms are defined as:

  It is widely recognized that the main determinant of travel choice is the value that an individual places on undertaking any particular journey over and above the perceived cost to that individual of doing so. This is referred to as 'consumer's surplus' value.
  It also leads directly to the concept of elasticity of demand for travel, that is, where a given (proportionate) change in the generalized cost of travel will cause a corresponding (proportionate) change in trip-making.

- Most of the research on the induced travel effect is focused on measuring the amount of induced vehicle travel (i.e., changes in VMT) with respect to changes in transportation network supply and are expressed using an elasticity metric (TRB-Caltrans).

- Overall, the elasticity of VMT to lane-miles from published research referenced in the review papers ranges from 0.0 to 0.68 for short-term effects and from 0.29 to 1.1 for long-term effects (TRB-Caltrans). Duranton and Turner, the most recent study cited, estimated long-term elasticity of approximately 1.0 for interstate highways and major roadways within metropolitan areas. Two papers measured the elasticity of VMT to travel time as -0.3 to -0.5 for short-term effects and -0.4 to -1.0 for long-term effects. After reviewing the available studies, Handy and Boarnet recommended that an elasticity close to 1.0 is the best estimate for the long-run effect of highway capacity on VMT.

- In conclusion, SACTRA-London study stated the following:

Considering all the sources of evidences, induced demand and resulting traffic can and does occur, probably quite extensively, though its size and significance is likely to vary widely in different circumstances.

- But there are fewer empirical observations to quantify the composition of induced traffic in terms of, for example, new trips, redistributed trips, transfers between modes, and trips associated with new developments. The composition will depend on the circumstances. There is evidence to suggest, however, that trip retiming is an important behavioral reaction to changes in road capacity, second only to changes of route.
- More recently, the WSP/RAND-London study confirmed the above SACTRA findings – "Induced demand continues to occur and may be significant in some situations". Some specific findings in this paper: state level road networks in the US and the national Dutch network indicate an elasticity of around 0.2 across the whole road network, i.e. 10% increase in road capacity could lead to 2% induced demand on the network.
- Despite the evidence supporting induced vehicle travel as a real and measurable effect, transportation planning practitioners have often challenged the concept and have not recognized the limitations of current travel forecasting models to fully account for these effects (TRB-Caltrans).
- Most traditional 4-step trip-based models fall short when there is the lack of a feedback mechanism to trip generation and land use allocation. Trip generation models are largely static and land use or socioeconomic forecasts are a fixed input in most model applications. The feedback mechanism would ideally respond to changes in the accessibility and travel time effects associated with capacity expansion projects to avoid downward biases in VMT forecasts (TRB-Caltrans)

How to Analyze in Travel Demand Framework?

- According to model practitioners (FHWA-TMIP), most traditional trip-based 4-step models can represent shifts in 1/2. Activity-based models (ABM) and some advanced trip-based models can also predict shifts in item 3. Handling land use shifts in a consistent way requires an integrated land use model.
- However, the following sensitivity/accuracy issues need to be checked for any meaningful analysis (TRB/Caltrans):

  Newly generated trips - Does the model contain a feedback process where person trip generation is influenced by travel time estimates informed by network modifications (i.e. does trip generation vary with the level of roadway congestion)?
  Longer trips - Does the model contain a feedback process where trip distribution is influenced by changes in travel time? Is this influence limited by trip length patterns estimated for the calibration year?
  Modal split - Does the model contain a mode choice process where modal split is influenced by changes in travel time by mode?
  Route diversions - Does the model contain a trip assignment process where route choice is 9 influenced by changes in travel time? This effect may not change the amount of overall travel, but it can be important for accurately forecasting location-specific traffic volumes for use in traffic operations analysis.
  Time of day shifts - Does the model contain a temporal process where departure time is influenced by changes in travel time? This effect is only related to travel changes between time

periods and not the amount of overall travel; however, this can be important in accurately forecasting peak period traffic volumes for use in traffic operations analysis.
Land use development pattern shifts - Does the model contain a process where long-term land use patterns are influenced by changes in accessibility and travel time?

- From a travel model professional's idea on how to define demand shifts or new demands (FHWA-TMIP):

Making more trips (that is, a person decides, for example, to go out to a movie theater, rather than watch a movie at home on Netflix, as a result of a highway project that adds road capacity.) This can be handled by an ABM, but generally not be an older trip-based model.

Making longer trips (for example, a person decides to go to a mall that is further away, but cooler than their lousy nearby mall, because of a highway project that added more capacity.) This as a rule can be handled by both older trip-based models and by ABMs.

Land use changes (and associated increase in trips). Development is induced in the vicinity of a widened freeway, for example. In theory, only a high-quality land use model can do this, but scenarios of different land use inputs can be tested within the model.

Changes in trip time of day (a new highway project reduces congestion, so people who have been avoiding the peak times decide to shift back to the peak.) Traditional models can rarely handle this, but most ABMs are capable to analyze this factor.

Changes in route (traffic forced off a congested highway moves back to it when that highway is widened.) A well-calibrated and validated model (of any type) can handle this.

Mode shift (people who rode transit due to highway congestion decide to drive again after a highway widening). A well-calibrated and validated model (of any type) can handle this.

Integrated Land Use + Transport + Econometric Model

- Induced travel is not necessarily a bad thing: new infrastructure may encourage drivers from local roads to the strategic road network – reducing local congestion, provide people with increased accessibility to activities or encourage new businesses to locate to areas with new infrastructure, which may be positive for society, even if travel is increased. The overall impact of induced travel arising from a road infrastructure improvement can be quantified by calculating the benefits across all relevant markets (WSP/RAND-London).

- Laird and Venables (2017) identify capturing the value of land use change as one of the three key challenges to the inclusion of the wider economic impacts of transport projects in appraisal. This is particularly the case if the land use change is stimulated by both the transport investment and by investment in the urban fabric. A multi-market analysis with changes in welfare measured at the household level may offer one solution to this problem – for instance using spatial computable general equilibrium (S-CGE) models (Bröcker and Mercenier, 2010); or land use transport interaction (LUTI) models (Martinez and Araya, 200057; Simmonds, 201258). But this type of advanced land use-transport models are rare among the planning agencies in U.S.,

and the few agencies who are using these models, the focus of analysis is to quantify broader societal and economic benefits, where induced demand is only a side consideration. For this very reason, the primary question of this paper may have become obsolete (FHWA-TMIP).