ITTS FEAT Tool

Methodology Review

presented to

ITTS Member States

presented by

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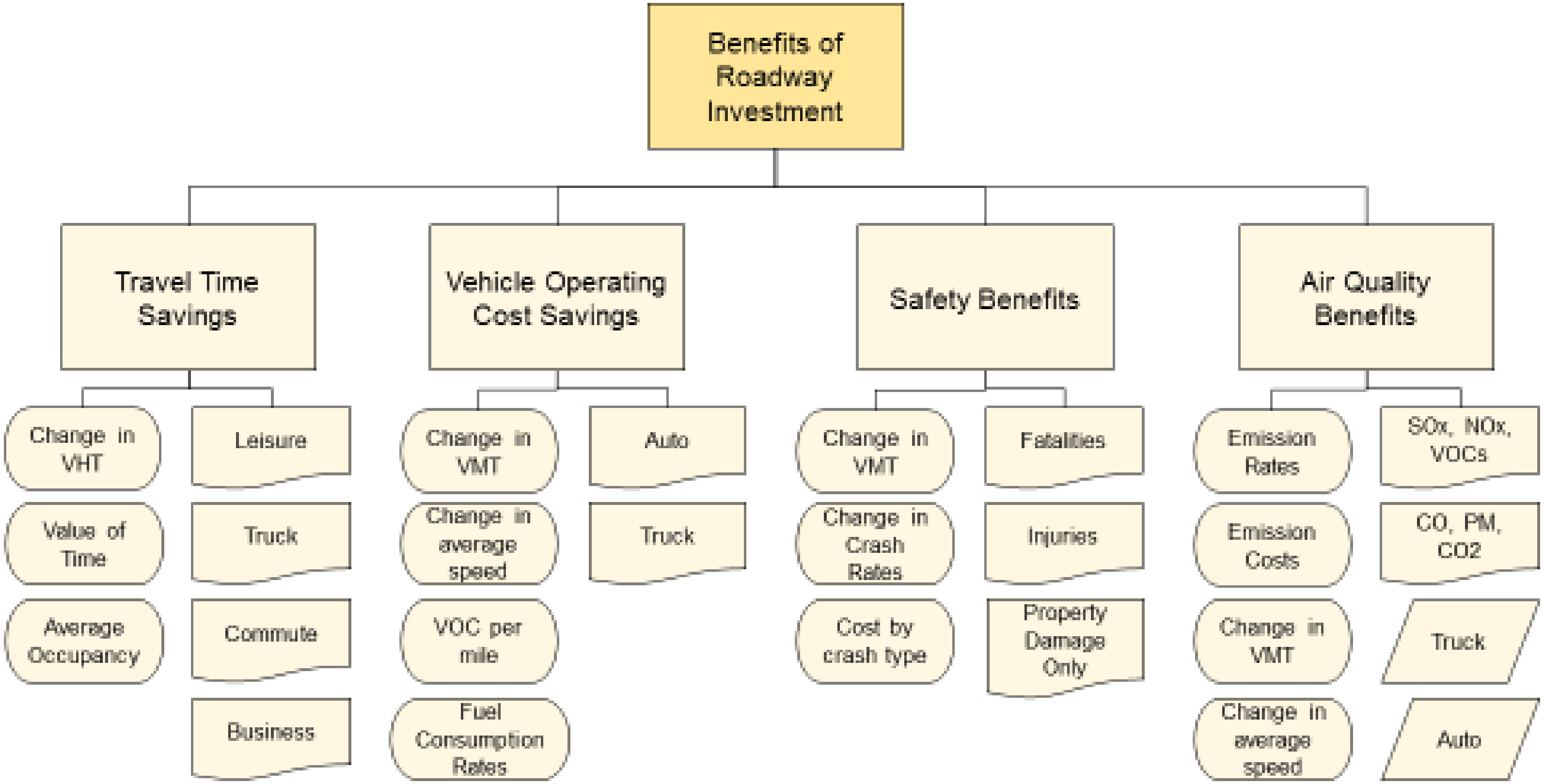
Overview

- Data requirements
- Roadway capacity projects
- Roadway operational projects
- Freight rail projects
- State-of-repair projects
- Logistics costs
- Economic modeling

Description	Roadway	Operational and Safety	Freight Rail	Logistics	State of Good Repair	Potential Sources
Construction Costs	Yes	Yes	Yes	Yes	Yes	User
Maintenance and Operations	No	No	No	No	Yes	User, State Financial Records
Construction Schedule	Yes	Yes	Yes	Yes	Yes	User
List of Improvements	Yes	Yes	Yes	Yes	Yes	User
Future Pavement Condition	No	No	No	No	Yes	User
Study Timeline	Yes	Yes	Yes	Yes	Yes	User
Discount Rates	Yes	Yes	Yes	No	No	User
Rail-Truck Diversion Rate	No	No	Yes	No	No	User (based on FAF4)
Annual Average Traffic Data	No	Yes	Yes	No	No	User
Number of train crossings	No	No	Yes	No	No	User
Vehicle Hours Traveled	Yes	No	No	Yes	Yes	Travel Demand Model
Vehicle Miles Traveled	Yes	No	No	Yes	Yes	Travel Demand Model
Delay	Yes	No	No	Yes	Yes	Travel Demand Model
Trips	Yes	No	No	Yes	Yes	Travel Demand Model
Occupancy	Yes	No	No	Yes	Yes	Travel Demand Model
Origin and Destination	No	No	No	Yes	No	Travel Demand Model
Trip Purpose	Yes	No	No	Yes	Yes	Travel Demand Model
Wage Rates	Yes	Yes	Yes	No	Yes	Bureau of Labor Statistics
Fuel Costs	Yes	Yes	Yes	No	Yes	US Energy Information Administration
Vehicle Operating Costs	Yes	Yes	Yes	No	Yes	AAA, ATRI
Crash Rates	Yes	Yes	Yes	No	Yes	Highway Statistics (FHA), State DOT's
Crash Values	Yes	Yes	Yes	No	Yes	US Department of Transportation
Emissions Rates	Yes	Yes	Yes	No	Yes	EPA, Department of Energy
Emissions Values	Yes	Yes	Yes	No	Yes	US Department of Transportation
Shipping Costs	No	No	Yes	No	No	Bureau of Transportation Studies, TIGER Methodology
Value of Freight	No	No	Yes	Yes	No	FAF4
Volume of Freight	No	No	Yes	No	No	FAF4
Weight per Truckload	No	No	Yes	No	No	FAF4
Buffer Indices	No	No	No	Yes	No	Federal Highway Administration
Current Pavement Conditions	No	No	No	No	Yes	State DOT's
Length of Road Segments	No	No	No	No	Yes	State DOT's
Consumer Price Index (CPI)	Yes	Yes	Yes	Yes	Yes	Bureau of Labor Statistics

Roadway Capacity Projects



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Travel Time Costs

$$\Delta \boldsymbol{TTC_{p,t}} = \boldsymbol{VOT_p} \times \Delta \boldsymbol{VHT_{p,t}} \times \boldsymbol{VOR_p}$$

Where:

- $\Delta TTC_{p,t}$ = the change in travel time costs of trip purpose p in year t
- VOT_p = the value of time for the study region, by trip purpose
- $\Delta VHT_{p,t}$ = the change in vehicle hours traveled, by trip purpose in year t
- VOR_p = the average vehicle occupancy rate by trip purpose
- p = subscript indicating the trip purpose
- t = subscript indicating the specific intermittent year over the analysis period

Vehicle Operating Costs – Non-fuel

$$\Delta AVOC_{v,t}^{nfc} = \Delta VMT_{v,t} \times VOC_{v}^{nfc}$$

Where:

- $\Delta AVOC_{p,t}^{nfc}$ = the annual change in non-fuel vehicle operating costs, for vehicle type v in year t
- $\Delta VMT_{v,t}$ = the change in vehicle miles travelled, for vehicle type v in year t
- VOC_{v}^{nfc} = the non-fuel operating costs per vehicle mile, for vehicle type v
- v = subscript indicating the vehicle type
- t = subscript indicating the specific intermittent year over the analysis period

Vehicle Operating Costs - Fuel

$$\Delta AVOC_{v,t}^{fc} = \Delta FCR_v \times \Delta VMT_{v,t} \times VOC_v^{fc}$$

Where:

- $\Delta AVOC_{p,t}^{fc}$ = the annual change in fuel costs, for vehicle type v in year t
- ΔFCR_v = change in the average fuel consumption rate for vehicle type v
- $\Delta VMT_{v,t}$ = the change in vehicle miles travelled, for vehicle type v in year t
- VOC_v^{fc} = fuel costs per vehicle gallon, for vehicle type v
- v = subscript indicating the vehicle type
- t = subscript indicating the specific intermittent year over the analysis period

Safety Impacts

$$\Delta \boldsymbol{ASC}_{c,t} = \Delta \boldsymbol{CR}_{c} \times \Delta \boldsymbol{VMT}_{t} \times \boldsymbol{SC}_{c}$$

Where:

- $\Delta ASC_{c,t}$ = the change in annual safety costs, for crash type c in year t
- ΔCR_{c} = change in the crash rate for crash type c
- ΔVMT_{t} = the change in vehicle miles travelled in year t
- SC_{c} = the economic cost of crash type c
- c = subscript indicating the crash type
- t = subscript indicating the specific intermittent year over the analysis period

Air Quality Impacts

$$\Delta AAQC_{e,v,t} = \Delta ER_{e,v} \times \Delta VMT_t \times AQC_e$$

Where:

- $\Delta AAQC_{e,v,t}$ = the change in annual air quality costs, for emissions type e from vehicle type v in year t
- $\Delta ER_{e,v}$ = change in the rate of emissions for emissions type e from vehicle type v
- ΔVMT_t = the change in vehicle miles travelled in year t
- AQC_e= the air quality cost of emissions in dollars per gram for emission type e
- e = subscript indicating the emission type
- v = subscript indicating the vehicle type
- t = subscript indicating the specific intermittent year over the analysis period

Operational/Safety Projects

- Increasing Length of Turn Bay
- Increasing the Turn Radius
- Striping Changes
- Signal Timing/Phasing Changes
- Prohibiting Left-Turn Movements
- Prohibiting On-Street Parking
- Adding Turn Lanes
- Adding a Through Lane
- Adding a Traffic Signal
- Adding a Roundabout
- Innovative Intersection (Continuous Flow, etc.)
- Bridge Replacement

Delay Per Vehicle Assumptions

Level of Service	Range of Delay per Vehicle (Seconds)	Default Assumption
A	Less than 10	0
B	10 to 20	10
C	20 to 35	20
D	35 to 55	35
E	55 to 80	55
F	More than 80	80

Impact Level Assumptions

Project Type	Operational Impact Level	Operational Time Reduction
Increase Length of Turn Bay	Minor	15%
Increase Turn Radius	Minor	15%
Striping Changes	Minor	15%
Signal Timing/Phasing Changes	Minor	15%
Prohibit Left-Turn Movements	Minor	15%
Prohibit On-Street Parking	Minor	15%
Adding Turn Lanes	Moderate	30%
Adding a Through Lane	Moderate	30%
Adding a Traffic Signal	Moderate	30%
Adding a Roundabout	Moderate	30%
Bridge Replacement	Moderate	30%
Interchange Construction	Moderate	30%
Innovative Intersection	Major	60%

Additional Assumptions

Parameters	Default Value
No-Build Level of Service	F
Delay per Vehicle	80
K-Factor	10%
Number of Congested Hours/day	4

Travel Time Impacts

$$\Delta AADTTC_{p,t} = VOT_p \times VOR_{p,t} \times (AADT_{p,t} \times K) \times PH_t \times D_t$$

Where:

- $\Delta AADTTC_{p,t}$ = the change in average annual daily travel time costs for trip purpose p in year t
- VOT_p = the value of time for trip purpose p
- $VOR_{p,t}$ = the average vehicle occupancy rate for trip purpose p in year t
- $AADT_{p,t}$ = the average annual daily traffic volume for trip purpose p in year t
- K = the K-Factor for the project
- PH_t = the number of congested (peak) hours per day in year t
- D_t = the daily delay per vehicle in hours during year t
- p = subscript indicating the trip purpose
- t = subscript indicating the specific intermittent year over the analysis period

Safety Project Impact Assumptions

Table Header	Safety Impact	Crash Rate Reduction
Increase Length of Turn Bay	Minor	20%
Increase Turn Radius	Minor	20%
Striping Changes	Minor	20%
Signal Timing/Phasing Changes	Minor	20%
Prohibit On-Street Parking	Minor	20%
Adding Turn Lanes	Minor	20%
Interchange Reconstruction	Moderate	40%
Adding a Through Lane	Moderate	40%
Adding a Traffic Signal	Moderate	40%
Adding a Roundabout	Moderate	40%
Bridge Replacement	Moderate	40%
Innovative Intersection	Major	80%
Prohibit Left-Turn Movements	Major	80%

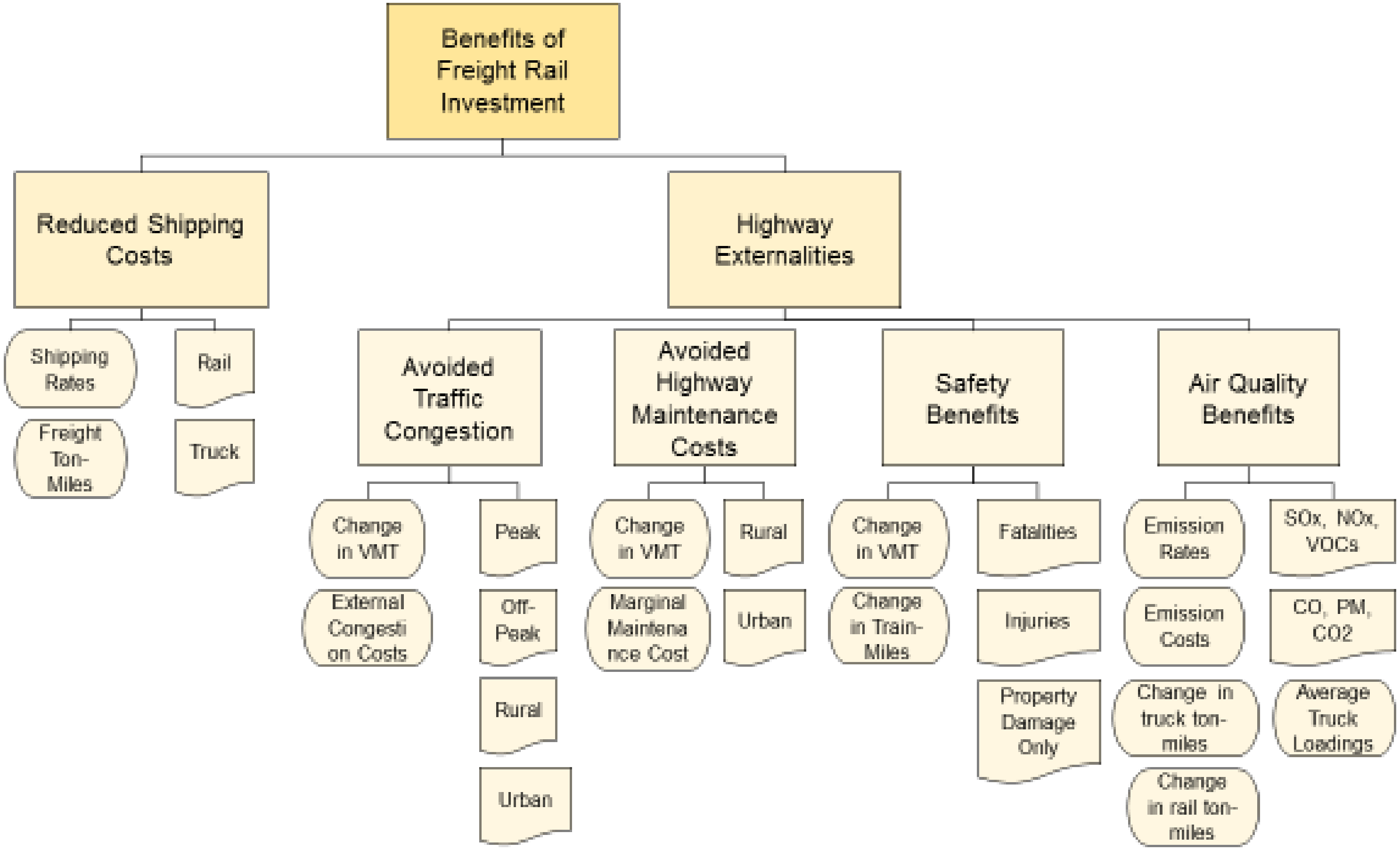
Estimating Safety Impacts

$$\Delta \boldsymbol{AADSC_{c,p,t}} = \Delta \boldsymbol{CR_c} \times \boldsymbol{AADT_p} \times \boldsymbol{L} \times \boldsymbol{SC_c}$$

Where:

- $\Delta AADSC_{c,p,t}$ = the change in average annual daily safety costs, for crash type c and trip purpose p, in year t
- ΔCR_c = the change in crash rate for crash type c
- $AADT_p$ = the average annual daily traffic volume for trip purpose p
- L = the extent of the project influence, in miles
- SC_c = the economic cost of crash type c
- c = subscript indicating the crash type
- p = subscript indicating the trip purpose
- t = subscript indicating the specific intermittent year over the analysis period

Freight Rail Projects



Truck to Rail Diversion

$$\boldsymbol{ADP_{g,t}^{r,sa} = AFV_{g,t}^{sa} \times \left(MS_{g}^{r,na} - MS_{g}^{r,sa}\right)}$$

Where:

- $ADP_{g,t}^{r,sa}$ = the annual potential rail diversion in the study area in ton-miles, for good g in year t
- $AFV_{g,t}^{sa}$ = the annual freight volume in ton-miles of good g in the study area in year t
- $MS_{g}^{r,na}$ = the rail mode share (percentage) nationally for good g
- $MS_{g}^{r,sa}$ = the rail mode share (percentage) in the study area for good g
- g = subscript indicating the type of good or commodity
- t = subscript indicating the specific intermittent year over the analysis period

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Shipping Cost Impacts

$$\Delta \boldsymbol{ASHC}_{\boldsymbol{g,t}} = (\boldsymbol{SR}^{\boldsymbol{r}} - \boldsymbol{SR}^{\boldsymbol{tr}}) \times \boldsymbol{ADP}_{\boldsymbol{g,t}}^{\boldsymbol{r,sa}}$$

Where:

- $\Delta ASHC_{g,t}$ = the change in annual shipping costs for good g in the study area in year t
- SR^{r} = average shipping rates per ton-mile for rail
- SR^{tr} = average shipping rates per ton-mile for truck
- $ADP_{g,t}^{r,sa}$ = the annual potential rail diversion in the study area in ton-miles, for good g in year t
- g = subscript indicating the type of good or commodity
- t = subscript indicating the specific intermittent year over the analysis period

Congestion Cost Impacts

$$\Delta ACC_t = CC^{tr} \times \left(DP_g^{r,sa} \times \frac{AFV_{g,t}^{sa}}{LF_g^{tr}} \right)$$

Where:

- ΔACC_t = the change in annual congestion cost in year t
- CC^{tr} = the cost of congestion per truck mile
- $AFV_{g,t}^{sa}$ = the annual freight volume in ton-miles of good g in the study area in year t
- $LF_{g,}^{tr}$ = the average truckload in tons for good g
- $DP_g^{r,sa}$ = the potential rail diversion percentage in the study area for good g

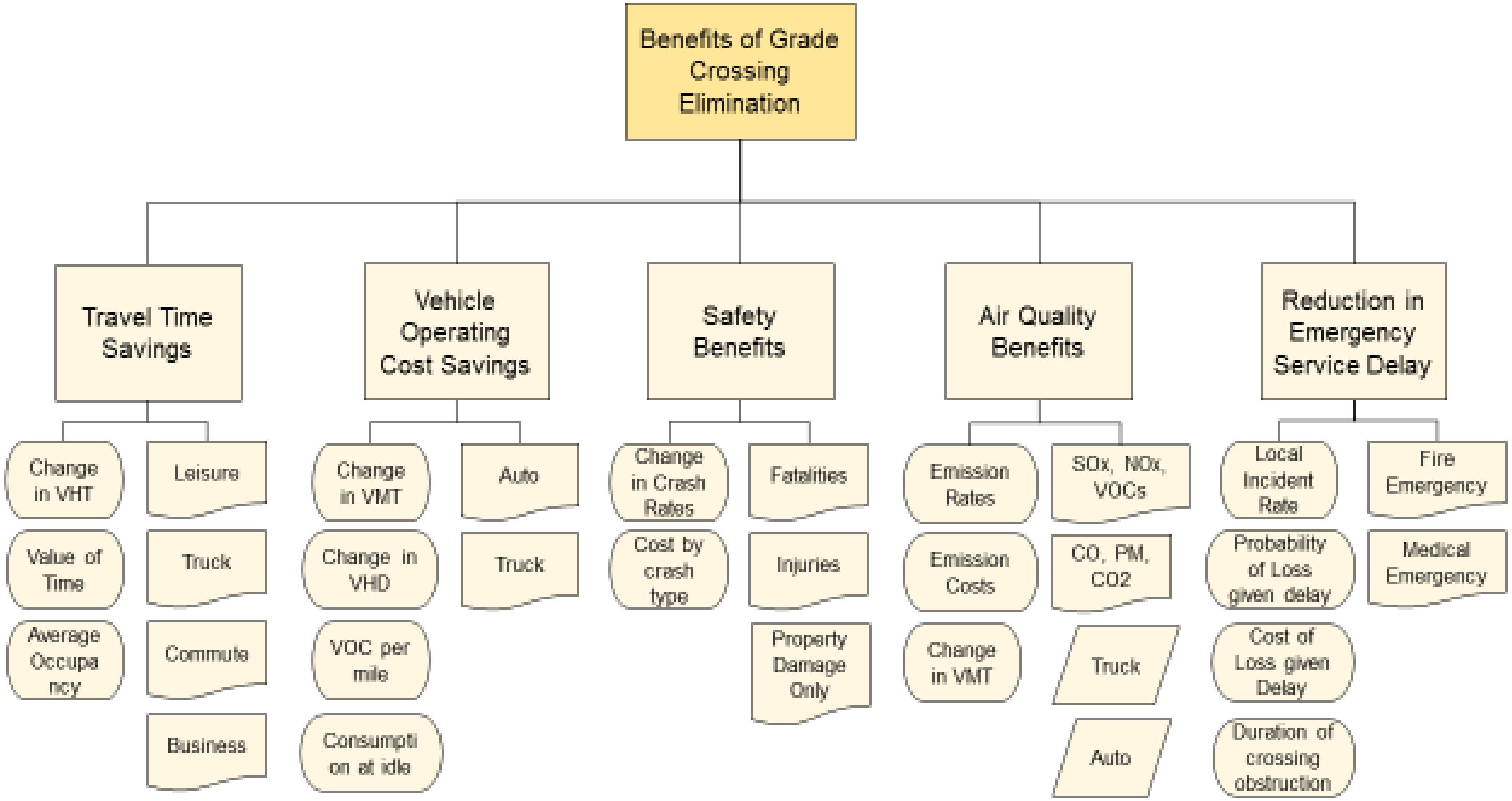
State of Repair Impacts

$$\Delta AHMC_t = HMC^{tr} \times \left(DP_g^{r,sa} \times \frac{AFV_{g,t}^{sa}}{LF_g^{tr}} \right)$$

Where:

- $\Delta AHMC_t$ = the change in annual highway maintenance cost in year t
- $HMCC^{tr}$ = the highway maintenance cost per truck mile
- $AFV_{g,t}^{sa}$ = the annual freight volume in ton-miles of good g in the study area in year t
- $LF_{g,}^{tr}$ = the average truckload in tons for good g
- $DP_g^{r,sa}$ = the potential rail diversion percentage in the study area for good g
- Also assess air quality and safety impacts as previously discussed

Grade Crossing Elimination



Grade Crossing Impacts

- Travel time impacts estimated using GradeDec

$$\Delta AVOC_{v,t}^{fc} = FCR_{v}^{id} \times AD_{v,t}^{gc} \times VOC_{v}^{fc}$$

Where:

- $\Delta AVOC_{v,t}^{fc}$ = the change in annual fuel costs from grade separation for vehicle type v in year t
- FCR_{v}^{id} = the fuel consumption rate when idle in gallons per hour, for vehicle type v
- $AD_{v,t}^{gc}$ = the annual delay at the grade crossing for vehicle type v in year t
- VOC_{v}^{fc} = the fuel cost per gallon for vehicle type v
- v = subscript indicating the vehicle type
- t = subscript indicating the specific intermittent year over the analysis period

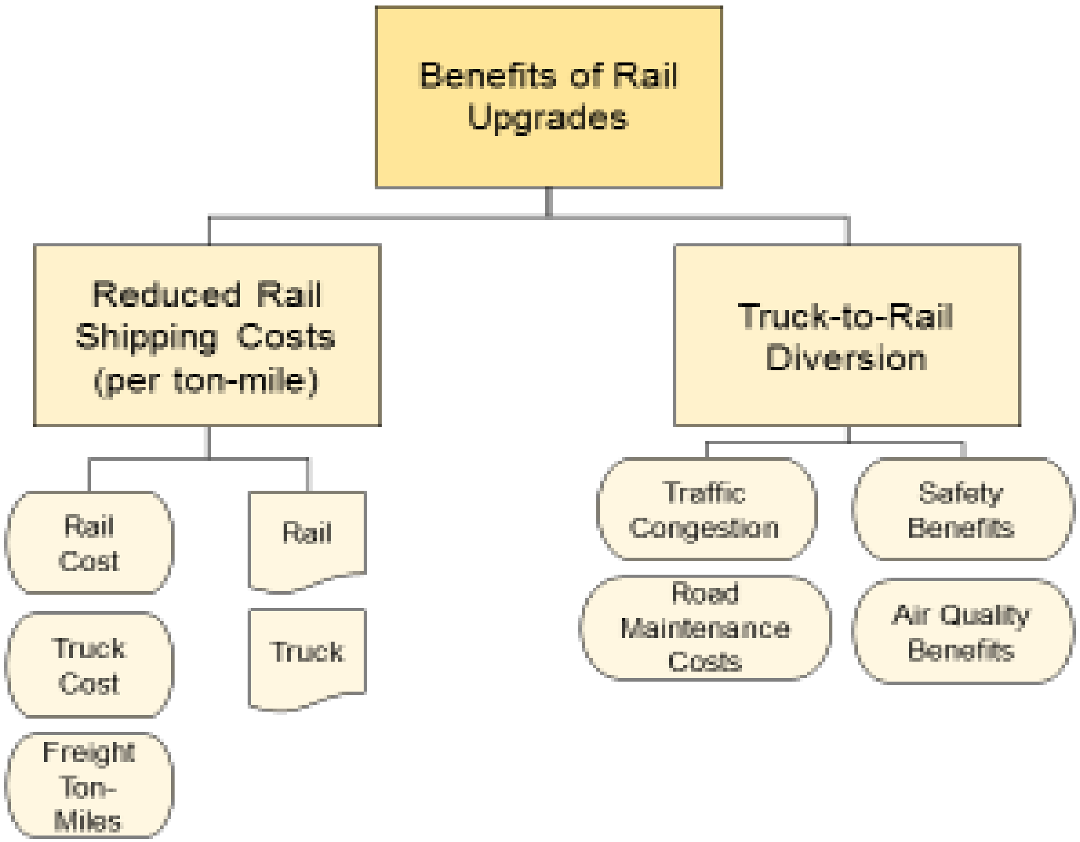
Safety Impacts

$$\Delta \boldsymbol{ASC}_{c,t} = \boldsymbol{ACR}_{c}^{gc} \times \boldsymbol{SC}_{c}$$

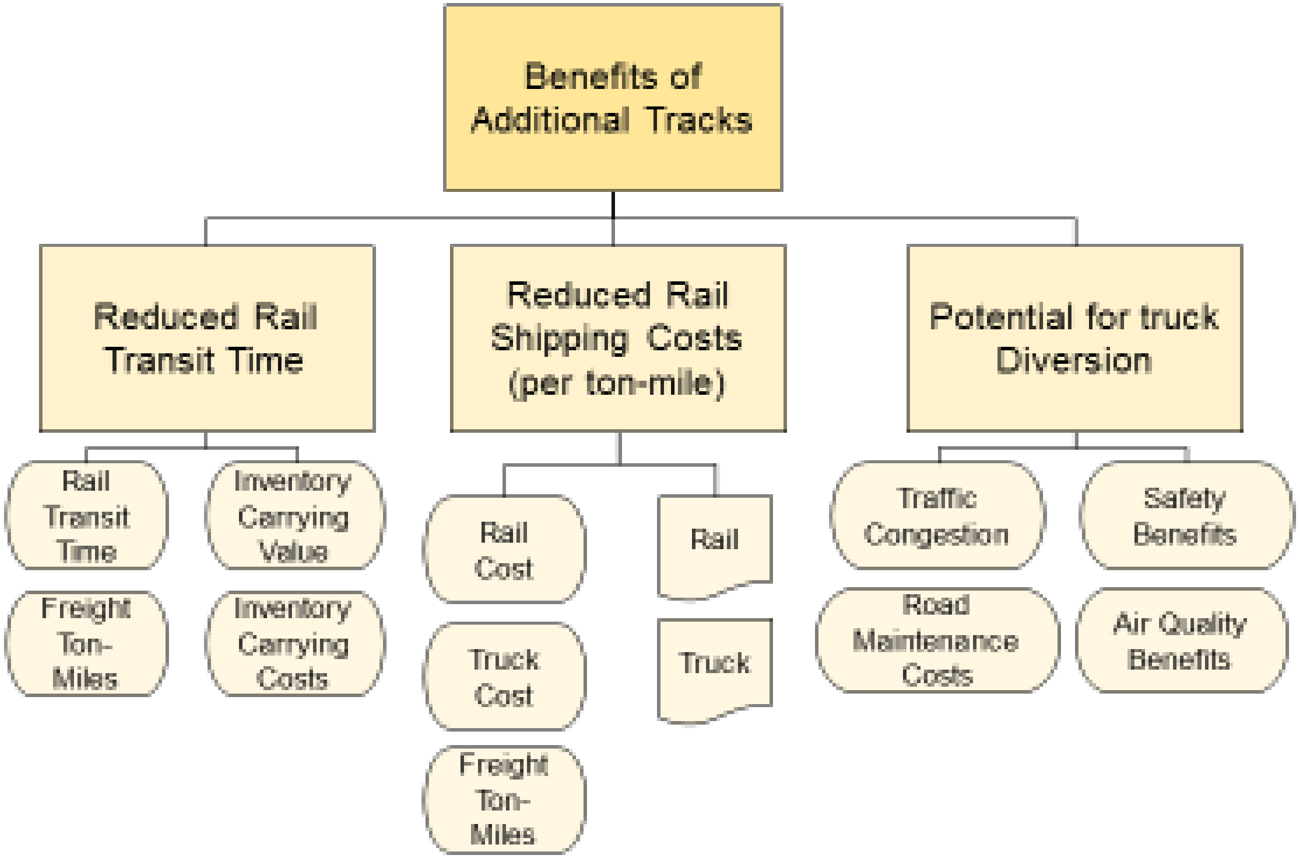
Where:

- $\Delta ASC_{c,t}$ = the change in annual safety cost from the grade separation, for crash type in year t
- ACR_{c}^{gc} = the annual crash rate at the grade crossing for crash type c
- SC_{c} = the economic cost of crash type c
- c = subscript indicating the crash type
- t = subscript indicating the specific intermittent year over the analysis period

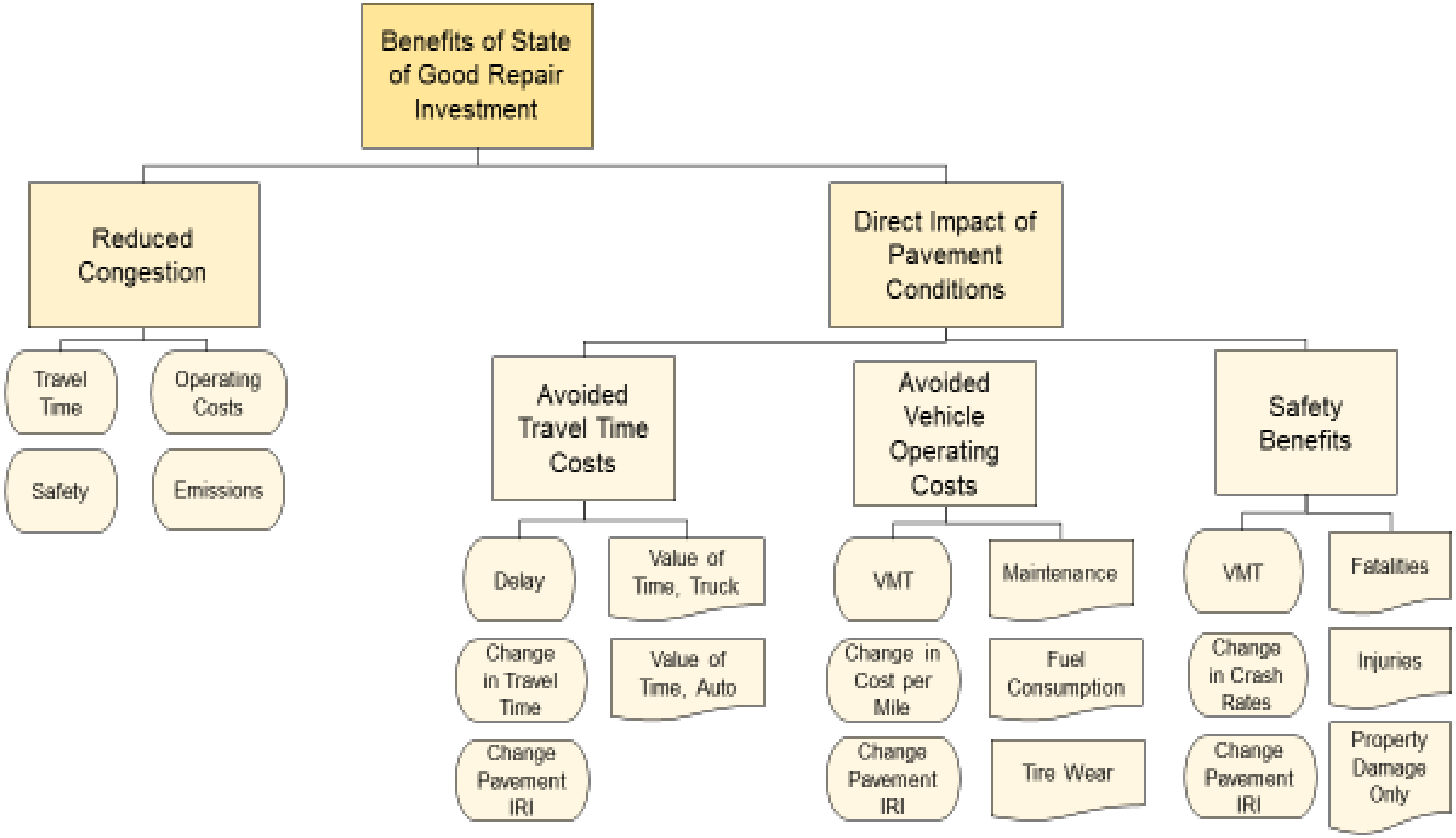
Rail Upgrades to 286K



Double-Tracking



State of Repair Impacts



Vehicle Operating Cost Impacts

Vehicle Operating Cost Type	Range	Impact on Passenger Cars	Impact on Commercial Vehicles
Fuel Consumption	An increase in IRI of 63.4 in/mi	2%	2% (Low Speeds)
			1% (Normal Speeds)
Repair and Maintenance	Up to IRI of 190.2 in/mi	0%	0%
	An increase in IRI up to 253.6 in/mi	10%	10%
	An increase in IRI up to 317.0 in/mi	40%	50%
	An increase in IRI up to 380.4 in/mi	70%	80%
Tire Wear	An increase in IRI of 63.4 in/mi	1%	1%

Travel Time Savings Impacts

- Study based in Ontario, Canada found that increases in IRI from 63.4 in/mi to 128 in/mi led to 1.95 mph (Karen et al, 1996)
- CalTrans Research (Wang et al, 2013)
  - One unit change in IRI leads to 0.3 to 0.4 mph (0.48 to 0.64 km/h) change in free-flow speed
  - Considered conservative approach since sample included pavement primarily in fair or better condition

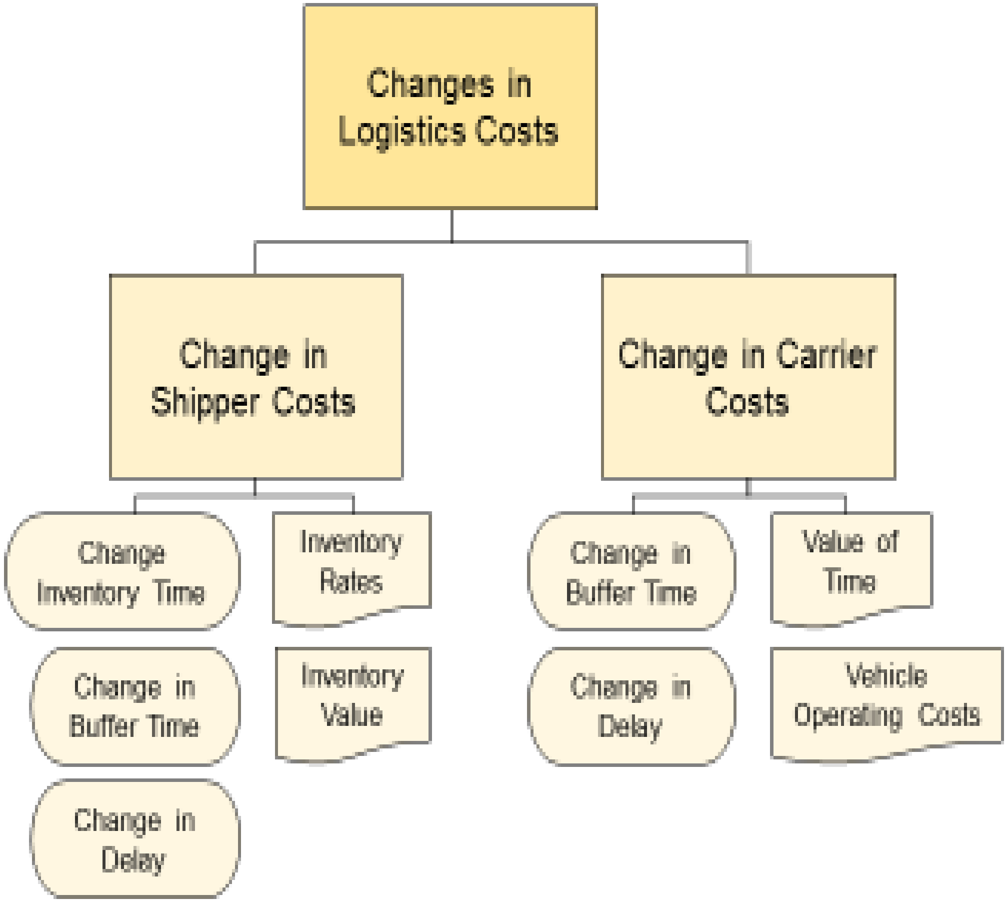
Safety Impacts

- An increase in IRI of 63.4 in/mi will increase crash rates by 25 percent on road segments with poor pavement condition and average travel speeds equal or greater than 43.5 mph.
- Applied to outputs of travel characteristics generated by the statewide TDM to identify the road segments that meet the travel speed criterion.

Calculation of Safety Impacts

- $\Delta Crash\ Rate_{C,S} = Crash\ Rate_{C,S} \times 0.25 \times \Delta IRI_{S}$
- $Annual\ Cash\ Cost_{S,t}^{VT} = \Delta\ Crash\ Rate_{C,S} \times AADT_{S,t}^{VT} \times Average\ Crash\ Cost_{t} \times Annualization\ Factor^{VT}$

Logistics Cost Impacts



Change in Carrier Costs

$$\Delta \boldsymbol{ACC_t} = \Delta \boldsymbol{ABT_t} \times \left(\boldsymbol{VOT^{t/hr}} + \boldsymbol{VOC^{t/hr}}\right)$$

Where:

- ΔACC_t = The change in annual carrier costs in year t
- $VOT^{t/hr}$ = the value of time for trucks, usually a wage rate for truckers
- $VOC^{t/hr}$ = the vehicle operating cost for trucks, in dollars per hour.
- t = subscript indicating the specific intermittent year over the analysis period
- *b* = subscript indicating the dollar year in which the relevant cost is given
- ΔABT_t = the change in annual buffer time in year t

Change in Inventory Carrying Costs

- $\Delta AIC_t = IR^{hr} \times AV_t^i \times \Delta AIT_t$

Where:

- ΔAIC_t = the annual change in inventory cost in year t
- IR^{hr} = the hourly rate charged for inventory. This rate is often an annual rate, calculated as some percentage of the value of the inventory. In this case the hourly rate is calculated from the annual, using 365 day of 24 hours each.
- AV_t^i = the annual value of the time sensitive inventory being shipped via truck, that has an origin and/or destination within the study area during year t
- t = subscript indicating the specific intermittent year over the analysis period
- ΔAIT_t = the change in inventory time.

Discussion on direct/indirect impacts

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Translating Impacts into Economic Model Inputs

Input Variable

Time Cost Factors
- Passenger Time
- Truck Crew Time
- Buffer Time

Vehicle Cost Factors
- VOC/mi-Congested
- VOC/mi-Free Flow
- VOC/hr-Idle

Travel Demand Factors
- Vehicle-Trips by trip type
- Vehicle Miles Traveled (VMT)
- Vehicle Hours Traveled (VHT)
- Buffer Time
- Average Crew per Vehicle
- Average Pass per Vehicle

Business Factors
- Transportation cost factors by industry

1 – Travel Costs by Cost Type
- Passenger Time Cost
- Crew Time Cost
- Freight Time Cost
- Reliability Time Cost
- Vehicle Operator Cost

2 – Travel Costs by "User" Type
- Household-Time
- Households-Out-of-Pocket
- Vehicle Operator (carrier)
- Industry-Freight (shipper)
- Industry-Nonfreight

Translating Impacts into Economic Model Inputs (cont.)