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Potential Payoffs From Ivhs: A Framework For Analysis Appendix C

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Rockwell International Science Center

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POTENTIAL PAYOFFS FROM IVHS: A FRAMEWORK FOR ANALYSIS

APPENDIX C

FINAL REPORT

January 22, 1992 through August 14, 1992

CONTRACT NO. PPBO02162

Prepared for:

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AUGUST 1992

Rockwell International
Science Center

Specific Tasks of

IVHS ANALYSIS AND DESIGN

in Support of the PATH Program

Task 1

Analysis of Goals, Functions, and Priorities

(Payoff Analysis)

Appendix C

**The Decision Modeling System (Demos)
as a Tool to
Perform IVHS Benefit Analysis**

Final Report

August, 1992

Prepared for:

The University of California at Berkeley

under

Contract Number: PPB002162

Prepared by:

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Appendix C

THE DECISION MODELING SYSTEM (DEMOS) AS A TOOL TO PERFORM IVHS BENEFIT ANALYSIS

TABLE OF CONTENTS

SECTION 1 .O

INTRODUCTION

The Decision Modeling System (DEMOS) is a computer tool used on the IVHS Analysis and Design Contract (Task 1: Analysis of Goals, Functions, and Priorities) to:

1.) Display the goals-to-actions relationship structure and provide for future expansion of data and analyses.

2.) Perform selected sensitivity analyses and estimate the potential improvements of key IVHS actions (high payoff items).

This Appendix documents the details of the IVHS benefit analysis DEMOS models and provides the PATH user information about what is contained in and how to use the models.

It should be noted that the objective of this contract was to structure an approach to evaluate the relationships of the top-level IVHS goals to the implementable actions and then, where possible, to assess the relative benefits of those actions toward accomplishing the goals. The results are not meant to be "the answer" but rather a beginning at understanding the problem and a point of departure for further analysis.

To this end, the DEMOS model has been used as a tool to analyze selected IVHS actions with the goal of determining the key driving parameters through the use of sensitivity analysis. The results of potential benefits of these actions are dictated by the assumptions made and are not meant to represent the only answer. Our recommendation is that PATH use the structure established in DEMOS to 1) assess the benefits of the selected IVHS actions using their own assumptions, and 2) further the benefits analysis for the other IVHS actions as yet not analyzed.

About DEMOS

The Decision Modeling System (DEMOS) is a general framework for constructing analytical models which is currently implemented on a Macintosh computer system. The key features of the software used in our activities include influence diagrams to display the model structure, hierarchical structure to organize large models, hypertext capability to allow "as you go" documentation, and array abstraction which provides for multidimensional models. DEMOS is ideal for performing engineering trade-off studies and sensitivity analysis on uncertain variables.

DEMOS has many other features, such as the ability to assign a probability distribution to any variable, that were not used in our analyses, but could be useful in future studies. For information regarding how to use DEMOS refer to Sections 3.0 and 4.0 of this Appendix.

DEMOS IVHS Models Developed and Analyses Performed

Three DEMOS models were developed under this contract corresponding to the IVHS scenarios evaluated. Within each of these models are the appropriate goals-to-actions relationships discussed in Chapter 3.0 of the final report. In addition to the goals-to-actions relationship structure, three separate analyses were developed and are contained in the appropriate DEMOS models. The three DEMOS models and the corresponding analyses conducted in each are as follows:

DEMOS MODELS	ANALYSES PERFORMED
• Urban Freeways	Vehicle Density Improvement, Safety
• Urban Arterials	Intersection Queue Clearing, Safety
• Downtown Networks	Safety

The safety analysis is the same in all three scenarios. The data was not in a form to allow a scenario breakdown, therefore, the same information has been included in each model.

Variables Used in Analyses and Resulting DEMOS Outputs

One of the key features of DEMOS is its ability to perform quick sensitivity studies of all variables affecting a specific output to determine which are the driving parameters. Each of the variables in the model can have multiple values allowing these sensitivities to be performed easily.

The three analyses developed under this contract (freeway vehicle density improvement, intersection queue clearing, and overall safety) are discussed below. The input variables, the corresponding outputs, and key sensitivities developed in the analyses using DEMOS are summarized.

Freeway Vehicle Density Improvement Analysis

The following are the input variables affecting the freeway vehicle density improvement analysis:

- Speed
- Improved driver reaction time
- Deceleration rate of Car B (fraction of car A)
- Intra-platoon spacing
- Car length
- Baseline traffic flow
- Current driver reaction time
- Deceleration rate of Car A
- Platoon size
- Space degradation factor
- Platoon size mix for multi-lanes

The following outputs can be obtained in the freeway vehicle density improvement analysis as a function of the appropriate input variables (above):

- Safe braking distances required to avoid an accident
- Lane flow parametrics
- Gap holding lane flow estimates
- Gap holding vs Baseline lane flow estimates
- Platooning lane flow estimates
- Platooning vs Baseline lane flow estimates
- Platooning vs Gap holding vs Baseline 'estimates for a 4 lane freeway

Some of the key sensitivities that impact lane flow that can be analyzed are:

- Relative braking capabilities of car A and car B
- Driver/Automated car reaction times
- Platoon sizes
- Intra-platoon spacing

Intersection Queue Clearing Analysis

The following are the input variables affecting the intersection queue clearing analysis:

- Number of cars to be evaluated
- Space between cars when stopped
- Initial car delay time (automated)
- Steady state spacing (automated)
- Car length
- Time of a green light
- Steady state spacing decay rate factor (manual only)
- Constant acceleration rate
- Initial car delay time (manual)
- Steady state spacing (manual)
- Max. speed the cars can attain
- Distance the 1st car must travel

The following outputs can be obtained in the intersection queue clearing analysis as a function of the appropriate input variables (above):

- Total distance required for all cars to travel
- Total time used due to spacing between the cars (manual and automated)
- Total time to clear the intersection (manual and automated)
- How many cars can get through the intersection given a green light time (manual and automated)

Some of the key sensitivities that impact the number of cars that can get through the intersection are:

- Constant acceleration rate
- Steady state spacing
- Distance the first car must travel to clear the intersection
- Maximum speed
- Green light time

Overall Safety Evaluation

The input variables affecting the overall safety evaluation are the current accident data by crash severity and manner of collision provided by the General Estimates System, Department of Transportation (1990), and the improvement factors (assuming some level of automation implemented) which are applied to the current data.

The outputs of the overall safety evaluation are the total accidents by severity of the crash and manner of collision for both the current and the improved data, and the percent improvement. The primary variables to be evaluated in this analysis are the improvement factors.

Contents of This Appendix

Section 2.0 of this appendix displays the three DEMOS models. This includes the printed DEMOS output for the entire model structure (screen by screen) and the information related to each element or object of the model. The information includes the name, a description, the definition (equations or values), the inputs, and the outputs for each variable.

The specific output of the analyses including the estimates of potential improvements due to implementation of a specific IVHS action and the sensitivity analyses are not shown in this document. It is left to the user to exercise the models for this information. A summary of the key results of the analyses are discussed in Chapter 4.0 of the final report.

Sections 3.0 and 4.0 are the DEMOS Tutorial and Quick Reference Guide, respectively. They are meant to provide the user with some important information on how to use the DEMOS system.

SECTION 2.0

DEMOS MODELS

This Section displays the following three DEMOS models:

- Urban Freeways
- Urban Arterials
- Downtown Networks

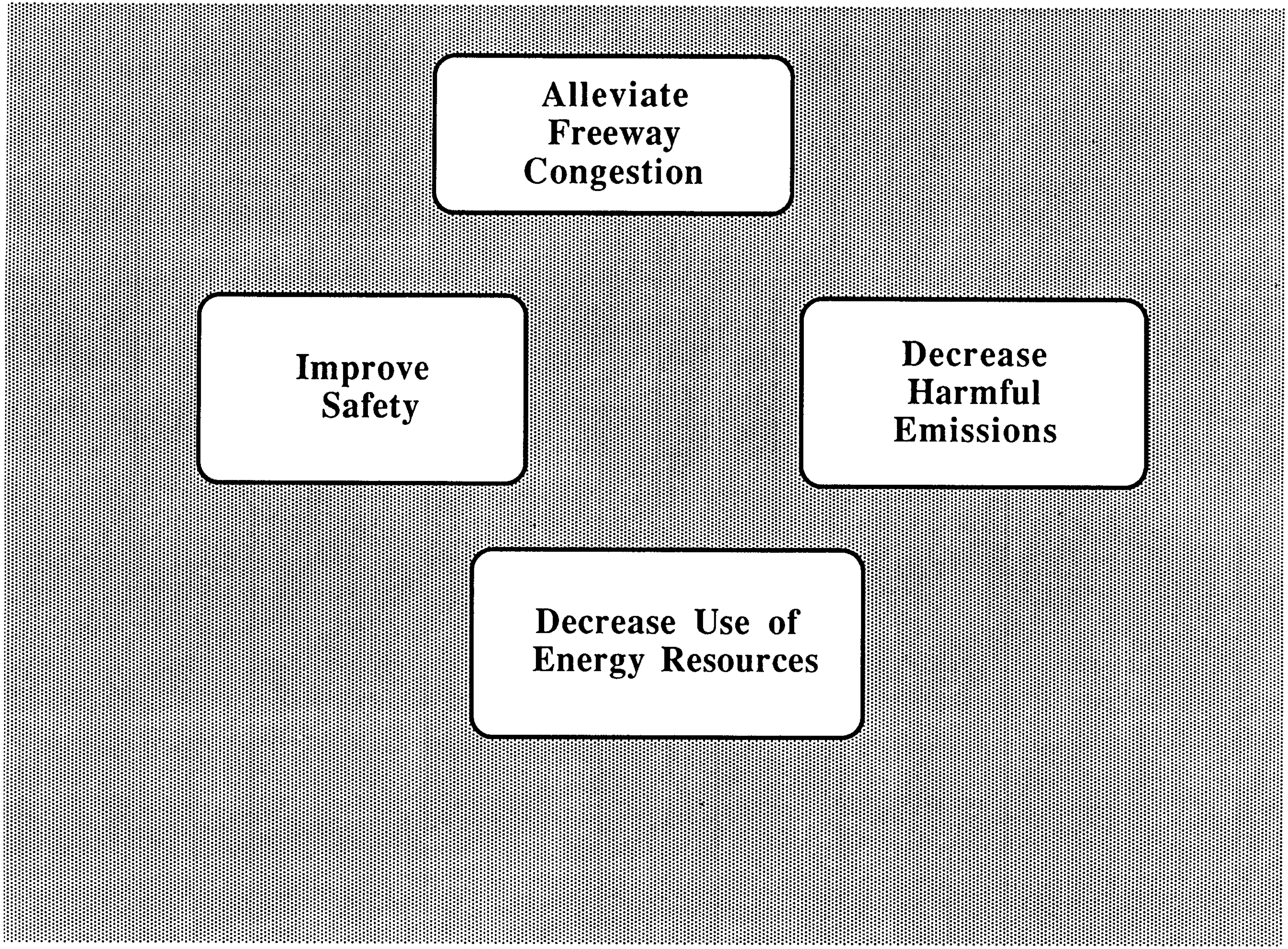
The models are displayed using the actual printed DEMOS outputs for the entire model structure (screen by screen) and the information related to each element or object of the model. The information includes the name, a description, the definition (equations or values), the inputs, and the outputs for each variable.

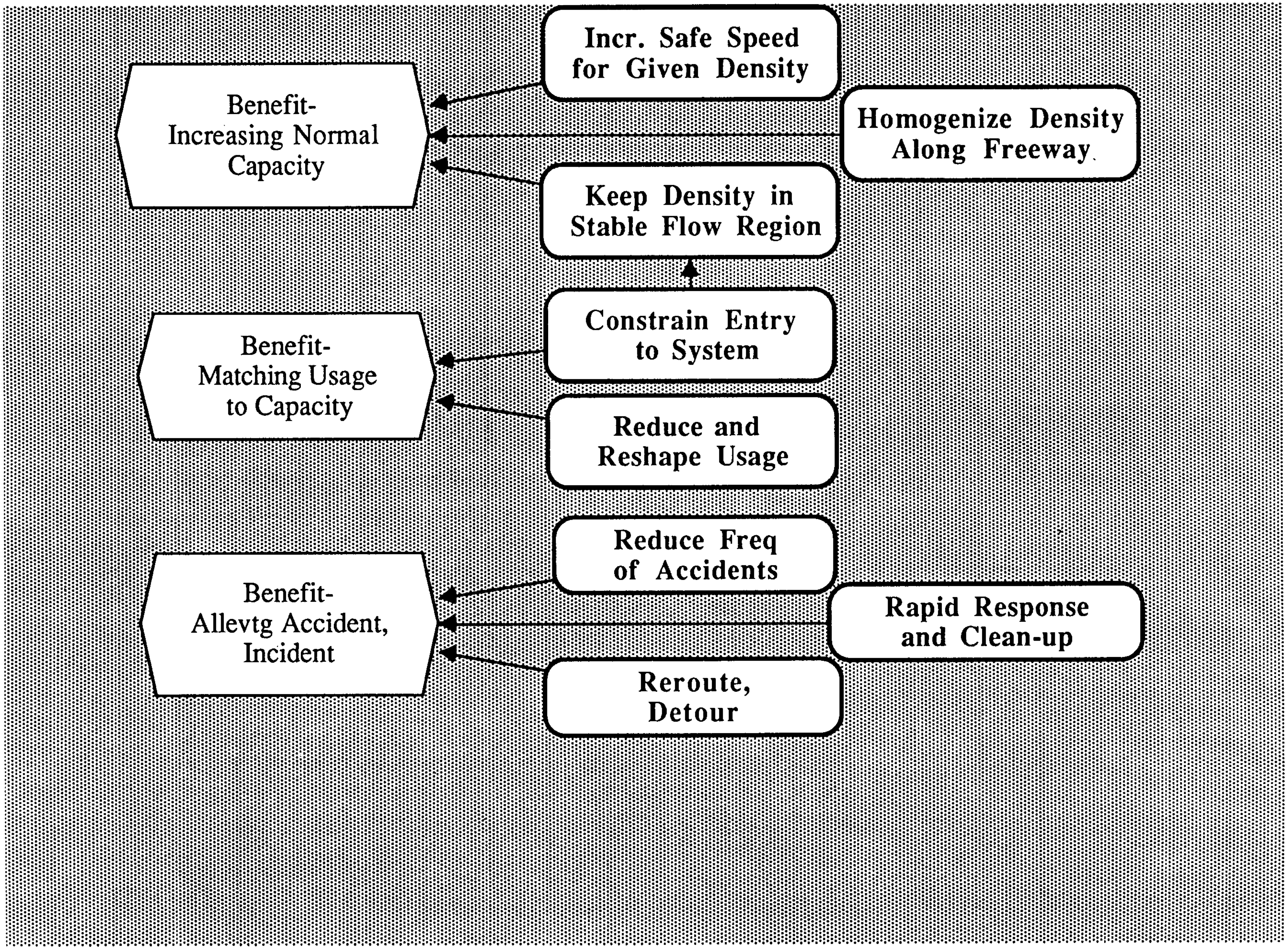
The specific output of the analyses including the estimates of potential improvements due to implementation of a specific IVHS action and the sensitivity analyses are not shown in this document. It is left to the user to exercise the models for this information. A summary of the key results of the analyses are discussed in Chapter 4.0 of the final report.

DEMOS MODEL

- URBAN FREEWAYS -

Diagram • IVHS Benefits




Incr. Safe Speed for Given Density
Benefit- Increasing Normal Capacity
Homogenize Density Along Freeway
Keep Density in Stable Flow Region
Constrain Entry to System
Benefit- Matching Usage to Capacity
Reduce and Reshape Usage
Reduce Freq of Accidents
Benefit- Allevtg Accident, Incident
Rapid Response and Clean-up
Reroute, Detour

(Objective Benefit-inc **Units:**

Title: Benefit-
Increasing Normal
Capacity

Description: **Evaluate the benefits of increasing the normal vehicle capacity by keeping vehicle density in stable flow region, homogenizing the density, or increasing the safe speed for a given density.**

Definition:

Estimate_ro
[redacted] Es[redacted]_sfb
Vehdens

Inputs:
- **Estimate-...** estimate of homogenized density
- Estimate-sfb estimate of stable flow . . .
- Vehdens Vehicle Density- % improve...

(Objective Benefit-m Units:

Title: Benefit-
Matching Usage
to Capacity

Description: Evaluate the benefits of matching usage to capacity by constaining the entry to the system and reducing and reshaping the usage.

Definition:

(Benefit_of+Selective_)
Encourage
Provided_t
Route-guid

Inputs:
- Benefit-of Benefit of Ramp Metering
- Encourage_ Encourage Mode Shift
- Provided-t Provided Traveler Information
- Route_guid Route Guidance
- Selective_ Selective Road Pricing

(Objective Benefit-a Units:

Title: Benefit-
Allevtg Accident,
incident

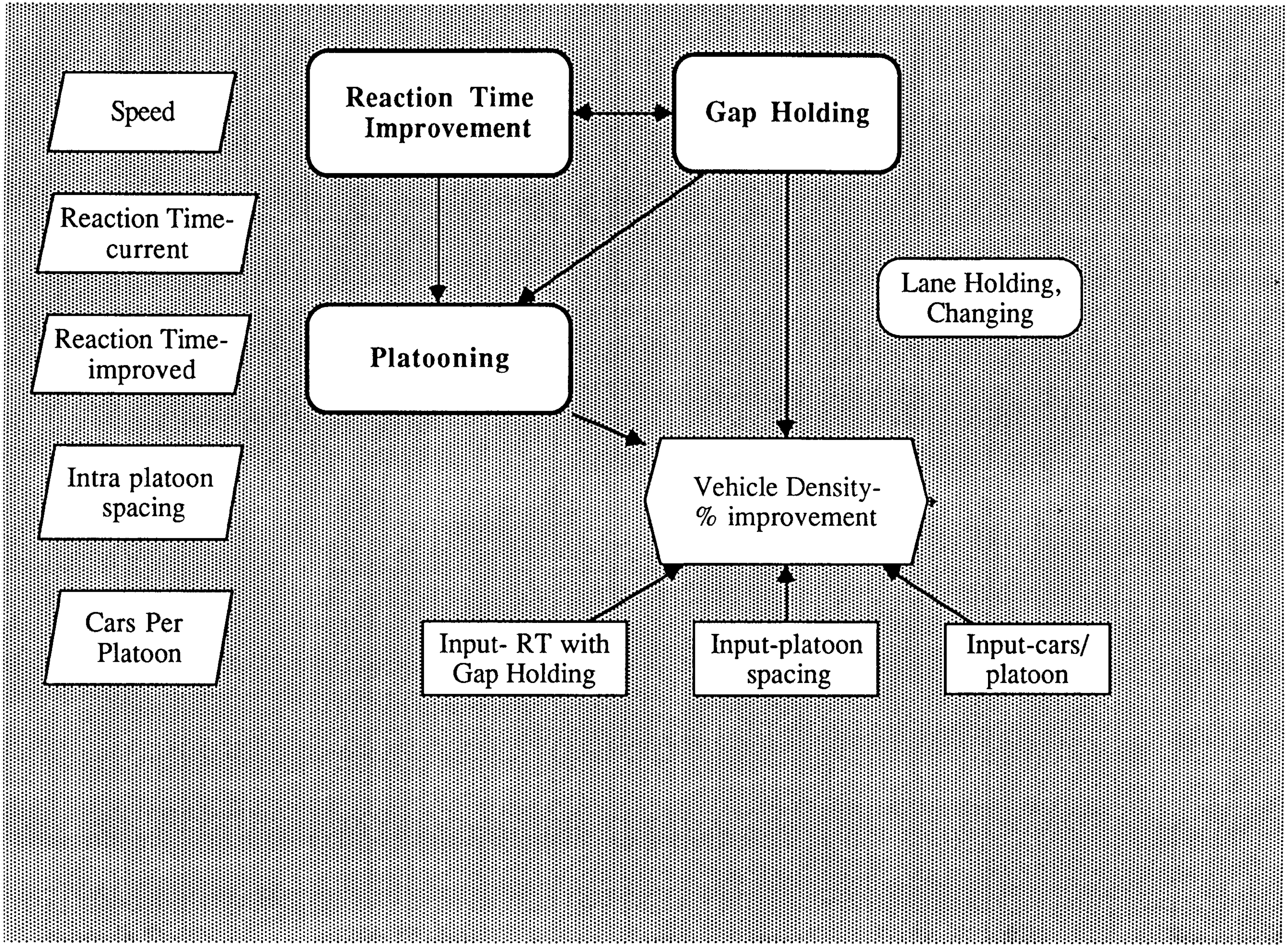
Description: Evaluate the benefits of alleviating accidents and incidents on congestion by reduced frequency of accidents, rerouted and detoured vehicles, and through rapid respnse and clean-up activities.

Definition:

Benefit_of1
Benefit_of2
Benefit of4

Inputs: Benefit-of1 Benefiiof Reduced Accidents
Benefit-of2 Benefit of Rapid Response, etc
Benefit-of4 Benefit of Reroute, Deto...

Diagram • Incr. Safe Speed for Given Density



Index **Speed** **Units: MPH**

Title: Speed

Description: **Index of speeds to be used for evaluation of vehicle density analyses**

expr ▼

Definition: Sequence(0,7)*10

outputs: Braking Distance- current RT ▼

Index Reaction-tim Units: seconds

Title: Reaction Time-current

Description: An index of possible reaction times that a driver of a following vehicle would exhibit before applying his/her brakes after a front car brakes. This index is for the current situation on the freeways.

Definition:

0.5
1
1.5

Outputs: Braking Distance- current RT

Index Reaction_ti2 **Units: seconds**

Title: Reaction Time-improved

Description: An index of possible reaction times that a driver of a following vehicle would exhibit before applying his/her brakes after a front car brakes. This index is for an automated case (both gap holding and platooning).

Definition:

0.1
0.2
0.3
0.4
0.5
0.75
1

outputs: Braking Distance- improved RT

Index Intra_platoo **Units:** feet

Title: Intra platoon spacing

Description: The space that would exist between cars within a platoon.

Definition:

3
5
10
15
20
25
30

Outputs: Vehicle Density- % improvement

Index Cars-per-pla **Units:** number

Title: Cars Per Platoon

Description: Number of cars within a platoon to be evaluated.

Definition:

1
2
3
4
5
10
15
20

outputs: Vehicle Density- % improvement

(Objective Vehdens   Units: **percentage**

Title : **Vehicle Density- % improvement**

Description: **Calculate the increase (as a %) in vehicle density due to various IVHS functions being implemented.**

Definition: Platooning__[Intra_platoo=Input_platoo, Cars_per_pla=Input_ca
Gap_holdinl[Gap_holding_=Input__

Inputs:
- **Cars-per-pla Cars Per Platoon**
- **Gap-holdinl Gap Holding % improve...**
- Gap_holding_ **Gap Holding Reaction Ti...**
- **Input-cars- Input-cars/ platoon**
- Input_platoo **Input-platoon spacing**
- Input__rt_wi **Input- RT with Gap** Hol...
- Intra_platoo **Intra platoon spacing**
- Platooning__ **Platooning- % improve...**

outputs: Benefit- Increasing Normal Capacity

Decision Input__rt_wi Units: seconds

Title: Input- RT with Gap Holding

Description: Reaction time for the Gap Holding case to brake in an emergency. User can input 0.1, 0.2, 0.3, 0.4, or 0.5 seconds.

expr

Definition: 0.3

outputs: Vehicle Density- % improvement

Decision Input_platoo **Units:** feet

Title: Input-platoon spacing

Description: The distance that the cars within a platoon are apart while travelling on the freeway.
User can input 2, 3, 4, 5, 6, 8, or 10.

expr

Definition: 10

Outputs: Vehicle Density- % improvement

Decision Input-cars- Units: number

Title: Input-cars/ platoon

Description: The number of cars within a platoon on average. User can input 2, 3, 4, 5, 10, 15, or 20.

expr

Definition: 3

outputs: Vehicle Density- % improvement

Chance Lane_holdi Units:

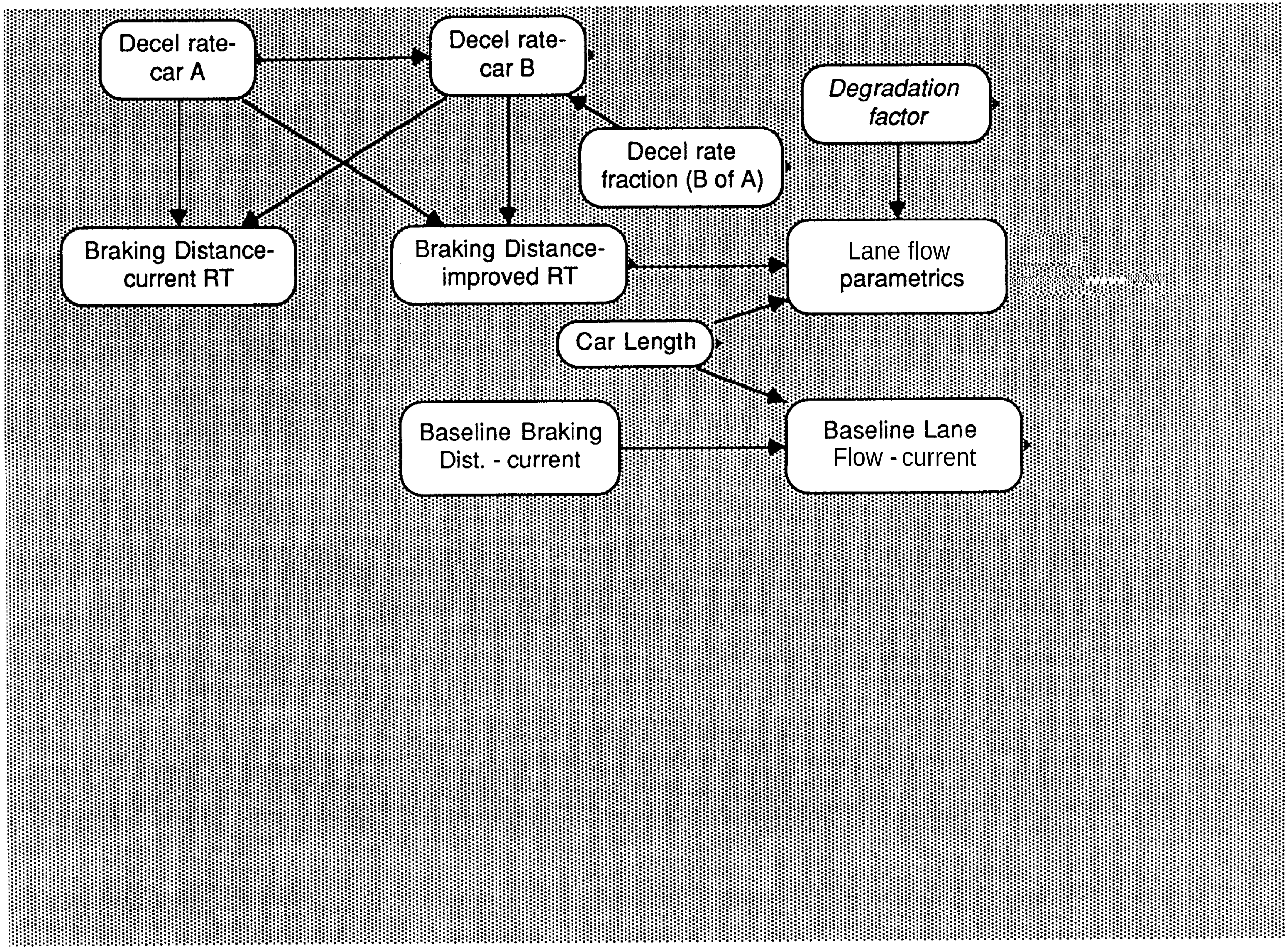
Title: Lane Holding, Changing

Description: Lane holding and changing is a key element of an implemented automatic system on the freeways, however, it does not directly effect vehicle density by itself. It has strong safety implications and is addressed in the safety section of the model. It is shown here only for completeness.

expr

Definition: 0

Diagram . Reaction Time Improvement



Chance Decel_rate__ **Units:** feet/sec/sec

Title: Decel rate-
car A

Description: The deceleration rate of the front car. The Baseline is 0.8g's (25.6 feet/sec/sec).

expr

Definition: 25.6

Outputs: B k g D R

Chance Decel_rate_1 Units: feet/sec/sec

Title: Decel rate-
car B

Description: The deceleration rate of a following car. Current baseline is 90% of the front car's braking capability.

expr

Definition: Decel_rate__*Decel_rate

Inputs: Decel_rate Decel rate fraction (B of A)
Decel_rate__ Decel rate- car A

outputs: Braking Distance- current RT

(Chance Decel_rate Units:

Title: Decel rate fraction (B of A)

Description: This is the fraction that the deceleration rate of car B (the following car) is of car A. For instance, if car A car brake at 0.8g's, then car B can brake at 90%, 80%, or 70% of that value. The baseline value is 90%.

Definition:

0.8
0.85
0.9
0.95

Outputs: Decel rate- car B

Chance Braking-dist Units: feet

Title: Braking Distance- current RT

Description: This block provides input data regarding the distance apart two cars on a freeway need to be travelling to avoid a collision. It varies by speed of the car from 0 to 70 and is provided for various reaction times of each of the cars. This data is for the current highway situation. The data can be generated for various stopping rates of both cars.

expr

Definition: (((Speed*Speed*2.151111111)/2)*((1/Decel_rate_1)-(1/Decel_rate__)))+Speed*1.466666667*Reaction_tim

Inputs:
- Decel_rate_1 Decel rate- car B
- Decel_rate__ Decel rate- car A
- Reaction_tim Reaction Time- current
- Speed Speed

Chance **Braking-disl** Units: **feet**

Title: **Braking Distance-improved RT**

Description: **This block provides input data regarding the distance apart two cars on a freeway need to be travelling to avoid a collision. It varies by speed of the car from 0 to 70 and is provided for various reaction times of each of the cars. This data is for the improved reaction times situation on the highway. The data can be generated for various stopping rates of each car.**

expr

Definition: (((Speed*Speed*2.151111111)/2)*((1/Decel_rate_1)-(1/Decel_rate__)))+Speed*1.466666667*Reaction_ti2

Inputs:
- Decel_rate_1 **Decel rate- car B**
- Decel_rate__ **Decel rate- car A**
- Reaction_ti2 **Reaction Time- improved**
- Speed Speed

Outputs: Lane flow **parametrics**

Chance Lane-flow-pa **Units:** Cars per hour

Title: Lane flow parametrics

Description: Estimate the lane flow capabilities for various reaction times at various speeds.

expr

Definition: ((Speed*5280)*Degradatio)/(Car_length+Braking_dis1)

Inputs: Braking-disl Braking Distance- imp...
Car-length Car Length
Degradatio Degradation factor
Speed Speed

Chance **Car-length** Units: **Feet**

Title: **Car Length**

Description: **The assumed length of one car.**

expr

Definition: 18

Outputs: Lane flow **parametrics**

Chance Degradatio **Units:** Factor

Title: Degradation factor

Description: This is a factor that represents a degradation in freeway space available to accommodate more vehicles due to the space required for cars to enter and exit gap held or platooning cars. The baseline is 0.85, which equates to a 15% reduction in space available.

expr

Definition: **0.85**

Outputs: **Lane flow parametrics**

Chance Baseline-b Units: Feet

Title: Baseline Braking Dist. - current

Description: This is our assumed safe braking distance for the current driver. it approximately matches the Highway capacity manual. It assumes a lg stop of a front car, a 0.7 sec reaction time, and a 0.5g stopping capability of the following car.

expr

Definition: (((Speed*Speed*2.151111111)/2)*((1/19.2)-(1/28.8)))+Speed*1.466666667*1.0

Inputs: Speed Speed

outputs: Baseline Lane Flow - current

Chance Baseline-l Units:

Tit l e : Baseline Lane
Flow - current

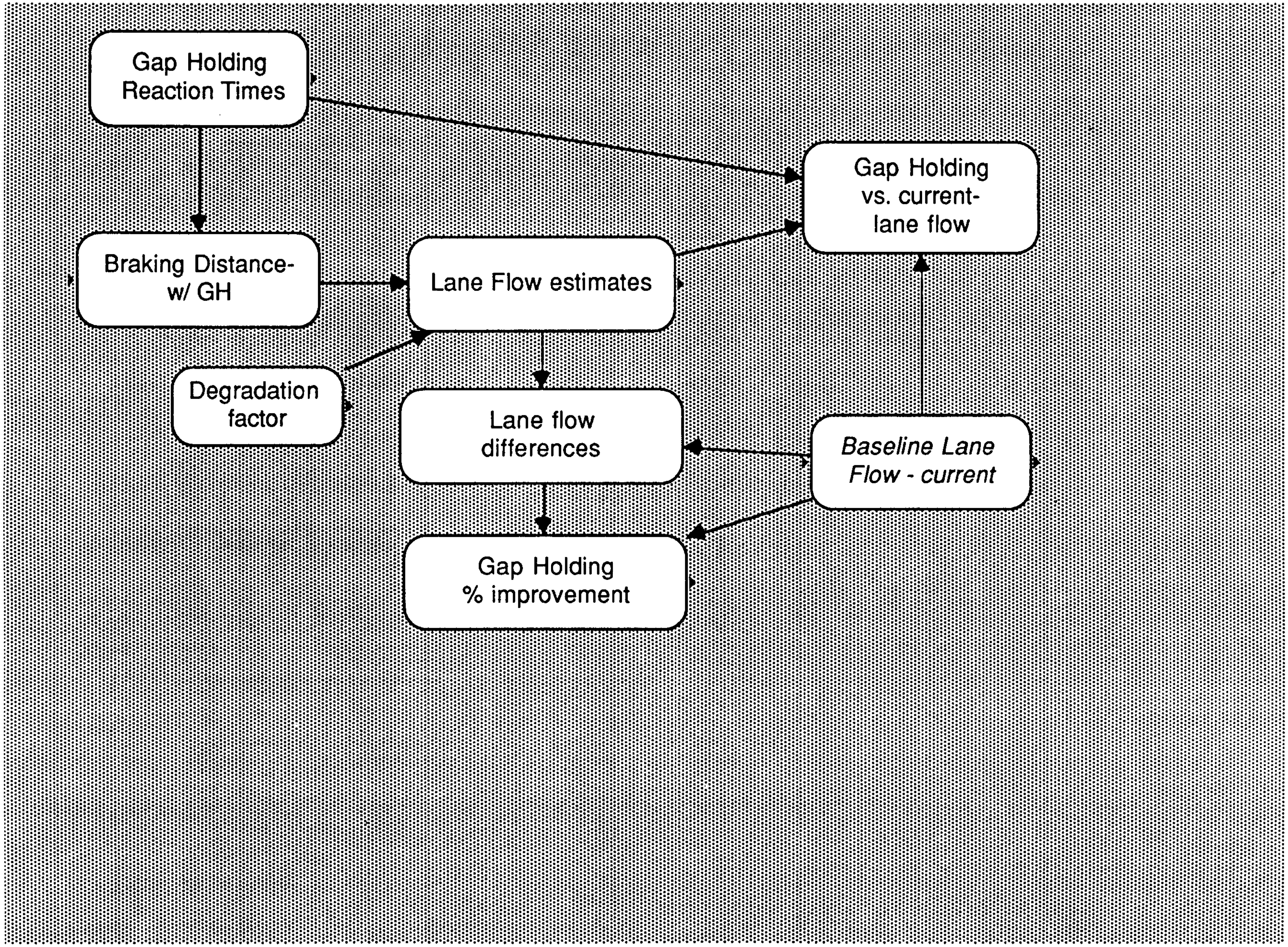
Description: Using the safe braking distance generated by the previous block, this block estimates the lane flow capability for the current conditions. This is an important variable because it is used for comparison purposes when evaluating the % improvement that could be realized through the various levels of automation.

expr

Definition: (Speed*5280)/(Car_length+Baseline_b)

Inputs: Baseline-b Baseline Braking Dist. - curr...
Car-length Car Length
Speed Speed

outputs: Platooning- % improvement


Gap Holding
Reaction Times
Gap Holding
vs. current-
lane flow
Braking Distance-
w/ GH
Lane Flow estimates
Degradation
factor
Lane flow
differences
Baseline Lane
Flow - current
Gap Holding
% improvement

Chance Gap_holding_ **Units:** seconds

Title: Gap Holding Reaction Times

Description: The automatic reaction times of a Gap Holding system to be evaluated.

Definition:

0.1
0.2
0.3
0.4
0.5

Outputs: Vehicle Density- % improvement

Chance Braking-dis2 Units: feet

Title: Braking Distance- w/ GH

Description: This input block provides input data regarding the distance apart two cars on a freeway need to be travelling to avoid a collision. It varies by speed of the car from 0 to 70 and is provided for various reaction times of each of the cars. This data represents gap holding being implemented on a car in the highway situation. The data can be generated for various stopping rates of each car. See the reaction time inprovement block for some of the data.

expr

Definition: (((Speed*Speed*2.151111111)/2)*((1/Decel_rate_1[Decel_rate=0.9])-(1/Decel_rate__)))+Speed*1.466666667*Gap_holding_

Inputs:

- Decel_rate Decel rate fraction (B of A)
- Decel_rate_1 Decel rate- car B
- Decel_rate__ Decel rate- car A
- Gap-holding- Gap Holding Reaction Ti...
- Speed Speed

Outputs: Lane Flow estimates

(Chance Lane-flow-es Units: cars per hour

Title : Lane Flow estimates

Description: Estimate the lane flow values in cars per hour for the Gap Holding case for various reaction times.

expr

Definition: ((Speed*5280)*Degradatio)/(Car_length+Braking_dis2)

Inputs:
- Braking-dis2 Braking Distance- w/ GH
- Car-length Car Length
- Degradatio Degradation factor
- Speed Speed

outputs: Trade comparison to GH and baseline

Chance Degradatio **Units:** Factor

Title: Degradation factor

Description: This is a factor that represents **a** degradation in freeway space available to accommodate more vehicles due to the space required for cars to enter and exit gap held or platooning cars. The baseline is 0.85, which equates to a 15% reduction in space available.

expr

Definition: 0.85

Outputs: **Lane flow parametrics**

Chance Gap_holdin **Units:**

Title: Gap Holding vs. current-lane flow

Description: This compares total lane flow for Gap Holding and the current condition. Currently, the gap holding case represents an 0.3 sec reaction time.

Definition:

Lane_flow_es[Gap_holding_=0.3]
Baseline 1

Inputs:
- **Baseline-l** Baseline Lane Flow - current
- Gap_holding_ **Gap Holding Reaction Ti...**
- **Lane-flow-es Lane Flow estimates**

Chance Lane-flow- Units: Cars per hour

Title: Lane flow differences

Description: This variable is the result of subtracting the lane flows for various gap holding reaction times from the baseline lane flows. This is an intermediate step to calculate the % improvement of gap holding over current conditions.

expr

Definition: Lane-flow-es-Baseline-l

Inputs: Baseline-l Baseline Lane Flow - current

Lane-flow-es Lane Flow estimates

outputs: Gap Holding % improvement

(Chance Gap-holdinl **Units**: Percentage

Title: Gap Holding
% improvement

Description: This calculates the % lane flow improvement of gap holding over current lane flows.

expr ▼

Definition: (Lane_flow_/Baseline_l)*100

Inputs: ⬭ Baseline-l Baseline Lane Flow - current
⬭ Lane-flow- Lane flow differences

outputs: **Vehicle Density- % improvement** ▼

Chance Baseline-l **Units:**

Title: Baseline Lane Flow - current

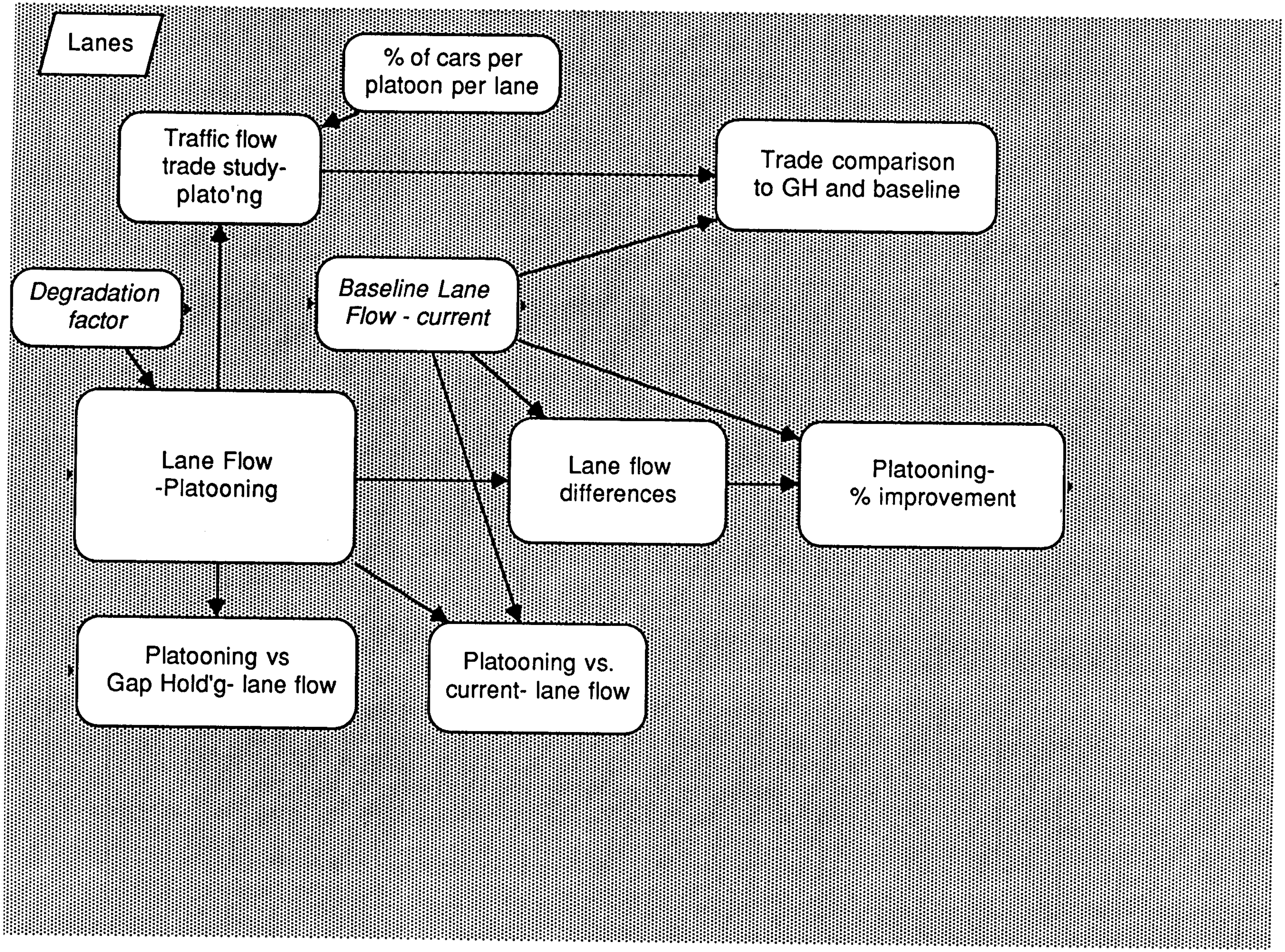
Description: Using the safe braking distance generated by the previous block, this block estimates the lane flow capability for the current conditions. This is an important variable because it is used for comparison purposes when evaluating the % improvement that could be realized through the various levels of automation.

expr

Definition: (Speed*5280)/(Car_length+Baseline_b)

Inputs: Baseline-b Baseline Braking Dist. - curr...
Car-length Car Length
Speed Speed

outputs: Platooning- % improvement


Lanes
% of cars per platoon per lane
Traffic flow trade study- plato'ng
Trade comparison to GH and baseline
Degradation factor
Baseline Lane Flow - current
Lane Flow -Platooning
Lane flow differences
Platooning- % improvement
Platooning vs Gap Hold'g- lane flow
Platooning vs. current- lane flow

Chance Lane-flow Units: Cars per hour

Title: Lane Flow -Platooning

Description: Calculate the lane flow of platooned cars as a function of speed, number of cars in the platoon, and intra-platoon spacing. This assumes that gap holding is in place and therefore automatic braking is implemented. A factor of 15% degradation is being used to account for ineffecient lane changing issues.

expr

Definition: (Speed*5280*Degradatio)/((Cars_per_pla*Car_length+((Cars_per_pla-1)*Intra_platoo)+Braking_Dis1[Reaction_ti2=0.1,Decel_rate=0.9])/Cars-per-pla)

Inputs:
- Braking-disl Braking Distance- imp...
- Cars-per-pla Cars Per Platoon
- Car-length Car Length
- Decel_rate Decel rate fraction (B of A)
- Degradatio Degradation factor
- Intra_platoo Intra platoon spacing
- Reaction_ti2 Reaction Time- improved
- Speed Speed

Outputs: Traffic flow trade study- plato'ng

(Chance Lane-flow-l Units:

Title: Lane flow differences

Description: This variable is the result of subtracting the lane flows for various platooning conditions from the baseline lane flows. This is an intermediate step to calculate the % improvement of platooning over current conditions.

expr

Definition: Lane-Flow-Baseline-l

Inputs: Baseline-l Baseline Lane Flow - current
Lane-flow Lane Flow -Platooning

outputs: Platooning- % improvement

(Chance Platooning__ Units : percentage

Title : Platooning-
% improvement

Description: Calculate the % improvement of platooning over the current baseline lane flows.

expr

Definition: (Lane_flow_1/Baseline_l)*100

Inputs: Baseline-l Baseline Lane Flow - current
Lane-flow-l Lane flow differences

outputs: Vehicle Density- % improvement

(Chance Platooning3 Units: Cars per hour

Title: Platooning vs
Gap Hold'g- lane flow

Description: A graph of lane flow comparisons between Gap Holding and platooning. The Gap Holding line represents a 0.3 sec reaction time. The platooning line represents a 5 car platoon with each car 3 feet apart.

Definition:

Lane_flow[Intra_platoo=10, Cars_per_pla=3]
Lane_flow_es[Gap_holding_=0.3]

Inputs:
- Cars-per-pla Cars Per Platoon
- Gap-holding- Gap Holding Reaction Ti...
- Intra_platoo Intra platoon spacing
- Lane-flow Lane Flow -Platooning
- Lane-flow-es Lane Flow estimates

Chance **Platooningl** Units: Cars per hour

Title: Platooning vs. current- lane flow

Description: A graph of lane flow comparisons between the current baseline and platooning. The platooning line represents a 3 car platoon with each car 3 feet apart.

Definition:

Lane_flow[Intra_platoo=10, Cars_per_pla=3]
Baseline 1

Inpu ts:
- Baseline-l — Baseline Lane Flow - current
- Cars-per-pla — Cars Per Platoon
- Intra_platoo — Intra platoon spacing
- Lane-flow — Lane Flow -Platooning

Chance Traffic-flow Units: Cars per hour

Title: Traffic flow trade study-plato'ng

Description: Evaluate the traffic flow (multiple lanes) of platooning in a 4 lane freeway assuming a certain percentage of time an average size platoon would exist in each lane.

expr ▼

Definition: Sum(Sum((Lane_flow[Intra_platoo=10]*A_of_cars_),Lanes),Cars_per_pla)

Inputs:
- A-of-cars- % of cars per platoon per lane
- Cars-per-pla Cars Per Platoon
- Intra_platoo Intra platoon spacing
- Lanes Lanes
- Lane-flow Lane Flow -Platooning

Outputs: Trade comparison to GH and baseline ▼

Chance A-of-cars- Units: Percentage

Title: % of cars per platoon per lane

Description: This tabular data provides the assumptions of what percentage of cars per platoon would be reprented in each lane to be used in the traffic flow trade study of a 4 lane freeway.

Definition: Edit Table indexed by Cars Per Platoon, Lanes

Inputs: Cars-per-pla Cars Per Platoon
Lanes Lanes

Outputs: Traffic flow trade study- plato'ng

Index Lanes **Units:** Text

Title: Lanes

Description: This is an index of lanes to be used in the traffic flow trade study of 4 lanes.

Definition:

'lane 1'
~~'lane 2'~~
'lane 3'
'lane 4'

outputs: Traffic flow trade study- plato'ng

Chance Parametric-2 **Units:** Cars per **hour**

Title: Trade comparison to GH and baseline

Description: Compare the platooning traffic flow trade results with 4 lanes of cars Gap Holding and 4 lanes of cars in the current baseline condition. The Gap Holding line assumes an 0.3 sec reaction time.

Definition:

Traffic-flow
(Lane_flow_es[Gap_holding_=0.3]*4)
(Baseline_l*4)

Inputs:

- Baseline-l — Baseline Lane Flow - current
- Gap_holding_ — Gap Holding Reaction Ti...
- Lane-flow-es — Lane Flow estimates
- Traffic-flow — Traffic flow trade study- plat...

Chance Estimate_ro Units:

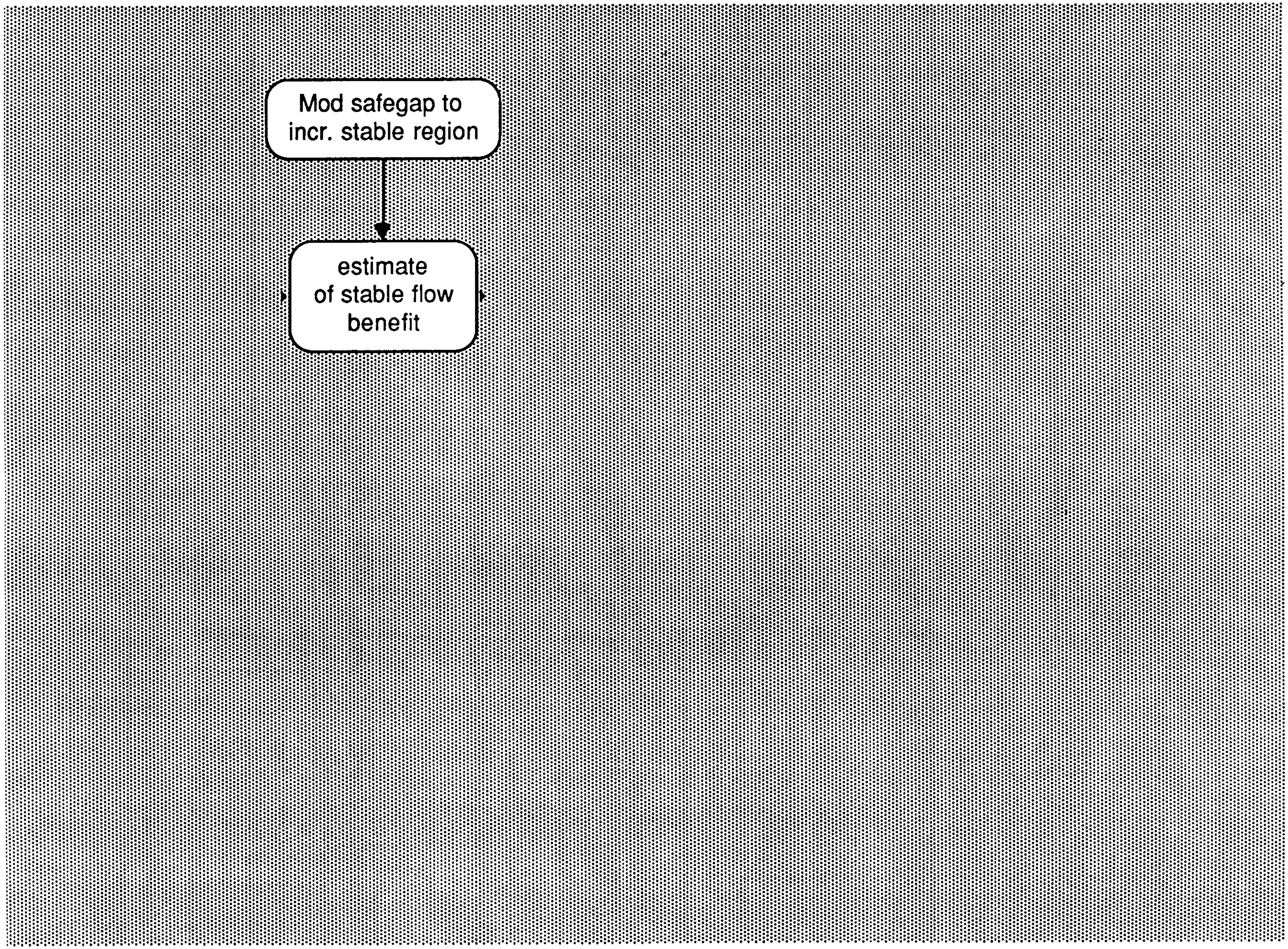
Title: estimate of homogenized density

Description: Refer to the final report for any information in this IVHS benefit analysis category.

expr

Definition: 0

outputs: Benefit- Increasing Normal Capacity


Mod safegap to
incr. stable region
estimate
of stable flow
benefit

Chance Mod_safega **Units:**

Title: Mod safegap to incr. stable region

Description: Refer to the final report for any information in this IVHS benefit analysis category.

expr

Definition: 0

Outputs: estimate of stable flow benefit

Chance Estimate-sfb Units:

Title: estimate of stable flow benefit

Description: Refer to the final report for any information in this IVHS benefit analysis category.

Definition:

Benefit-of
Mod-safega

Inputs: Benefit-of Benefit of Ramp Metering

Mod_safega Mod safegap to incr. stable reg...

Outputs: Benefit- Increasing Normal Capacity

Chance Benefit-of Units:

Title : Benefit of Ramp Metering

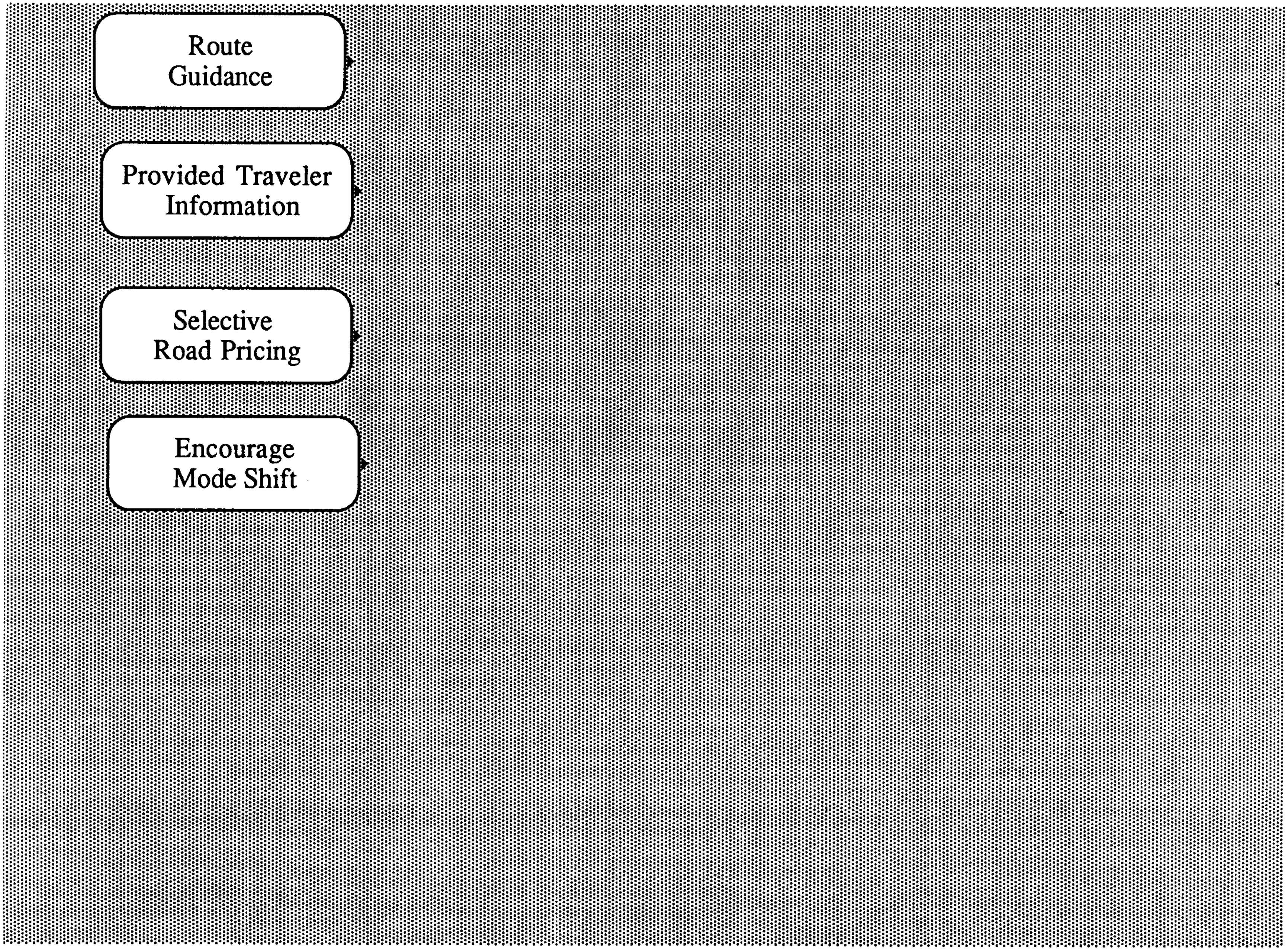
Description: Refer to the final report for any information in this IVHS benefit analysis category.

expr

Definition: 0

outputs: estimate of stable flow benefit

Diagram • Reduce and Reshape Usage



Chance Route_guid Units:

Title: Route
Guidance

Description: Refer to the final report for any information in this IVHS benefit analysis category.

expr

Definition: 0

outputs: Benefit- Matching Usage to Capacity

(Chance Provided-t Units:

Tit l e : Provided Traveler Information

Description: Refer to the final report for any information in this IVHS benefit analysis category.

expr ▼

Definition: 0

outputs: Benefit- Matching Usage to Capacity ▼

Chance Selective_ Units:

Title: Selective Road Pricing

Description: Refer to the final report for any information in this IVHS benefit analysis category.

expr

Definition: 0

outputs: Benefit- Matching Usage to Capacity

Chance Encourage_ **Units:**

Title: Encourage
Mode Shift

Description: Refer to the final report for any information in this IVHS benefit analysis category.

expr

Definition: 0

Outputs: Benefit- Matching Usage to Capacity

Chance Benefit_of1 Units:

Title: Benefit of Reduced Accidents

Description: Refer to the final report for any information in this IVHS benefit analysis category; Also some useful information can be found in DEMOS under the safety IVHS goal (overall safety analysis).

expr

Definition: 0

Outputs: Benefit- Allevtg Accident, Incident

Chance Benefit-of2 Units:

Title: Benefit of
Rapid Response, etc

Description : Refer to the final report for any information in this IVHS benefit analysis category.

expr

Definition: 0

outputs: Benefit- Allevtg Accident, Incident

Chance Benefit_of4 Units:

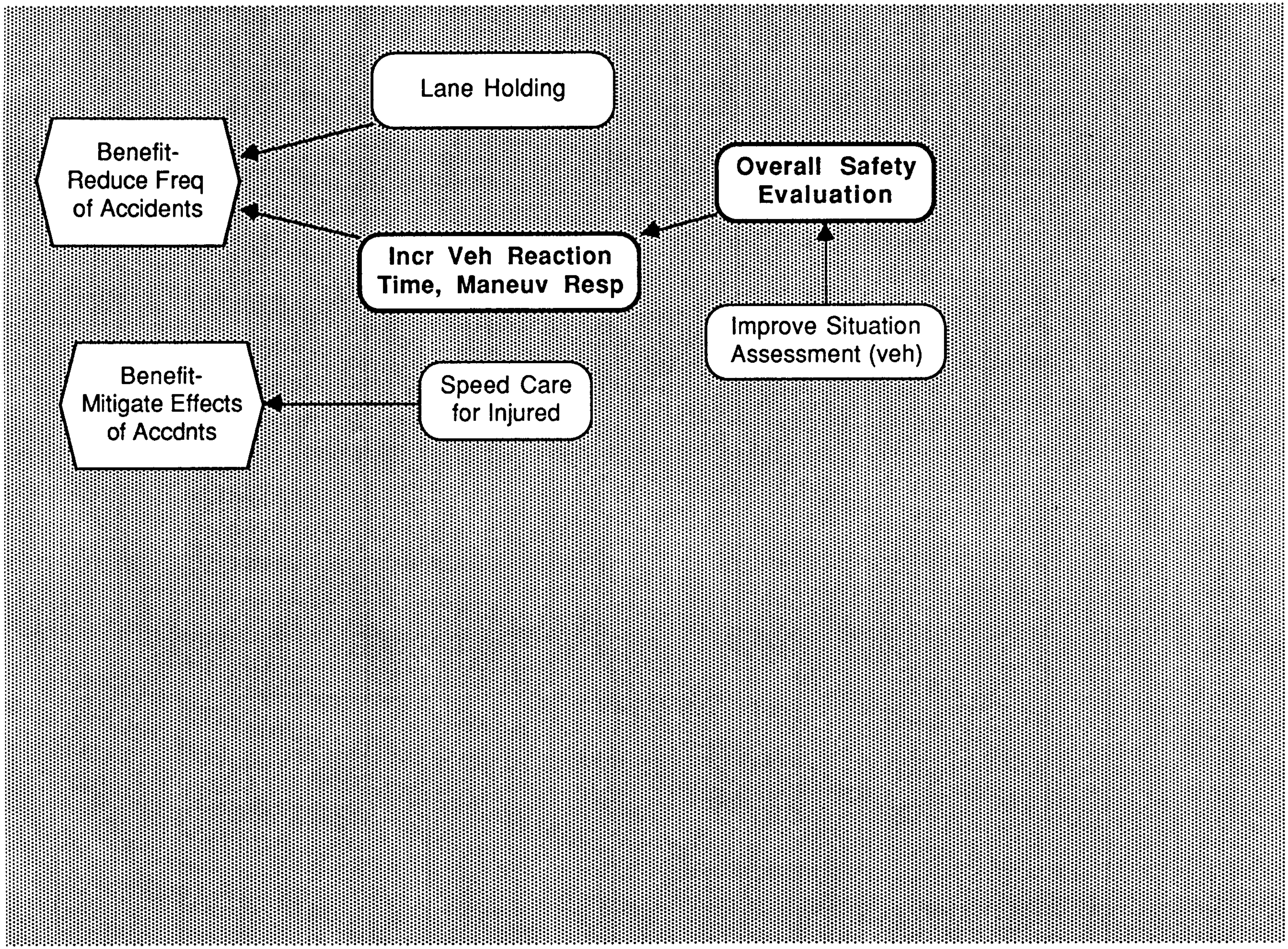
Title: Benefit of
Reroute, Detour

Description: Refer to the final report for any information in this IVHS benefit analysis category.

expr

Definition: 0

outputs: Benefit- Allevtg Accident, Incident


Lane Holding
Benefit-
Reduce Freq
of Accidents
Overall Safety
Evaluation
Incr Veh Reaction
Time, Maneuv Resp
Improve Situation
Assessment (veh)
Benefit-
Mitigate Effects
of Accdnts
Speed Care
for Injured

Objective Benefit__r **Units:**

Title: Benefit-
Reduce Freq
of Accidents

Description: Evaluate the benefit of reduced frequency of accidents. Refer to the final report for any information in this IVHS benefit analysis category.

Definition:

Lane_holdil
Evaluate_g
Evaluate l

Inputs:

- Evaluate_g — Evaluate gap control (safety)
- Evaluate_l — Evaluate lateral threat response
- Lane_hold... — Lane Holding

Chance Lane-holdil Units:

Title: Lane Holding

Description: Refer to the final report for any information in this IVHS benefit analysis category.

expr

Definition: 0

Outputs: Benefit- Reduce Freq of Accidents

(Objective Benefit__m2 **Units:**

Title: Benefit-
Mitigate Effects
of Accdnts

Description: Evaluate the benefit of mitigated effects of accidents. Refer to the final report for any information in this IVHS benefit analysis category.

expr ▼

Definition: Speed-care

Inputs: ⬭ Speed-care Speed Care for Injured

Chance Speed_care **Units:**

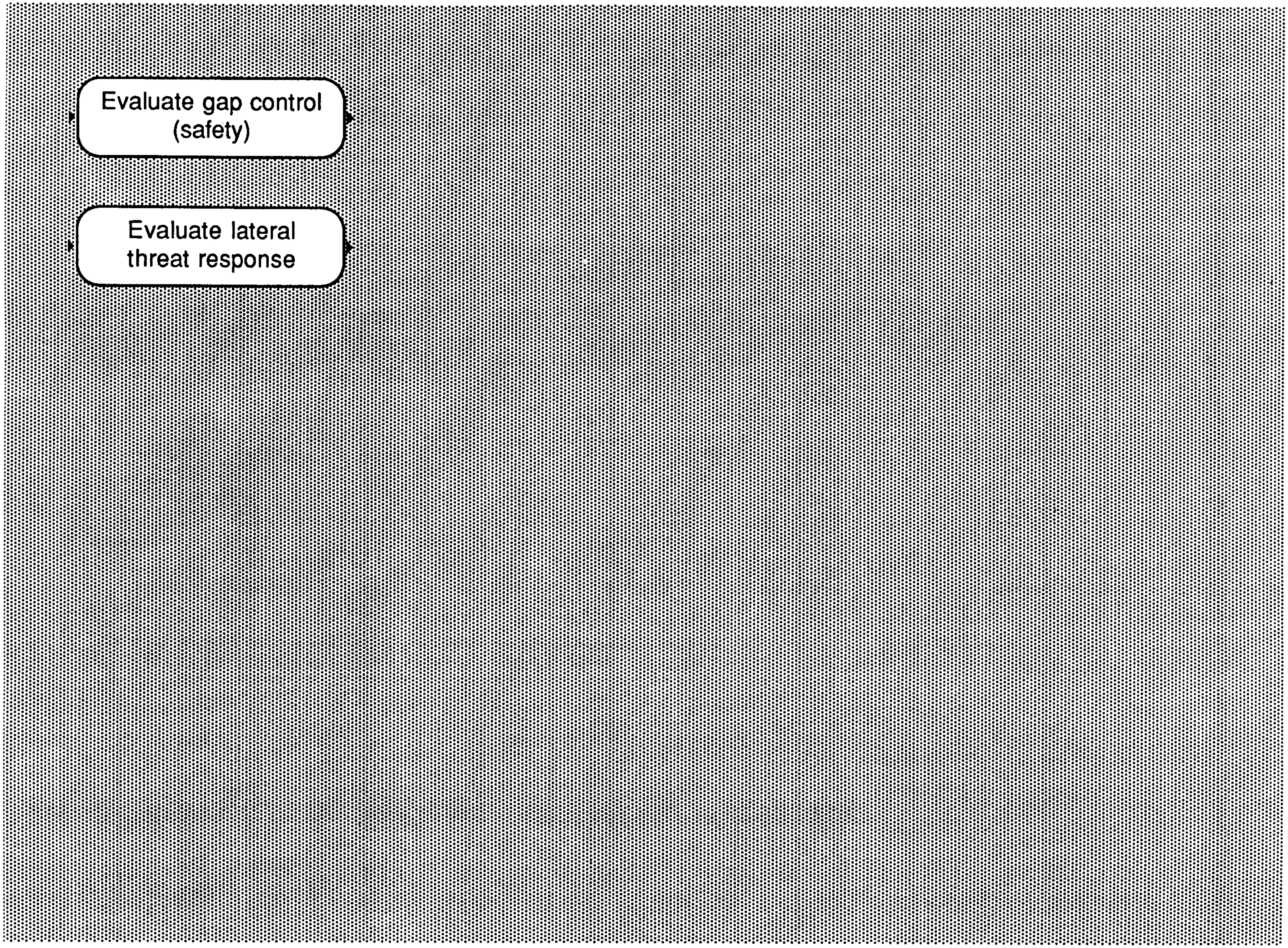
Title: Speed Care
for Injured

Description: Refer to the final report for any information in this IVHS benefit analysis category.

expr

Definition: 0

Outputs: Benefit- Mitigate Effects of Accdnts


Evaluate gap control (safety)
Evaluate lateral threat response

Chance **Evaluate-g** Units:

Title: Evaluate gap control (safety)

Description: **This parameter is a function of the data presented in the overall Safety evaluation. Gap control would impact the 'angle' and 'sideswipe' accident types. In this case we have decided to average the estimated benefit of each. Remember, this data is for freeway and arterials and is not divided for our analysis.**

expr

Definition: (((Current_to[Manner_of_='Angle']+Current_to[Manner_of_='Sideswipe'])-(Improved_t[Manner_of_='Angle']+Improved_t[Manner_of_='Sideswipe']))/(Current_to[Manner_of_='Angle']+Current_to[Manner_of_='Sideswipe']))*100

Inputs: **Current-to** Current Total Accidents by Ma...
Improved-t Improved Tot Accidents by Ma...
Manner_o... Manner of Collision

outputs: **Benefit- Reduce Freq of Accidents**

Chance Evaluate-l **Units:**

Title: Evaluate lateral threat response

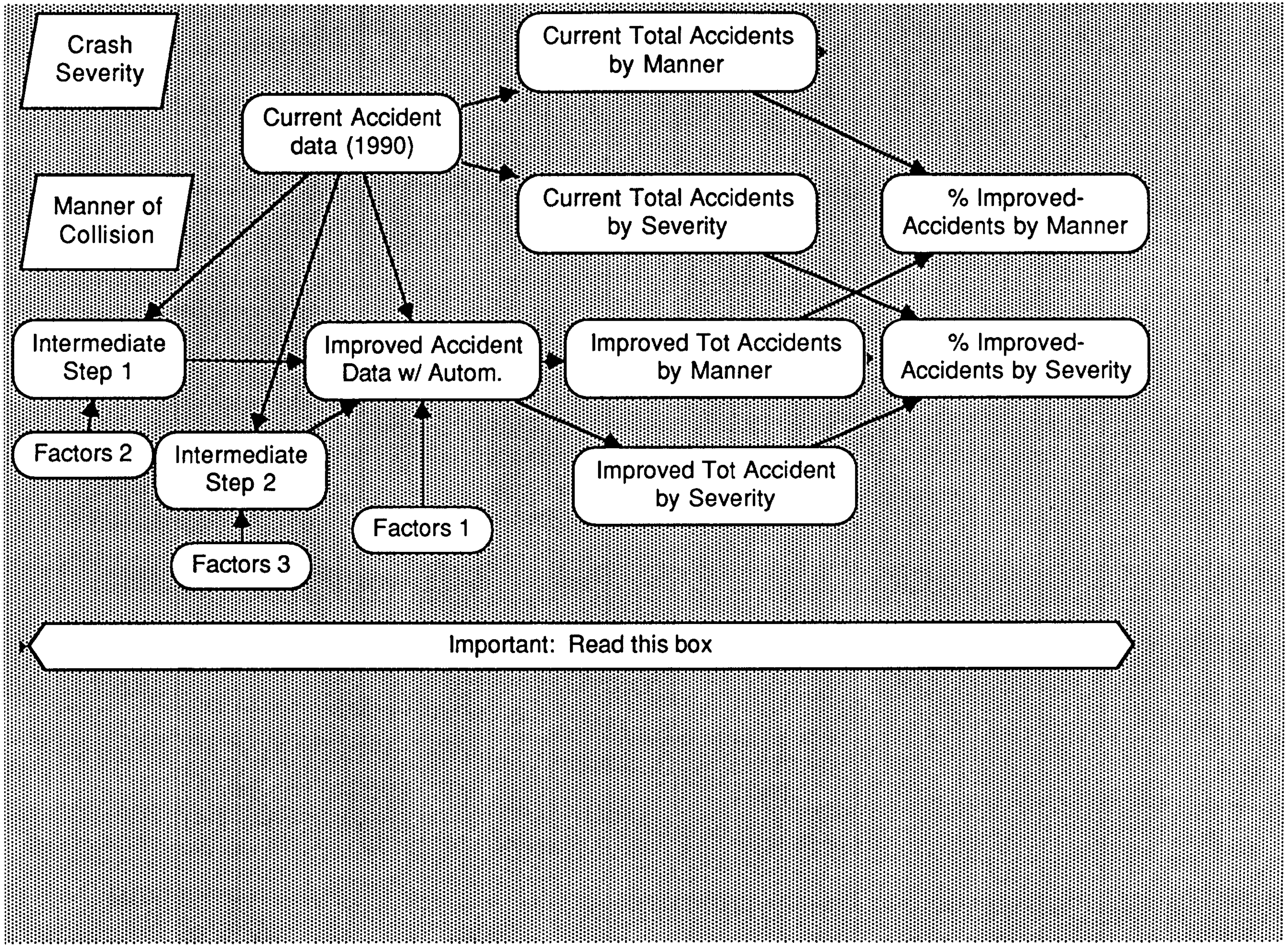
Description: This parameter is a function of the data presented in the overall Safety evaluation. lateral threat response would impact the 'rear-end' and 'Head-on' accident types. In this case we have decided to average the estimated the benefit of each. Remember, this data is for freeway and arterials and is not divided for our analysis.

expr

Definition: (((Current_to[Manner_of_='Rear-end']+Current_to[Manner_of_='Head-on'])-(Improved_t[Manner_of_='Rear-end']+Improved_t[Manner_of_='Head-on']))/(Current_to[Manner_of_='Rear-end']+Current_to[Manner_of_='Head-on']))*100

Inputs: Current-to Current Total Accidents by Ma...
Improved-t Improved Tot Accidents by Ma...
Manner_o... Manner of Collision

outputs: **Benefit- Reduce Freq of Accidents**


Crash Severity
Current Total Accidents by Manner
Current Accident data (1990)
Manner of Collision
Current Total Accidents by Severity
% Improved- Accidents by Manner
Intermediate Step 1
Improved Accident Data w/ Autom.
Improved Tot Accidents by Manner
% Improved- Accidents by Severity
Factors 2
Intermediate Step 2
Improved Tot Accident by Severity
Factors 1
Factors 3
Important: Read this box

(Objective Important_ **Units:**

Title: **Important: Read this box**

Description: **The information in this diagram represents a safety analysis on data from 1990. The current data was not divided among our senarios (Freeway, Arterials, etc.) and there was no acceptable way to break it down. Therefore, the data used in this analysis is a total of accidents on the freeway and arterials/networks. The information will be repeated in other DEMOS models for completeness.**

expr ▼

Definition: Improve-si

Inputs: ⬭ **Improve-si** **Improve** Situation Assessment...

Index Crash-seve Units: Type

Title: Crash Severity

Description: The index of crash severities as used by the 1990 General Estimates System of the . . . . . These severities range from property damage only, to minor or moderate injury, to severe or fatal injury.

Definition:

'Property damage only'
'Minor or moderate injury'
'Severe or fatal injury'

outputs: Current Accident data (1990)

Index Crash-seve Units: Type

Title: Crash Severity

Description: The index of crash severities as used by the 1990 General Estimates System, Department of Transportation. These severities range from property damage only, to minor or moderate injury, to severe or fatal injury.

Definition:

'Property damage only'
'Minor or moderate injury'
'Severe or fatal injury'

Outputs: Current Accident data (1990)

Index Manner_of_ **Units: Type**

Title: Manner of Collision

Description: This is the index of the manners of collision. This includes angle, rear-end, head-on, and sideswipe collisions.

Definition:

'Angle'
'Rear-end'
'Head-on'
'Sideswipe'

Outputs: Evaluate gap control (safety)

(Chance Current-ac Units : Number of accidents

Title: Current Accident data (1990)

Description: This is the current (1990) multi-vehicle crashes by manner of collision and crash severity. The data source is the General Estimates System (1990) published by the Department of Transportation, National Highway Traffic Safety Administration.

Definition: (Edit] indexed by Crash Severity, Manner of Collision

Inputs: Crash-seve Crash Severity
Manner_o... Manner of Collision

Outputs: Current Total Accidents bv Manner

Chance Current-to **Units:** Number of accidents

Title: Current Total Accidents by Manner

Description: This sums up the total accidents by manner of collision. Using the current data.

expr

Definition: Sum((Current_ac),Crash_seve)

Inputs: Crash-seve Crash Severity

Current_ac Current Accident data (1990)

outputs: Evaluate gap control (safety)

Chance Current_to1 Units: Number of accidents

Tit l e : Current Total Accidents
by Severity

Description: This sums up the total accidents by crash severity. Using the current data.

expr ▼

Definition: Sum((Current_ac),Manner_of_)

Inputs: Current-ac Current Accident data (1990)
Manner_o... Manner of Collision

outputs: % Improved- Accidents by Severity ▼

Chance **Intermedia** Units:

Title: Intermediate
Step 1

Description: **This is an intermediate step to derive the Improved accident data.**

Definition: **index (Edit)** **indexed by Crash Severity, Manner of Collision**

Inputs: **Crash-seve Crash Severity**
Current-ac Current Accident data (1990)
Factors-2 Factors 2
Manner_o... **Manner of Collision**

Outputs: **Improved Accident Data w/ Autom.**

Chance Factors-2 **Units:** Factor

Title: Factors 2

Description: These factors are the percentages of the severe or fatal category that through automation are moved downward in category. For instance, 30% of the severe or fatal angle accidents will become minor or moderate accidents, and so forth.

Definition : (Edit) indexed by Crash Severity, Manner of Collision

Inputs: Crash-seve Crash Severity
Manner_o... Manner of Collision

Outputs: **Intermediate Step 1**

Chance Intermedial Units:

Title: Intermediate
Step 2

Description: This is an intermediate step to derive the Improved accident data.

Definition: (Edit] indexed by Crash Severity, Manner of Collision

Inputs: Crash-seve Crash Severity
Current-ac Current Accident data (1990)
Factors-3 Factors 3
Manner_o... Manner of Collision

outputs: Improved Accident Data w/ Autom.

Chance Factors-3 Units: Factor

Title: Factors 3

Description: These factors are the percentages of the minor or moderate injury category that through automation are moved downward in category to property damage only. For instance,10% of the minor or moderate injury angle accidents will become property damage only accidents, and so forth.

Definition : (Edit] indexed by Crash Severity, Manner of Collision

Inputs: Crash_seve Crash Severity
Manner_o... Manner of Collision

outputs: Intermediate Step 2

Chance Improved_a **Units:** Number of accidents

Title: Improved Accident Data w/ Autom.

Description: This represents the improved accident data as estimated using the improvement factors.

expr

Definition: ((Factors_1*Current_ac)+Intermedia+Intermedia1)

Inputs:

Current_ac	Current Accident data (1990)
Factors_1	Factors 1
Intermedia	Intermediate Step 1
Intermedi...	Intermediate Step 2

Outputs: **Improved Tot Accidents by Manner**

Chance Factors-l **Units:** Factor

Title: Factors 1

Description: These are the improvement factors applied to the current accident data to develop one element of the improved accident data. There is a factor for each manner and severity of accident. These factors are the fraction which remain in that category. In others words, they are the percentages of each category that automation can't do anything about.

Definition: **Edit Table** indexed by Crash Severity, Manner of Collision

Inputs: Crash-seve Crash Severity
Manner_o... Manner of Collision

outputs: **Improved Accident Data w/ Autom.**

Chance Improved_t **Units:** Number of accidents

Title: Improved Tot Accidents by Manner

Description: This sums up the total accidents by manner of collision. Using the improved data.

expr

Definition: Sum((Improved_a),Crash_seve)

Inputs: Crash_seve Crash Severity
Improved_a Improved Accident Data w/ Au...

Outputs: **Evaluate gap control (safety)**

Chance Improved_t1 Units: Number of accidents

Title: Improved Tot Accident by Severity

Description: This sums up the total accidents by crash severity. Using the improved data.

expr

Definition: Sum((Improved_a),Manner_of_)

Inputs: Improved-a Improved Accident Data w/Au...

Manner_o... Manner of Collision

outputs: % Improved- Accidents by Severity

Chance A-improved Units : Percentage

Title: % Improved-
Accidents by Manner

Description: This calculates the % improvement that is achieved through automation by manner of collision.

expr

Definition: ((Current-to-Improved-t)/Current-to)*100

Inputs: Current-to Current Total Accidents by Ma...
Improved-t Improved Tot Accidents by Ma...

(Chance A-improved1 Units: Percentage

Title: % Improved-
Accidents by Severity

Description: This calculates the % improvement that is achieved through automation by crash severity.

expr

Definition: ((Current_to1-Improved_t1)/Current_to1)*100

Inputs: Current_to1 Current Total Accidents by Se...
Improved_t1 Improved Tot Accident by Seve...

Chance Improve_si Units:

Title: Improve Situation Assessment (veh)

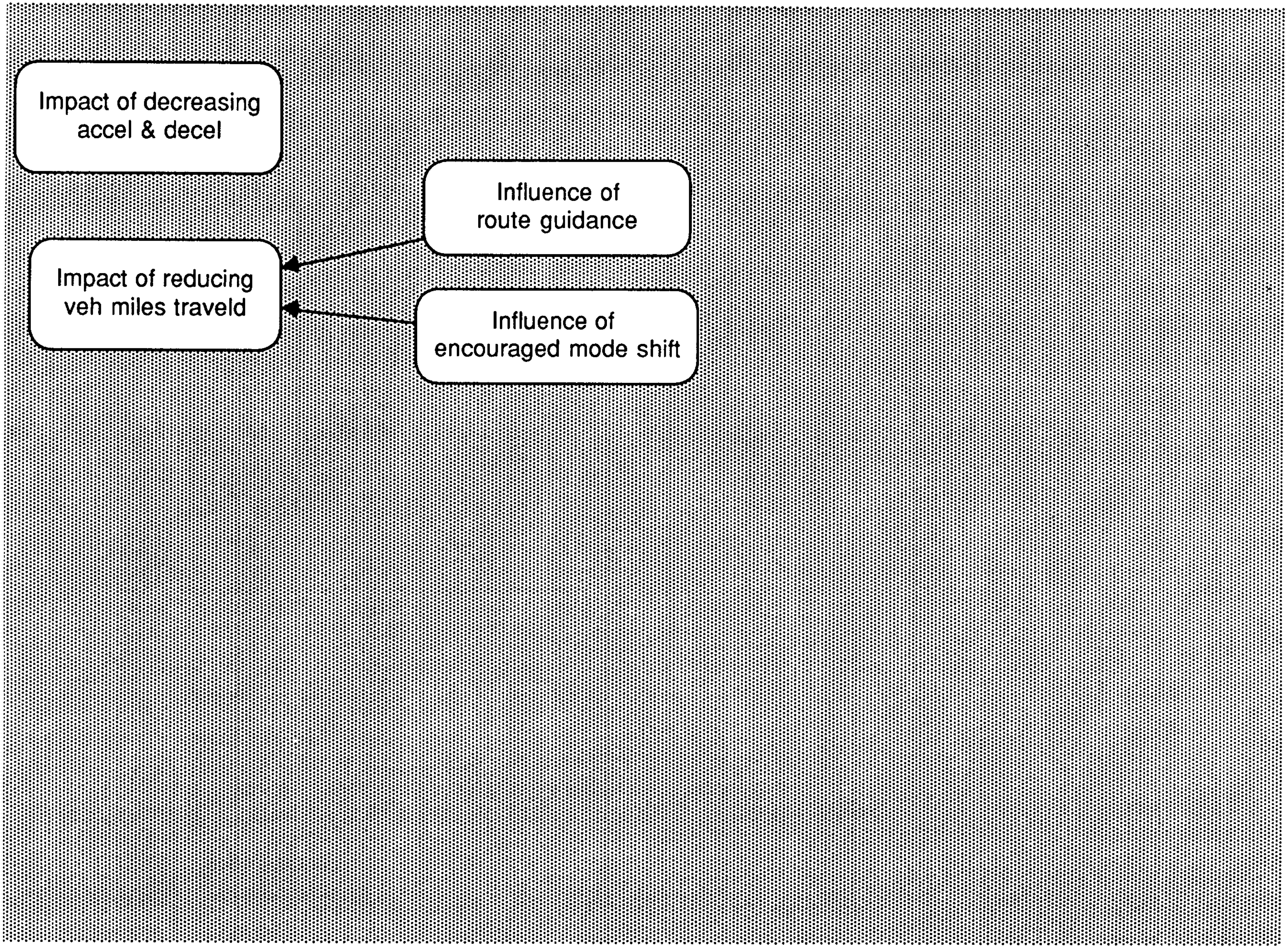
Description: This parameter is the beginning of making something happening. It has no impact unless because of assessing the situation you decide to do something about it. Therefore, this is an input to the overall Safety evaluation as shown.

expr

Definition: 0

outputs: Important: Read this box

Diagram • Decrease Harmful Emissions



Chance Impact-of- Units:

Title: Impact of decreasing
accel & decel

Description: Refer to the final report for any information in this IVHS benefit analysis category.

expr ▼

Definition: 0

Chance **Impact-of-I** **Units:**

Title: Impact of reducing veh miles traveld

Description: Refer to the final report for any information in this IVHS benefit analysis category.

Definition:

Influence_
Influence 1

Inputs:

Influence-	Influence of route guidance
Influence...	Influence of encouraged mode...

Chance Influence_ **Units:**

Title: Influence of route guidance

Description: Refer to the final report for any information in this IVHS benefit analysis category.

expr

Definition: 0

outputs: Impact of reducing veh miles traveld

Chance Influence-l Units:

Title: Influence of encouraged mode shift

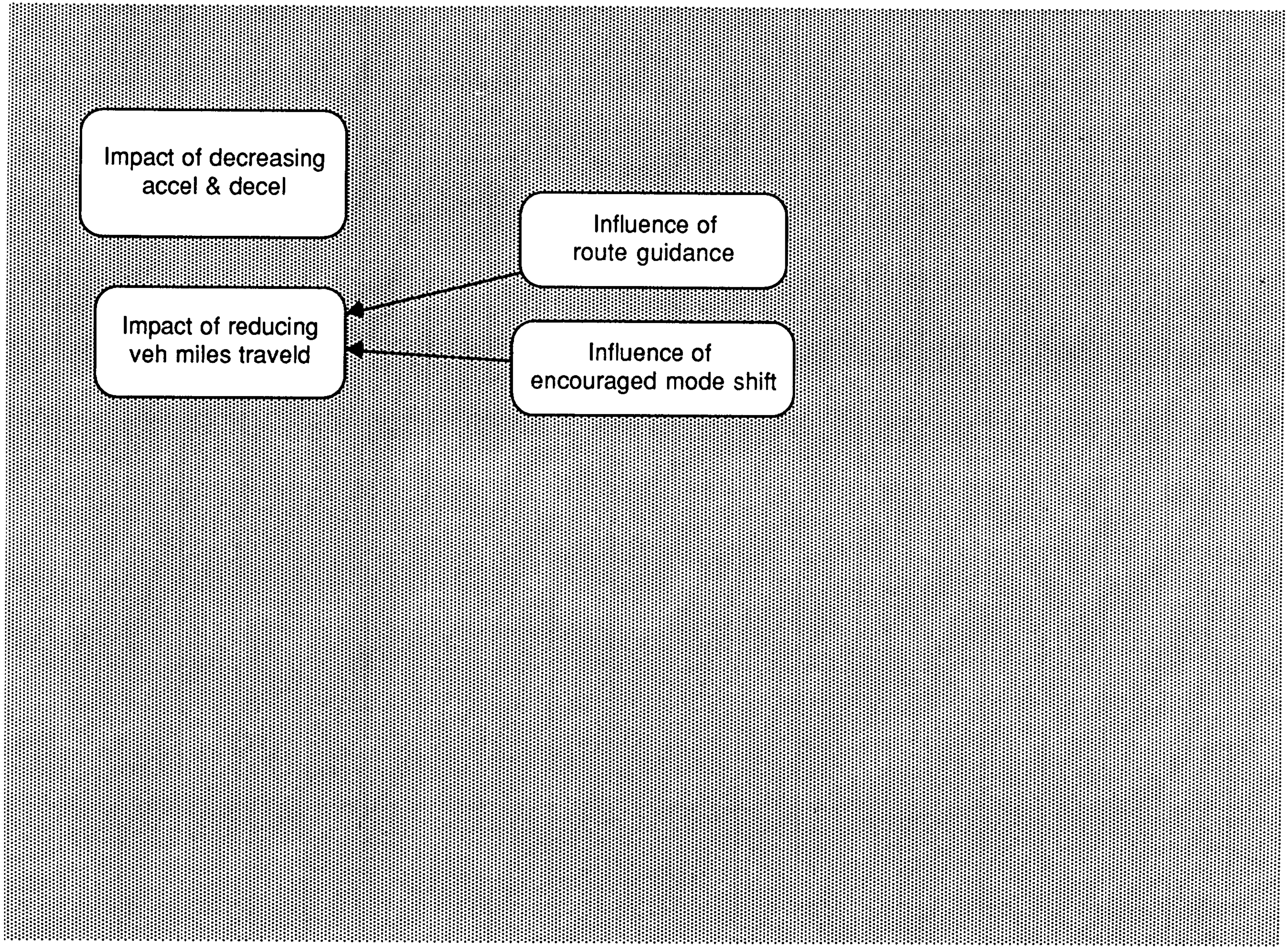
Description: Refer to the final report for any information in this IVHS benefit analysis category.

expr

Definition: 0

outputs: Impact of reducing veh miles traveld

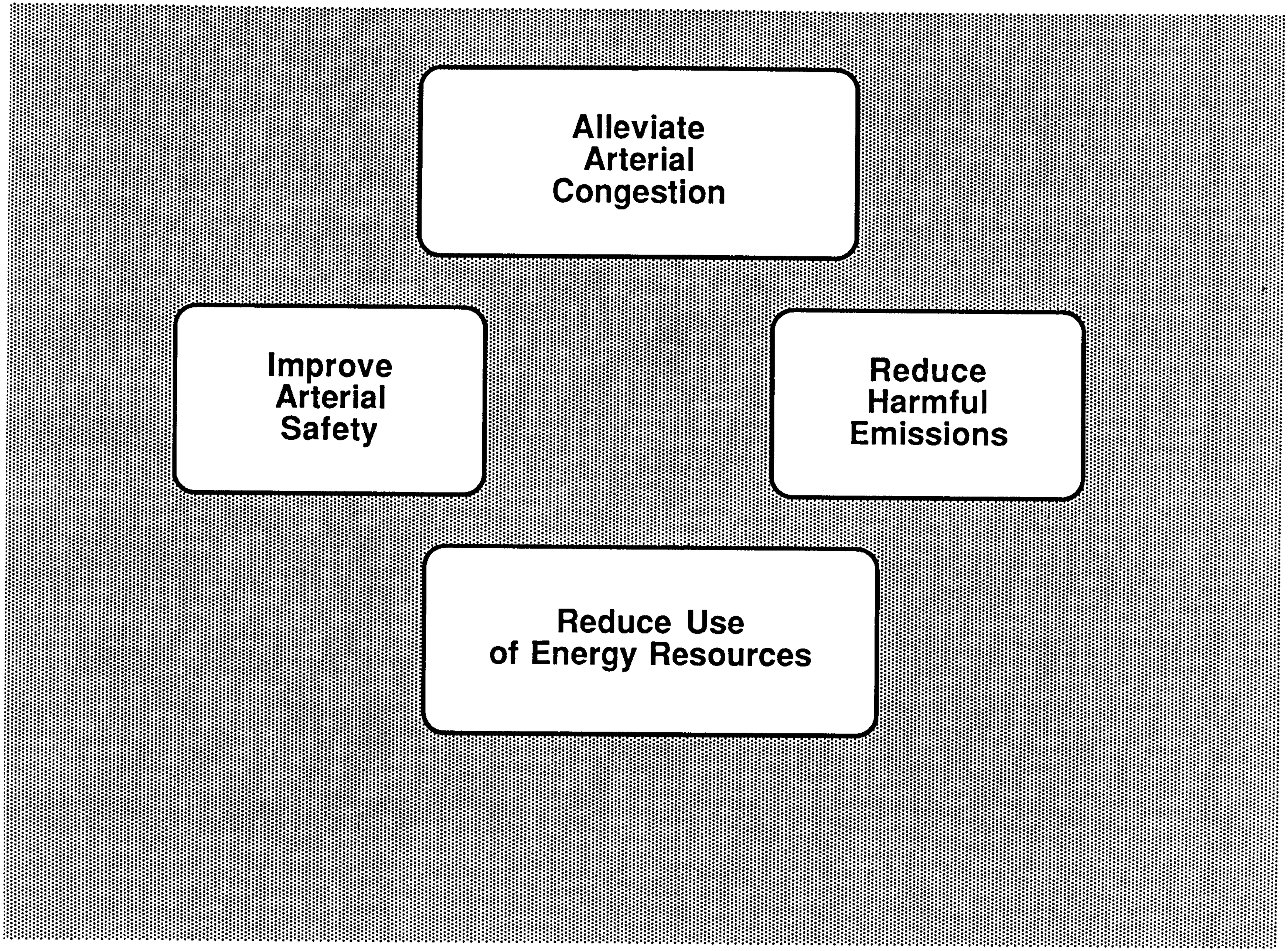
Diagram • Decrease Use of Energy Resources

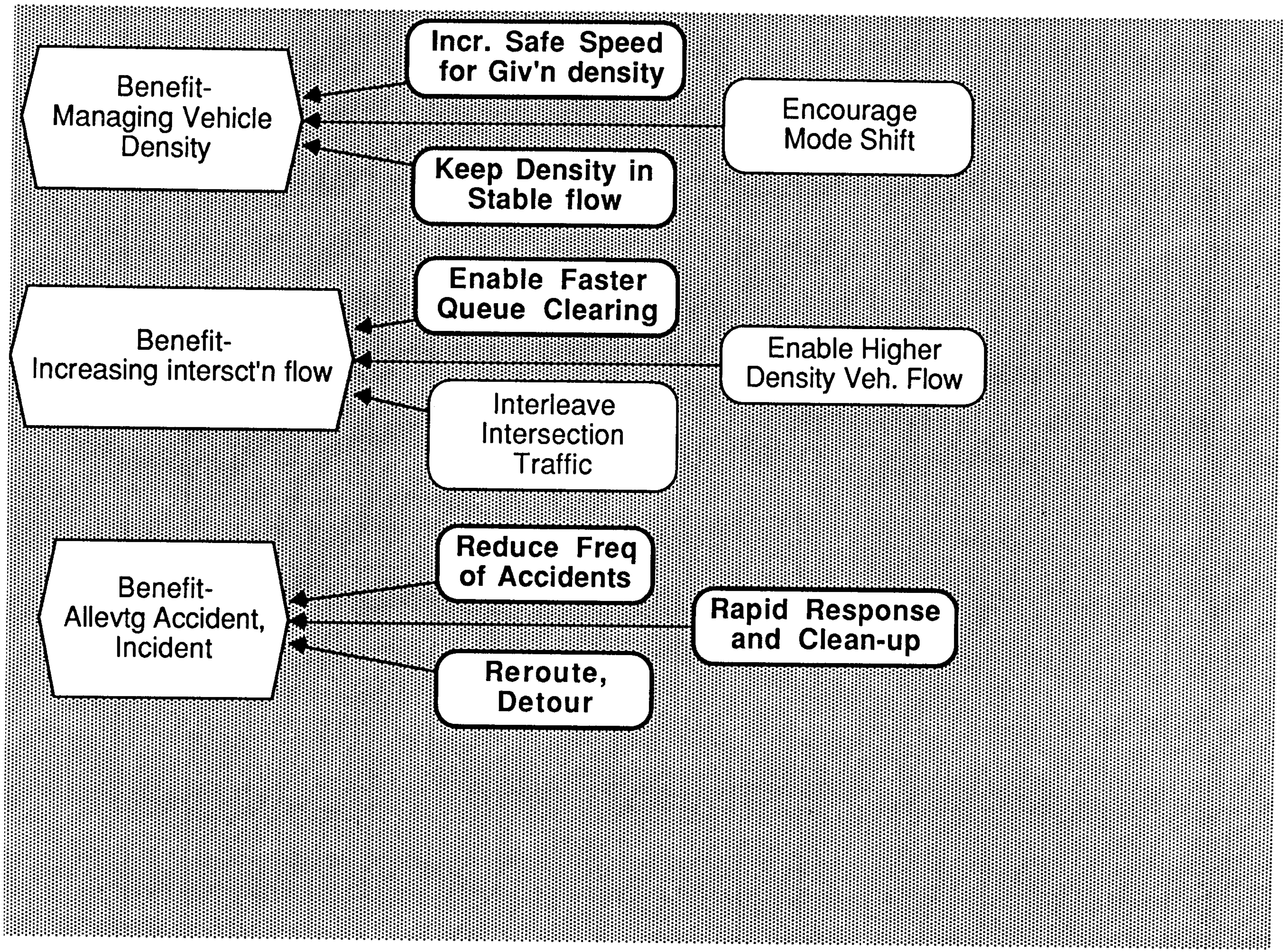


DEMOS MODEL

- URBAN ARTERIALS -

Diagram • Ivhsbenurbarterials1




Benefit-
Managing Vehicle
Density
Incr. Safe Speed
for Giv'n density
Encourage
Mode Shift
Keep Density in
Stable flow
Benefit-
Increasing intersct'n flow
Enable Faster
Queue Clearing
Enable Higher
Density Veh. Flow
Interleave
Intersection
Traffic
Benefit-
Allevtg Accident,
Incident
Reduce Freq
of Accidents
Rapid Response
and Clean-up
Reroute,
Detour

(Objective Benefit-m Units:

Title: Benefit-
Managing Vehicle
Density

Description: Documents the benefit of managing vehicular density on major arterials.

Definition:

Encour_mod
Gap_contro
Platooning
Gap-control
Modify-saf

Inputs:
- Encour_... Encourage Mode Shift
- Gap_contro Gap Control
- Gap-control Gap Control
- Modify-saf Modify Safegap Function
- Platooning Platooning

(Objective Benefit-i **Units:**

Title: Benefit-
Increasing intersct'n flow

Description: Documents the benefit of Increasing intersection flow on arterials.

Definition:

Enable_hig
Interleave
Compare-ma

Inputs:
- Compare-ma Compare manual and Au...
- Enable-hig Enable Higher Density Veh. Flow
- Interleave Interleave Intersection Traffic

(Objective Benefit-a Units:

Title: Benefit- Allevtg Accident, Incident

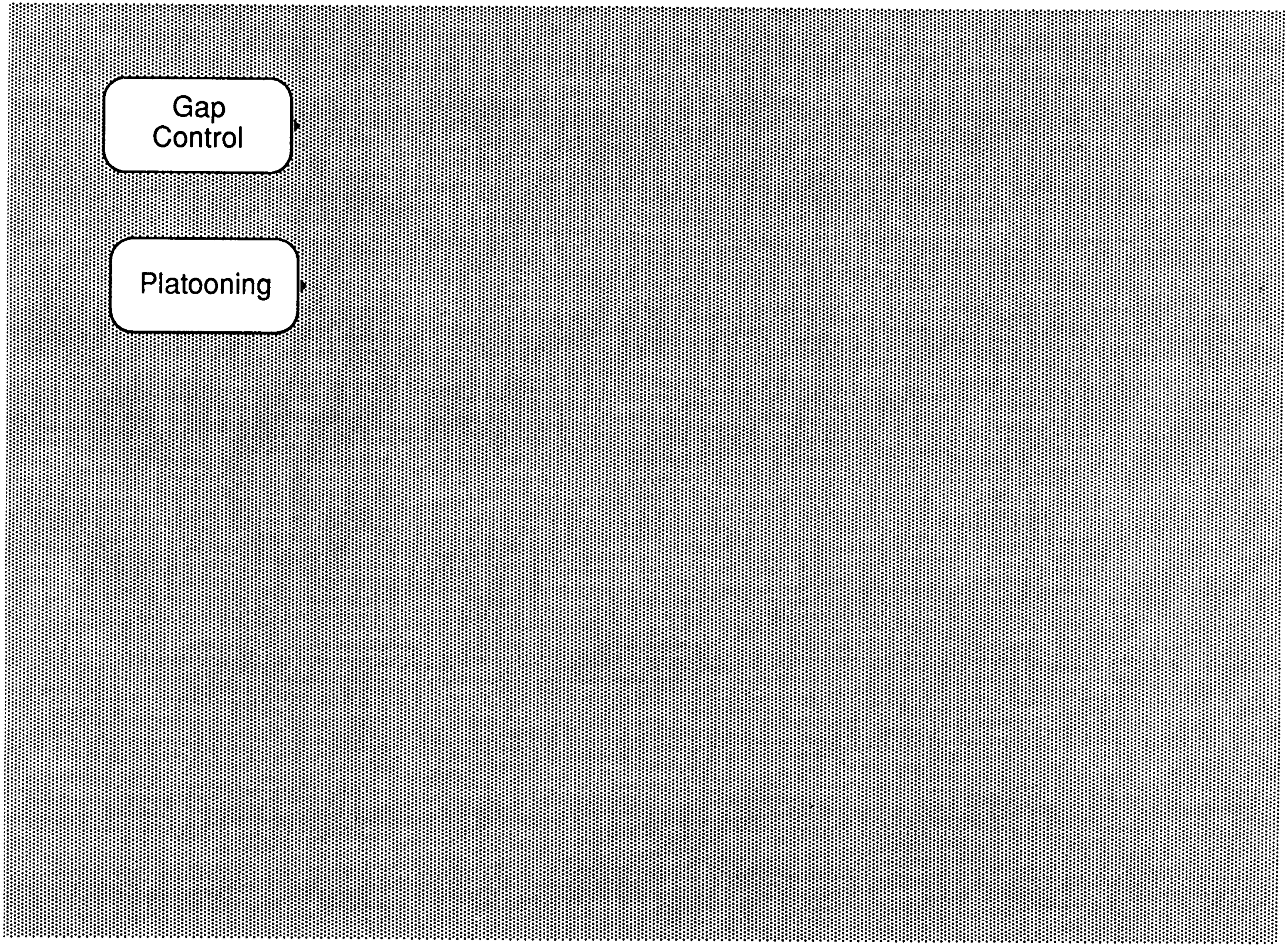
Description: Documents the benefit of alleviating accidents and incidents.

Definition:

Estimate-r
Estimate_r1
Estimate r2

Inputs:
- **Estimate-r** Estimate Reducing Freqof Acc...
- Estimate_r1 **Estimate Rapid** Reponse,Clean...
- **Estimate-r2 Estimate Reroute, Detour**

Diagram . Incr. Safe Speed for Giv'n density



Chance Gap_contro Units:

Title: Gap Control

Description: Refer to the final report regarding any information in this IVHS benefit analysis category.

expr

Definition: 0

outputs: Benefit- Managing Vehicle Density

Chance Platooning Units:

Title: Platooning

Description: Refer to the final report regarding any information in this IVHS benefit analysis category.

expr

Definition: 0

outputs: Benefit- Managing Vehicle Density

Chance Encour_mod **Units:**

Title: Encourage
Mode Shift

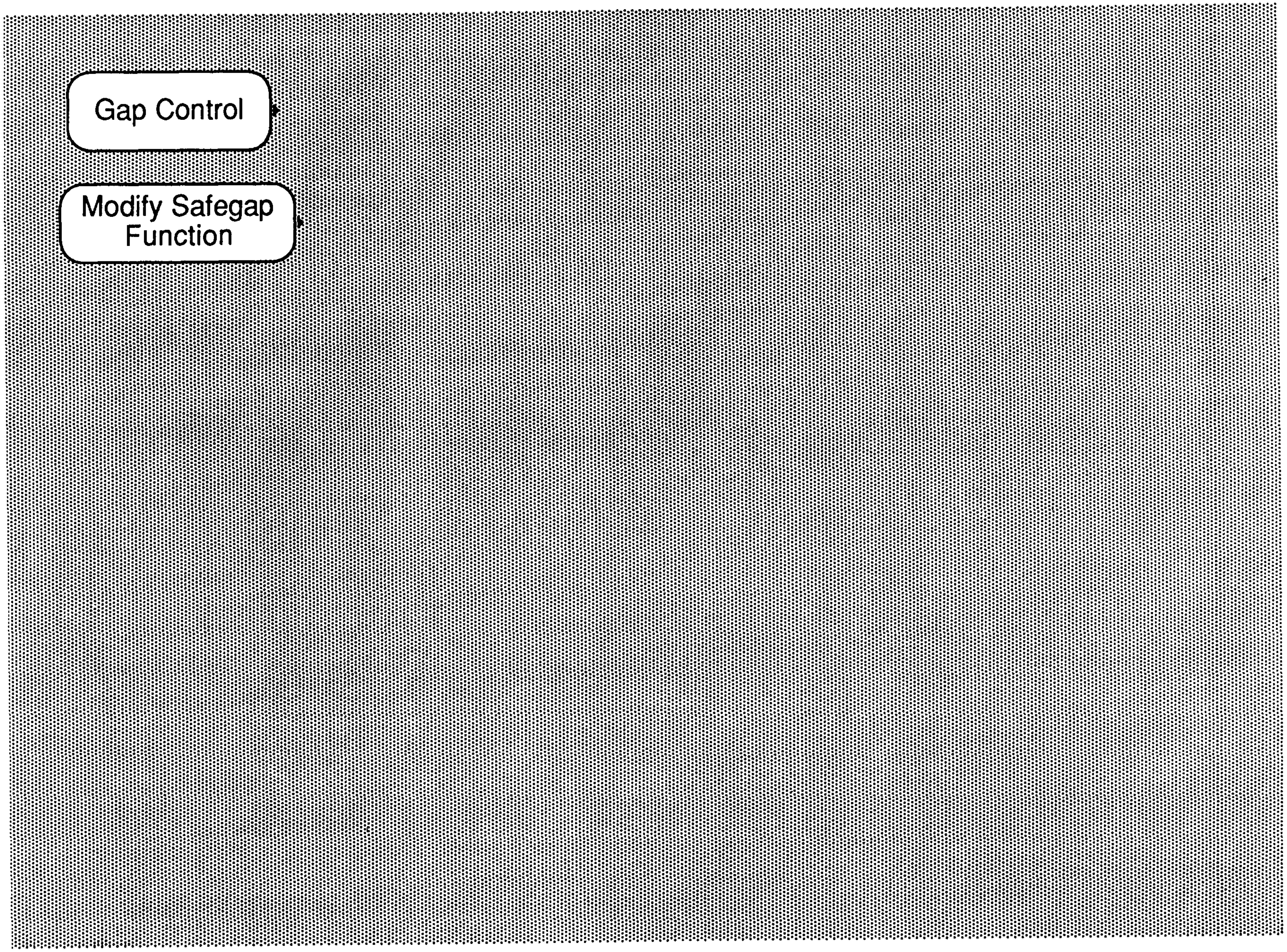
Description: Refer to the final report regarding any information in this IVHS benefit analysis category.

expr

Definition: 0

Outputs: Benefit- Managing Vehicle Density

Diagram . Keep Density in Stable flow



Chance Gap-control Units:

Title: Gap Control

Description: Refer to the final report regarding any information in this IVHS benefit analysis category.

expr

Definition: 0

outputs: Benefit- Managing Vehicle Density

(Chance Modify-saf Units:

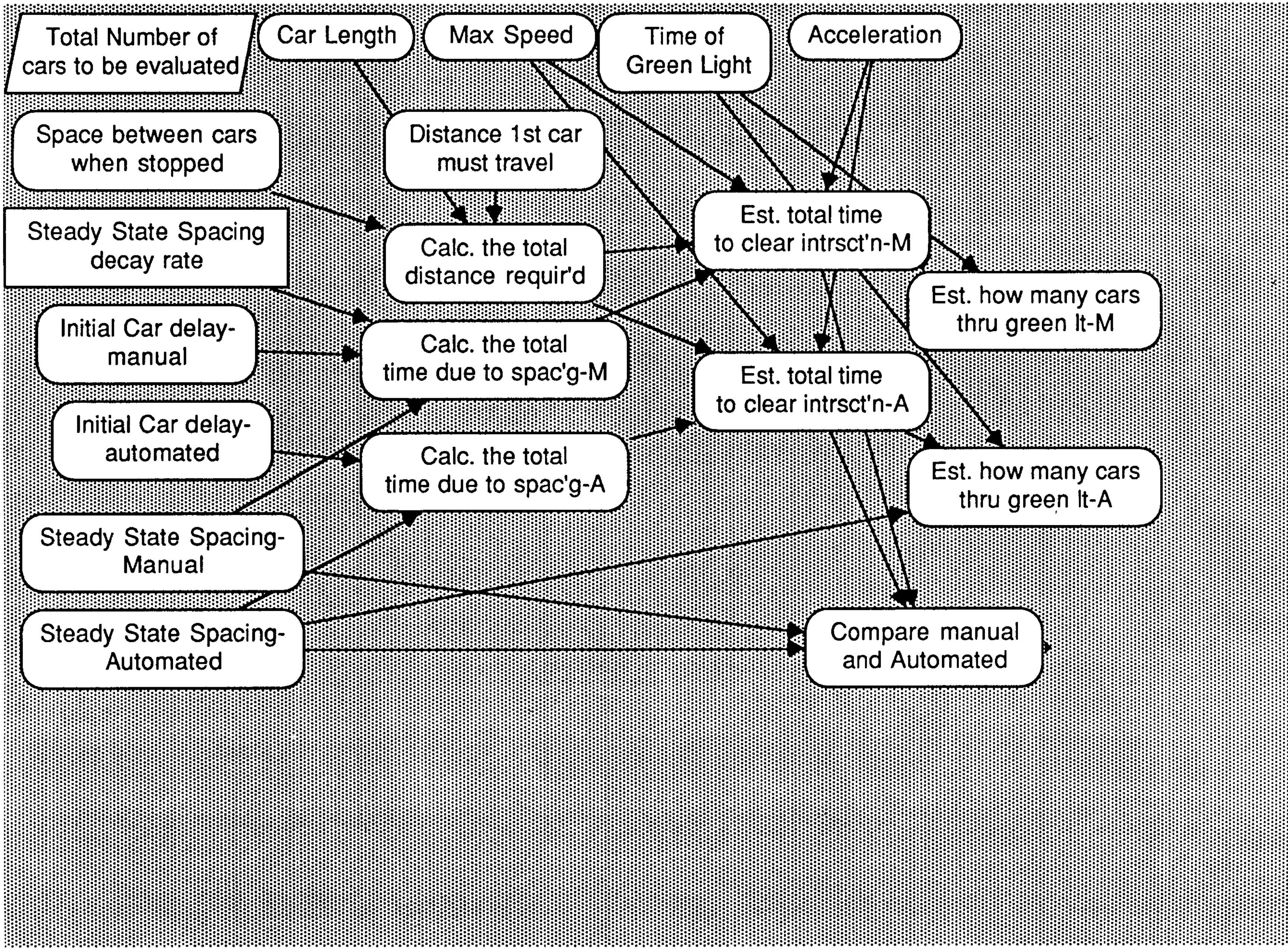
Title: Modify Safegap Function

Description: Refer to the final report regarding any information in this IVHS benefit analysis category.

expr

Definition: 0

Outputs: Benefit- Managing Vehicle Density


Total Number of cars to be evaluated
Car Length
Max Speed
Time of Green Light
Acceleration
Space between cars when stopped
Distance 1st car must travel
Steady State Spacing decay rate
Calc. the total distance requir'd
Est. total time to clear intrsct'n-M
Est. how many cars thru green lt-M
Initial Car delay-manual
Calc. the total time due to spac'g-M
Est. total time to clear intrsct'n-A
Initial Car delay-automated
Calc. the total time due to spac'g-A
Est. how many cars thru green lt-A
Steady State Spacing-Manual
Steady State Spacing-Automated
Compare manual and Automated

Index Total-numb Units: Number

Title: Total Number of cars to be evaluated

Description: This is the total number of cars that will be evaluated to get through the intersection.

expr ▼

Definition: Sequence(1,60)*1

Outputs: Calc. the total distance requir'd ▼

Chance Space-betw Units: feet

Title: Space between cars
when stopped

Description: This is the space between each car when stopped at an intersection waiting for the light to turn green.

expr

Definition: 4

outputs: Calc. the total distance requir'd

Decision Steady-sta Units: constant

Title: Steady State Spacing
decay rate

Description: This is a constant to represent the decay rate that impacts the steady state spacing of cars as they begin to move through the intersection.

expr

Definition: 2.0

outputs: Calc. the total time due to spac'g-M

Chance Initial-ca Units: seconds

Title: Initial Car delay-
manual

Description: This is the time (seconds) that the first car delays before entering intersection after the light turns green. It represents the manual driver.

expr

Definition: 3.5

outputs: Calc. the total time due to spac'g-M

Chance Initial_ca1 Units: seconds

Title: Initial Car delay-automated

Description: This is the time (seconds) that the first car delays before entering intersection after the light turns green. It represents the automated case.

expr

Definition: 0.1

outputs: Calc. the total time due to spac'g-A

Chance   **Steady-stal**   **Units: seconds**

Title: Steady State Spacing-Manual

Description: This is the spacing that the cars would attain when beginning to clear an intersection after the light turns green. It represents the manual driver.

Definition:

1
2
3

outputs: Calc. the total time due to spac'g-M

(Chance **Steady-sta2** **Units: seconds**

Title: Steady State Spacing-Automated

Description: This is the spacing that the cars would attain when beginning to clear an intersection after the light turns green. It represents the automated case.

Definition:

0.1
0.2
0.5
0.7
0.8
1

outputs: Calc. the total time due to spac'g-A

Chance Car-length Units: feet

Title: Car Length

Description: The length of a car.

expr

Definition: 15

outputs: Calc. the total distance requir'd

Chance Max-speed **Units:** feet per second

Title: Max Speed

Description: The maximum speed that a car is allowed to attain progressing through an intersection. The baseline is 30 MPH or 44 feet per second.

expr

Definition: 30.0*1.466666

Outputs: Est. total time to clear intrsct'n-M

Chance Distance_1 **Units:** feet

Title: Distance 1st car must travel

Description: This is the criteria for clearing the intersection. We have choosen 75 feet to be representative of a large intersection.

expr

Definition: 75

Outputs: **Calc. the total distance requir'd**

Chance Accelerati Units : feet/sec/sec

Title : Acceleration

Description: This is the acceleration that the car exhibits as it moves through the intersection. We are using 0.15g's or 4.8feet per second per second.

expr

Definition: 0.15*32

outputs: Est. total time to clear intrsct'n-M

(Chance Time-of-g Units: seconds

Title: Time of Green Light

Description: This is the time that the intersection light is green and therefore the cars can progress through the intersection. We have choosen to evaluate a range of 20 to 60 seconds.

Definition:

20
30
40
50
60

outputs: Est. how many cars thru green lt-M

(Chance Calc._the_ Units: feet

Title: Calc. the total distance requir'd

Description: This is the total distance required to clear all of the cars through the intersection.

expr

Definition: (Distance_1+((Total_numb-1)*(Car_length+Space_betw)))

Inputs:
- Car-length Car Length
- Distance-l Distance 1st car must travel
- Space-betw Space between cars when stop...
- Total-numb Total Number of cars to be eva...

outputs: Est. total time to clear intrsct'n-M

(Chance Calc._the_2 Units: seconds

Title: Calc. the total time due to spac'g-M

Description: This is the total time used due to the spacing required between cars as they move through the intersection. It includes a decay rate function to represent that cars in the front of the queue allow more spacing than the cars at the end of the line. This is for the manual driver.

expr

Definition: If
Total_numb=1
then Initial-ca
Else
Cumulate((Steady_sta1+(Initial_ca/(Total_numb^Steady_sta))),Total_numb)

Inputs:
- Initial-ca — Initial Car delay- manual
- Steady-sta — Steady State Spacing decay rate
- Steady_st... — Steady State Spacing- Manual
- Total-numb — Total Number of cars to be eva...

outputs: Est. total time to clear intrsct'n-M

(Chance Calc._the_1 Units:

Title: Calc. the total time due to spac'g-A

Description : This is the total time used due to the spacing required between cars as they move through the intersection. It includes a decay rate function to represent that cars in the front of the queue allow more spacing than the cars at the end of the line. This is for the automated car.

expr

Definition: If
Total_numb=1
then Initial-Cal
Else Initial-Cal +Steady_sta2*(Total_numb-1)

Inputs: Initial-cat Initial Car delay- automated
Steady-St... Steady State Spacing- Automated
Total-numb Total Number of cars to be eva...

outputs: Est. total time to clear intrsct'n-A

Chance Est.-total Units:

Title: Est. total time
to clear intrsct'n-M

Description: This object estimates the total time it takes to clear the intersection of all cars being evaluated. It represents the manual driver situation.

expr

Definition: If
(Max_speed^2)/(2*Accelerati)>=Calc._the_
Then Calc._the_2+((2*(Calc._the_/Accelerati))^0.5)
Else
Calc._the_2+(Max_speed/(2*Accelerati))+(Calc._the_/Max_speed)

Inputs: Accelerati Acceleration
Calc._the_ Calc. the total distance requir'd
Calc._the... Calc. the total time due to spac'...
Max-speed Max Speed

outputs: Compare manual and Automated

Chance **Est._total2** **Units:**

Title: Est. total time
to clear intrsct'n-A

Description: This object estimates the total time it takes to clear the intersection of all cars being evaluated. It represents the automated car case.

expr

Definition: If
(Max_speed^2)/(2*Accelerati)>=Calc._the_
Then Calc._the_1+((2*(Calc._the_/Accelerati))^0.5)
Else
Calc._the_1+(Max_speed/(2*Accelerati))+(Calc._the_/Max_speed)

Inputs : Accelerati Acceleration
Calc._the_ Calc. the total distance requir'd
Calc._the... Calc. the total time due to spac'...
Max-speed Max Speed

Outputs: Compare manual and Automated

Chance **Compare-ma** **Units:**

Title: **Compare manual and Automated**

Description: **This compares the times for the manual driver and the automted car case.**

Definition:

Est._total[Steady_sta1=2]
Est. total2[Steadv sta2=0.5]

Inputs:

- **Est.-total** Est. **total** time to clear intrsct'...
- **Est.-total2** Est. **total** time to clear intrsct'...
- **Steady-St...** Steady State Spacing- Manual
- **Steady-St...** Steady State Spacing- Automated

(Chance Est.-how-m Units:

Title: Est. how many cars thru green lt-M

Description: This object attempts to estimate the number of cars that get through the intersection for the green light times evaluated. This is the manual driver situation. This is not working corectly yet.

expr ▼

Definition: If
(Est.-total <= Time-of-g)
then Total-numb
Else 0

Inputs:
- Est.-total Est. total time to clear intrsct'...
- Time-of-... Time of Green Light
- Total-numb Total Number of cars to be eva...

(Chance Est._how_m2 Units:

Title: Est. how many cars
thru green lt-A

Description: This object attempts to estimate the number of cars that get through the intersection for the green light times evaluated. This is the automated car case. This is not working corectly yet.

expr

Definition: If
Est._total2[Steady_sta2=0.5] <= Time-of-g
then Total-numb
Else 0

Inputs:

⬭	Est._total2	Est. total time to clear intrsct'...
⬭	Steady-St...	Steady State Spacing- Automated
⬭	Time-of-...	Time of Green Light
▱	Total-numb	Total Number of cars to be eva...

Chance Enable-hig Units:

Title: Enable Higher
Density Veh. Flow

Description: Refer to the final report regarding any information in this IVHS benefit analysis category.

expr

Definition: 0

outputs: Benefit- Increasing intersct'n flow

Chance Interleave Units:

Title: Interleave
Intersection
Traffic

Description: Refer to the final report regarding any information in this IVHS benefit analysis category.

expr

Definition: 0

Outputs: Benefit- Increasing intersct'n flow

Chance Estimate-r Units:

Tit l e : Estimate Reducing
Freq of Accidents

Description: Refer to the final report regarding any information in this IVHS benefit analysis category.

expr

Definition: 0

Outputs: Benefit- Allevtg Accident, Incident

Chance Estimate_r1 **Units:**

Title: Estimate Rapid Reponse,Clean-up

Description: Refer to the final report regarding any information in this IVHS benefit analysis category.

expr

Definition: 0

Outputs: **Benefit- Allevtg Accident, Incident**

Chance **Estimate-r2** **Units:**

Title: Estimate Reroute, Detour

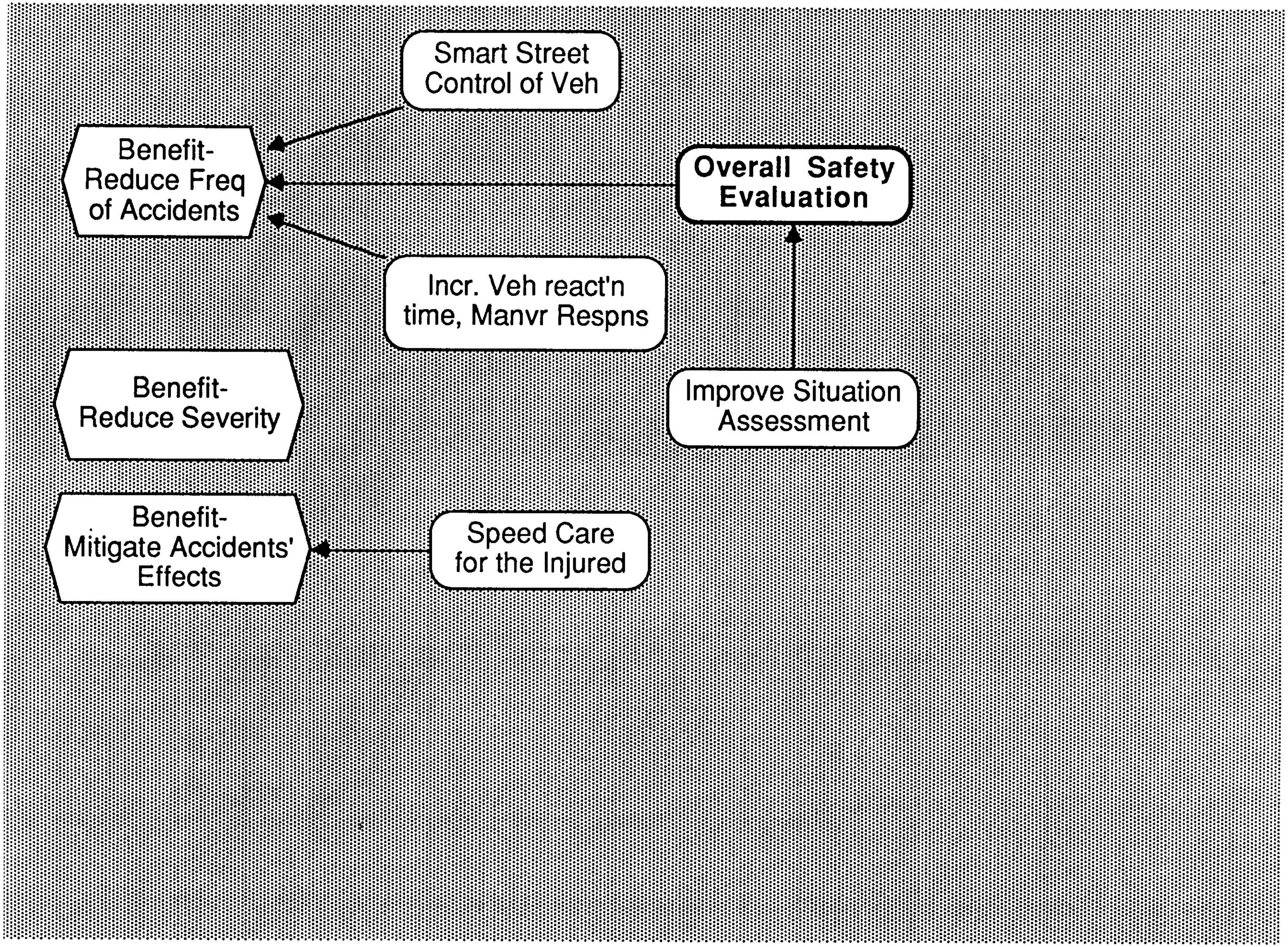
Description: Refer to the final report regarding any information in this IVHS benefit analysis category.

expr

Definition: 0

outputs: Benefit- Allevtg Accident, Incident

Diagram • Improve Arterial Safety



(Objective Benefit_r Units:

Title: Benefit-
Reduce Freq
of Accidents

Description: Evaluate the benefit of improving arterial safety by reducing the frequency of accidents.

Definition:

Smart_stre
Incr._veh_
Important_

Inputs:
- Important- Important: Read this box
- Incr._veh_ Incr. Veh react'n time, Manvr . . .
- Smart-stre Smart Street Control of Veh

(Objective Benefit__r1 **Units:**

Title: Benefit-
Reduce Severity

Description: Evaluate the benefit of improving arterial safety by reducing the severity of accidents. Refer to the final report regarding any information in this IVHS benefits analysis category.

expr ▼

Definition: 0

(Objective Benefit-ml Units:

Title: Benefit-
Mitigate Accidents'
Effects

Description: Evaluate the benefit of improving arterial safety by mitigating the effects of accidents.

expr ▼

Definition: Speed-care

Inputs: ⬭ Speed-care Speed Care for the Inju...

Chance Smart-stre Units:

Title: Smart Street
Control of Veh

Description: Refer to the final report regarding any information in this IVHS benefit analysis category.

expr

Definition: 0

outputs: Benefit- Reduce Freq of Accidents

Chance Incr._veh_ Units:

Title: Incr. Veh react'n time, Manvr Respns

Description: Refer to the final report regarding any information in this IVHS benefits analysis category.

expr

Definition: 0

outputs: Benefit- Reduce Freq of Accidents

Chance Speed_care

Units:

Title: Speed Care for the Injured

Description: Refer to the final report regarding any information in this IVHS benefit analysis category.

expr

Definition: 0

Outputs: Benefit- Mitigate Accidents' Effects

Chance Improve-si Units:

Title: Improve Situation Assessment

Description: Refer to the final report regarding any information in this IVHS benefits analysis category.

expr

Definition: 0

outputs: Important: Read this box

Diagram • Overall Safety Evaluation

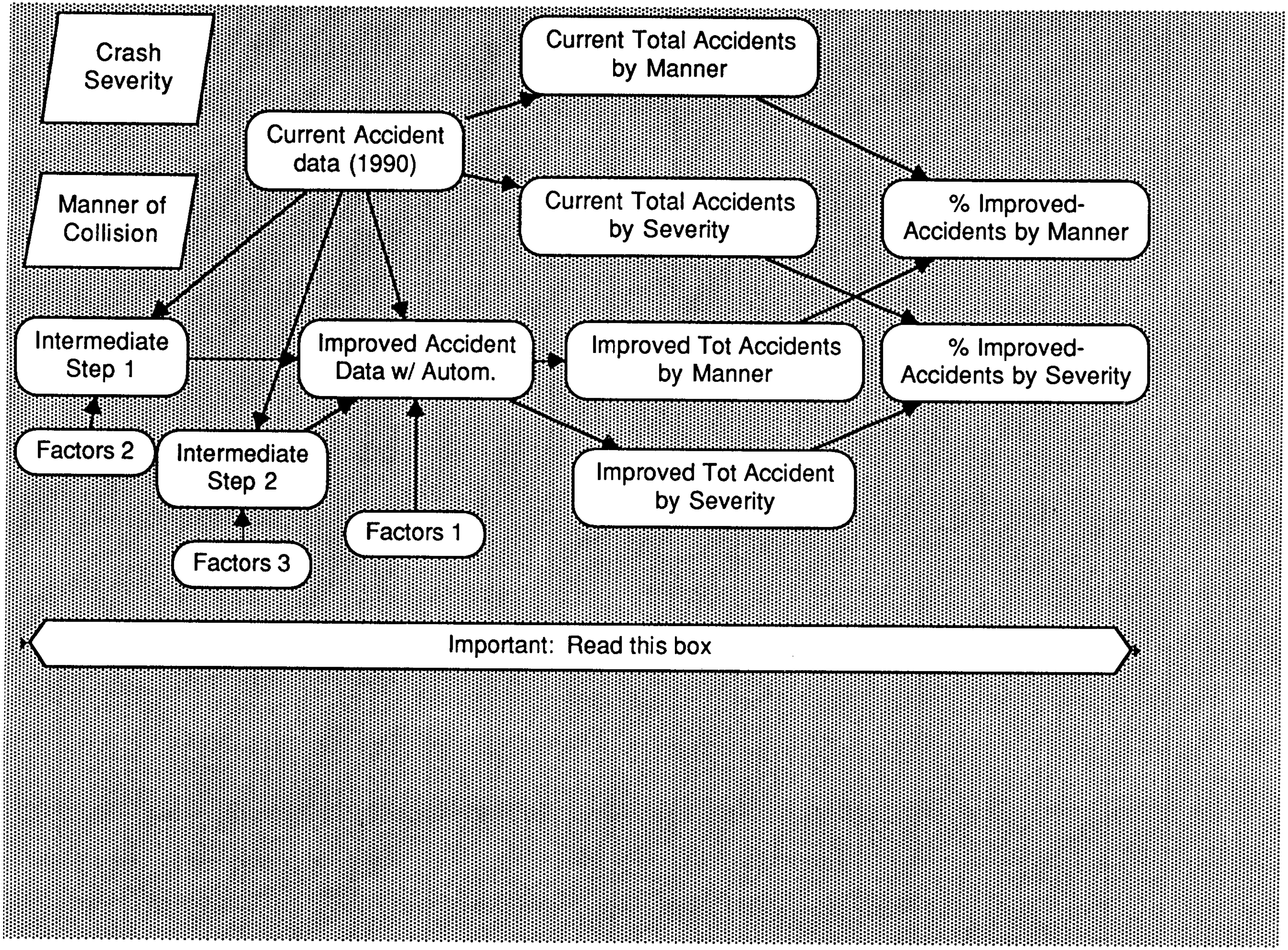
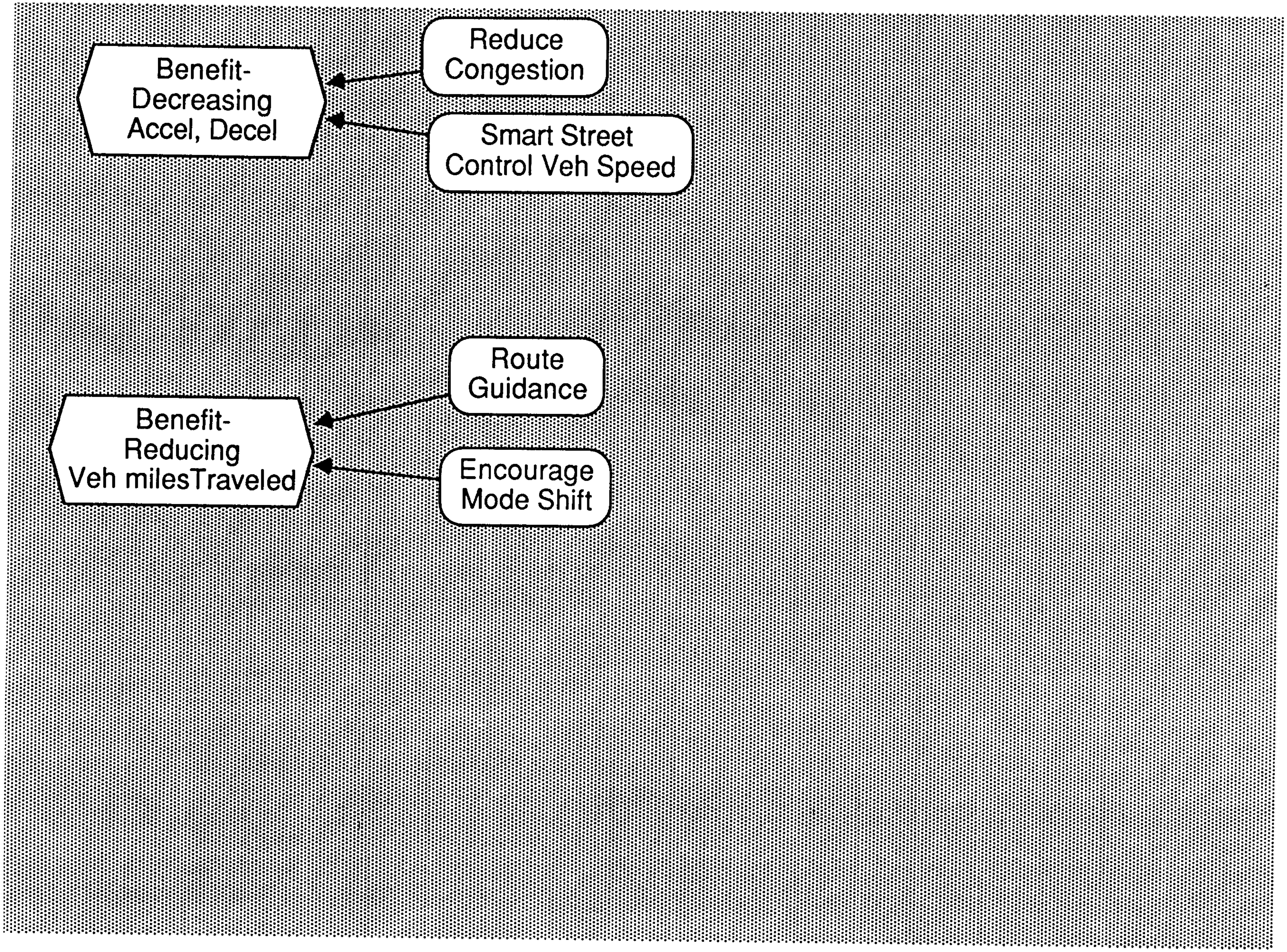


Diagram • Reduce Harmful Emissions



(Objective Benefit-d Units:

Title: Benefit-
Decreasing
Accel, Decel

Description : Estimate the benefit of reducing harmful emissions through decreasing the accelerations and decelerations of automobiles.

Definition:

Reduce_con
Smart_strel

Inputs: Reduce-con Reduce Congestion
Smart-strel Smart Street Control V...

Chance Reduce_con Units:

Title: Reduce Congestion

Description: Refer to the final report regarding any information in this IVHS benefit analysis category.

expr

Definition: 0

Outputs: Benefit- Decreasing Accel, Decel

Chance Smart_stre1 Units:

Title: Smart Street
Control Veh Speed

Description: Refer to the final report regarding any information in this IVHS benefit analysis category.

expr

Definition: 0

outputs: Benefit- Decreasing Accel, Decel

(Objective **Benefit-r2** **Units:**

Title: Benefit-
Reducing
Veh milesTraveled

Description: Estimate the benefit of reducing harmful emissions through reducing the vehicle miles traveled.

Definition:

Encourage-l
Route quid

Inputs: Encourage-l Encourage Mode Shift
Route_guid Route Guidance

Chance Route_guid Units:

Title: Route Guidance

Description: Refer to the final report regarding any information in this IVHS benefit analysis category.

expr

Definition: 0

Outputs: Benefit- Reducing Veh milesTraveled

Chance Encourage_ **Units:**

Title: Encourage
Mode Shift

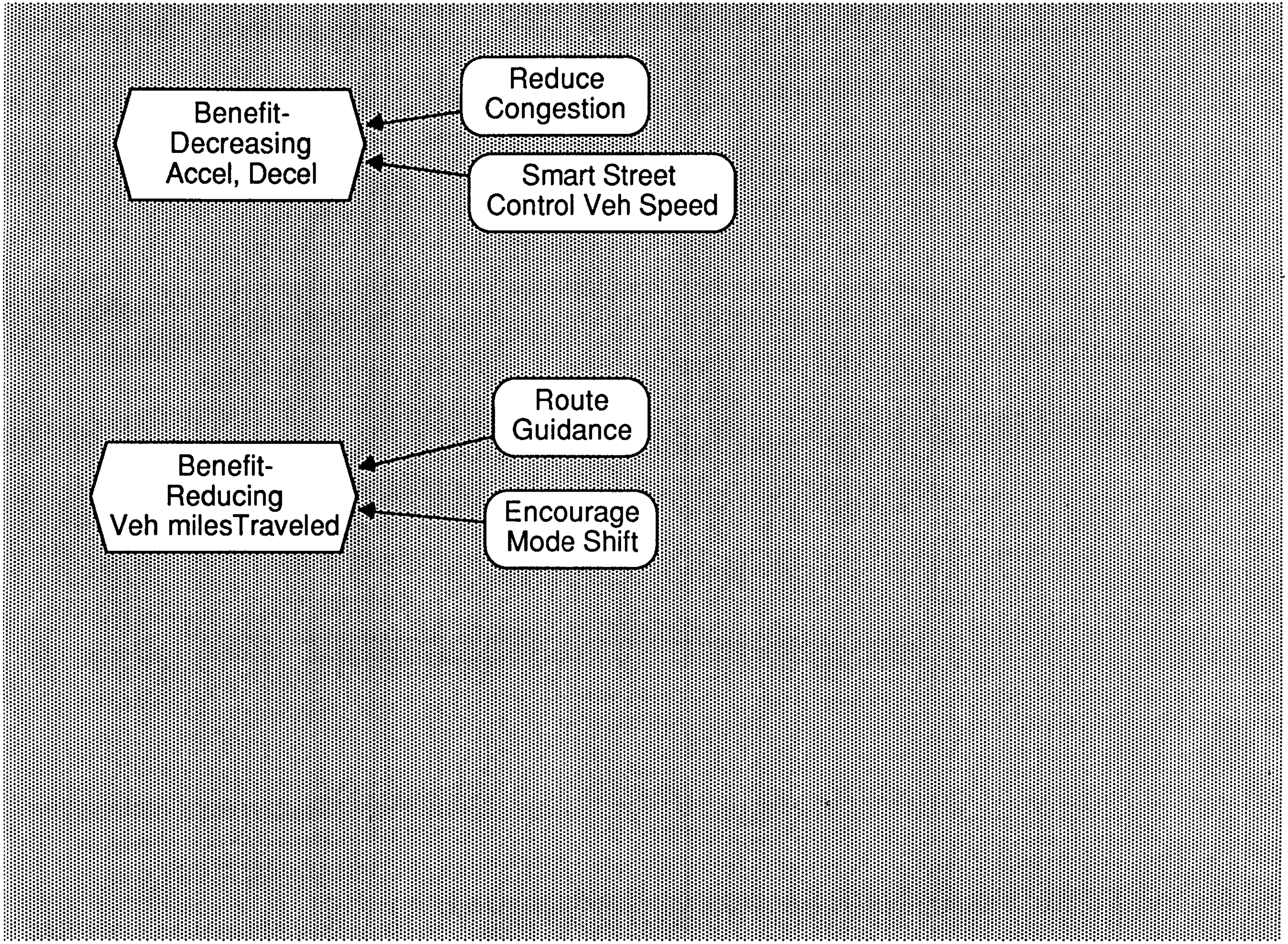
Description: Refer to the final report regarding any information in this IVHS benefit analysis category.

expr

Definition: 0

Outputs: Benefit- Reducing Veh milesTraveled

Diagram • Reduce Use of Energy Resources



DEMOS MODEL

- DOWNTOWN NETWORKS -

0

Diagram . Ivhsbenhidendwntwnl

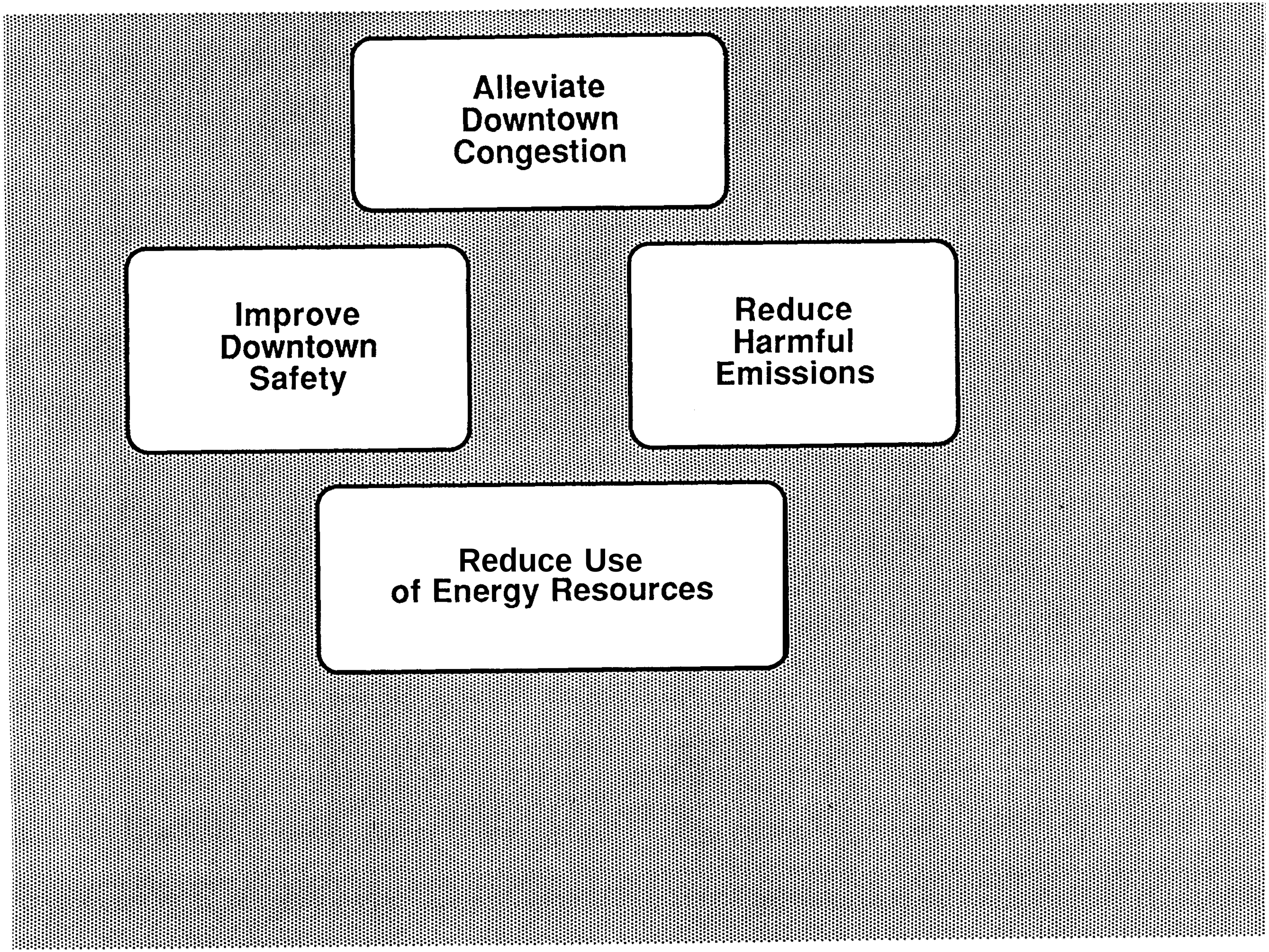
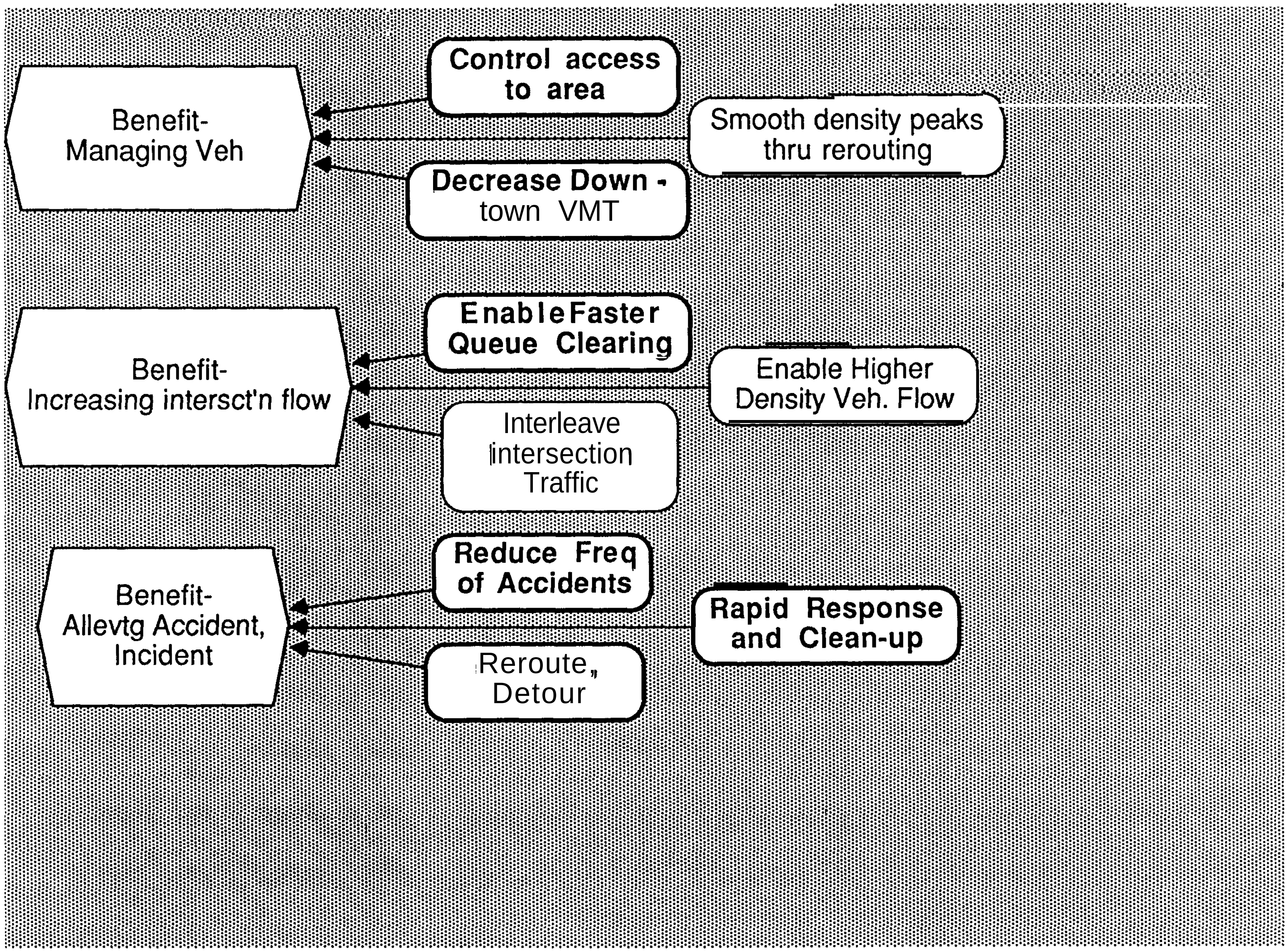


Diagram . Alleviate Downtown Congestion



(Objective Benefit-m

Units:

Title: Benefit-
Managing Veh Density

Description: Documents the benefit of managing vehicular density in downtown areas.

Definition:

Smooth-den
Evaluate__
Selective_
Encourage_
Route__gui

Inputs : Encourage- Encourage Mode Shift
Evaluate__ Evaluate Access metering
Route-gui Route Guidance
Selective_ Selective Road Pricing
Smooth-den Smooth density peaks thru re...

Chance **Smooth-den** **Units:**

Title: Smooth density peaks thru rerouting

Description: Refer to the final report regarding any information on this IVHS benefit category.

expr

Definition: 0

outputs: Benefit- Managing Veh Density

Chance Evaluate__ **Units:**

Title: Evaluate
Access metering

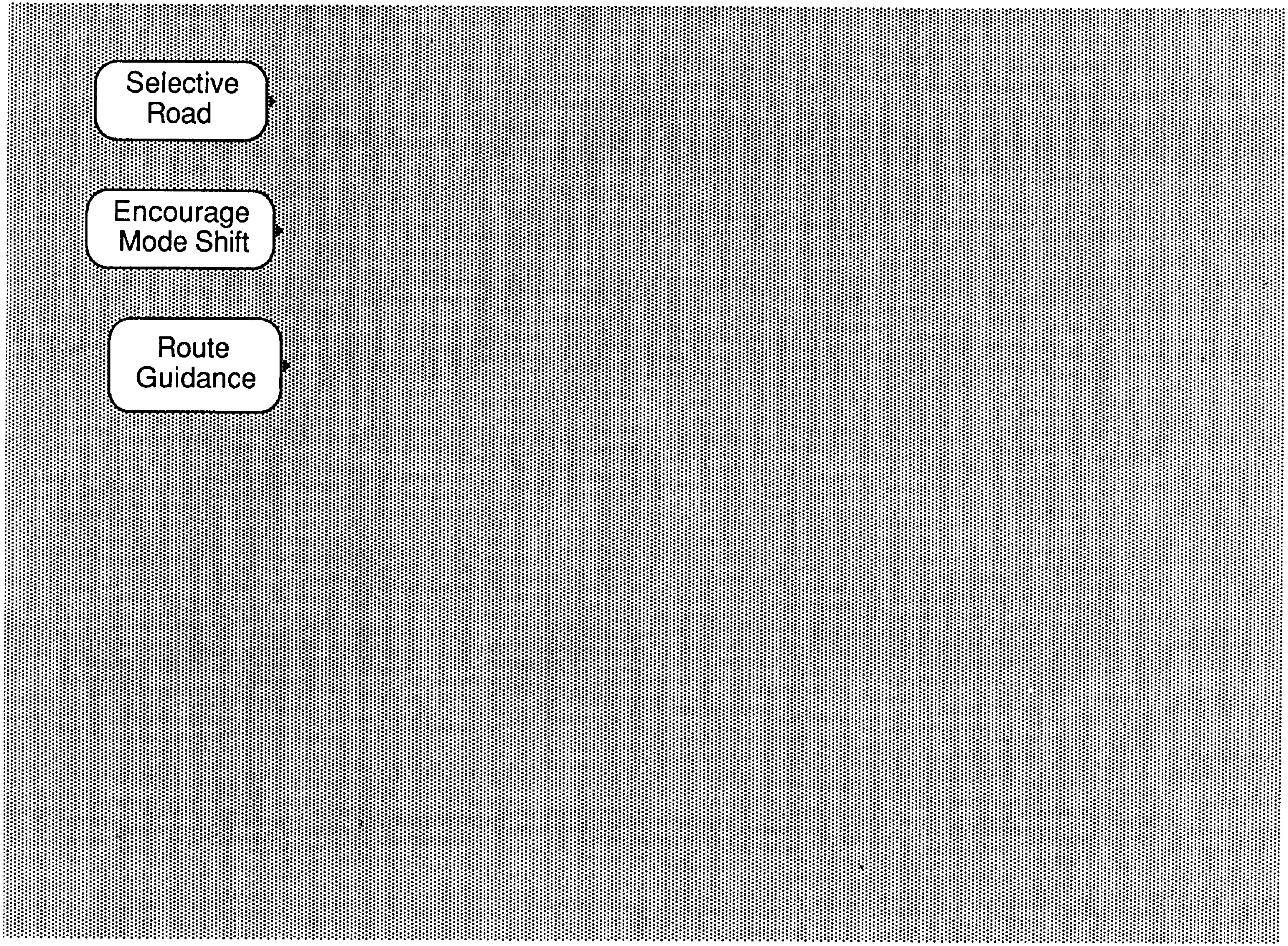
Description: Refer to the final report regarding any information on this IVHS benefit category.

expr

Definition: 0

Outputs: Benefit- Managing Veh Density

Diagram Decrease Down- town VMT



Chance Selective_ Units:

Title: Selective Road Pricing

Description: Refer to the final report regarding any information on this IVHS benefit category.

expr

Definition: 0

outputs: Benefit- Managing Veh Density

Chance Encourage_ **Units:**

Title: Encourage Mode Shift

Description: Refer to the final report regarding any information on this IVHS benefit category.

expr

Definition: 0

Outputs: Benefit- Managing Veh Density

Chance Route__gui **Units:**

Title: Route
Guidance

Description: Refer to the final report regarding any information on this IVHS benefit category.

expr

Definition: 0

Outputs: Benefit- Managing Veh Density

Objective Benefit__i **Units:**

Title: Benefit-
Increasing intersct'n flow

Description: Documents the benefit of increasing intersection flow in the downtown areas.

Definition:

Enable_hig
Interleave
Evaluate_f

Inputs:

Enable_hig	Enable Higher Density Veh. Flow
Evaluate_f	Evaluate Faster Queue Clearing
Interleave	Interleave Intersection Traffic

Chance Evaluate-f Units:

Title: Evaluate
Faster Queue Clearing

Description: A specific analysis of faster queue clearing in the downtown areas has not been accomplished. However, an analysis to estimate the effects of AVCS technologies on clearing of intersections on major arterials is contained in the urban arterials DEMOS model. Those results indicate a significant improvement could be achieved.

expr

Definition: 0

Outputs: Benefit- Increasing intersct'n flow

Chance Enable-hig Units:

Title: Enable Higher Density Veh. Flow

Description: Refer to the final report regarding any information on this IVHS benefit category.

expr

Definition: 0

outputs: Benefit- Increasing intersct'n flow

Chance Interleave Units:

Title: **Interleave Intersection Traffic**

Description: **Refer to the final report regarding any information on this IVHS benefit category.**

expr

Definition: 0

outputs: Benefit- Increasing intersct'n flow

(Objective Benefit-a   Units:

Title: Benefit-
Allevtg Accident,
Incident

Description: Documents the benefit of alleviating accidents and incidents in the downtown areas.

Definition:

Estimate_r
Estimate_r1
Estimate r2

Inputs:
- Estimate-r Estimate Reducing Freq of Acc...
- Estimate_r1 Estimate Rapid Reponse,Clean...
- Estimate-r2 Estimate Reroute, Detour

Chance Estimate-r Units:

Title: Estimate Reducing Freq of Accidents

Description: Refer to the final report regarding any information on this IVHS benefit category.

expr

Definition: 0

outputs: Benefit- Allevtg Accident, Incident

(Chance Estimate_r1 Units:

Title: Estimate Rapid Reponse,Clean-up

Description: Refer to the final report regarding any information on this IVHS benefit category.

expr

Definition: 0

outputs: Benefit- Allevtg Accident, Incident

Chance Estimate_r2 **Units**

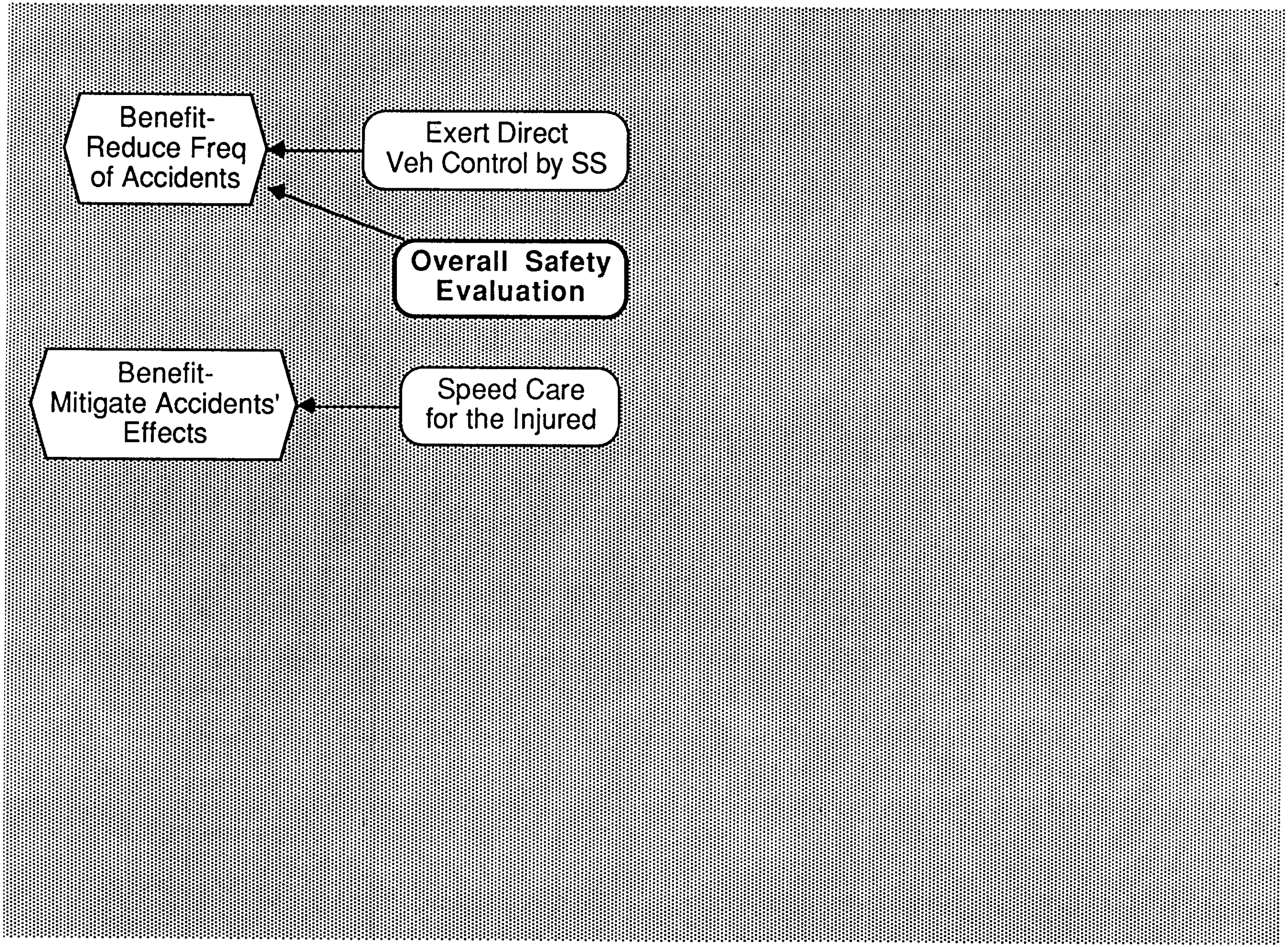
Title: Estimate Reroute,
Detour

Description: Refer to the final report regarding any information on this IVHS benefit category.

expr

Definition: 0

Outputs: Benefit- Allevtg Accident, Incident


Benefit-
Reduce Freq
of Accidents
Exert Direct
Veh Control by SS
Overall Safety
Evaluation
Benefit-
Mitigate Accidents'
Effects
Speed Care
for the Injured

(Objective Benefit-r Units:

Title: Benefit-
Reduce Freq
of Accidents

Description: Assess the benefit of reducing the frequency of accidents.

Definition:

Exert dire
Important-

Inputs: Exert-dire Exert Direct Veh Control by SS

Important_ Important: Read this box

Chance Exert-dire Units:

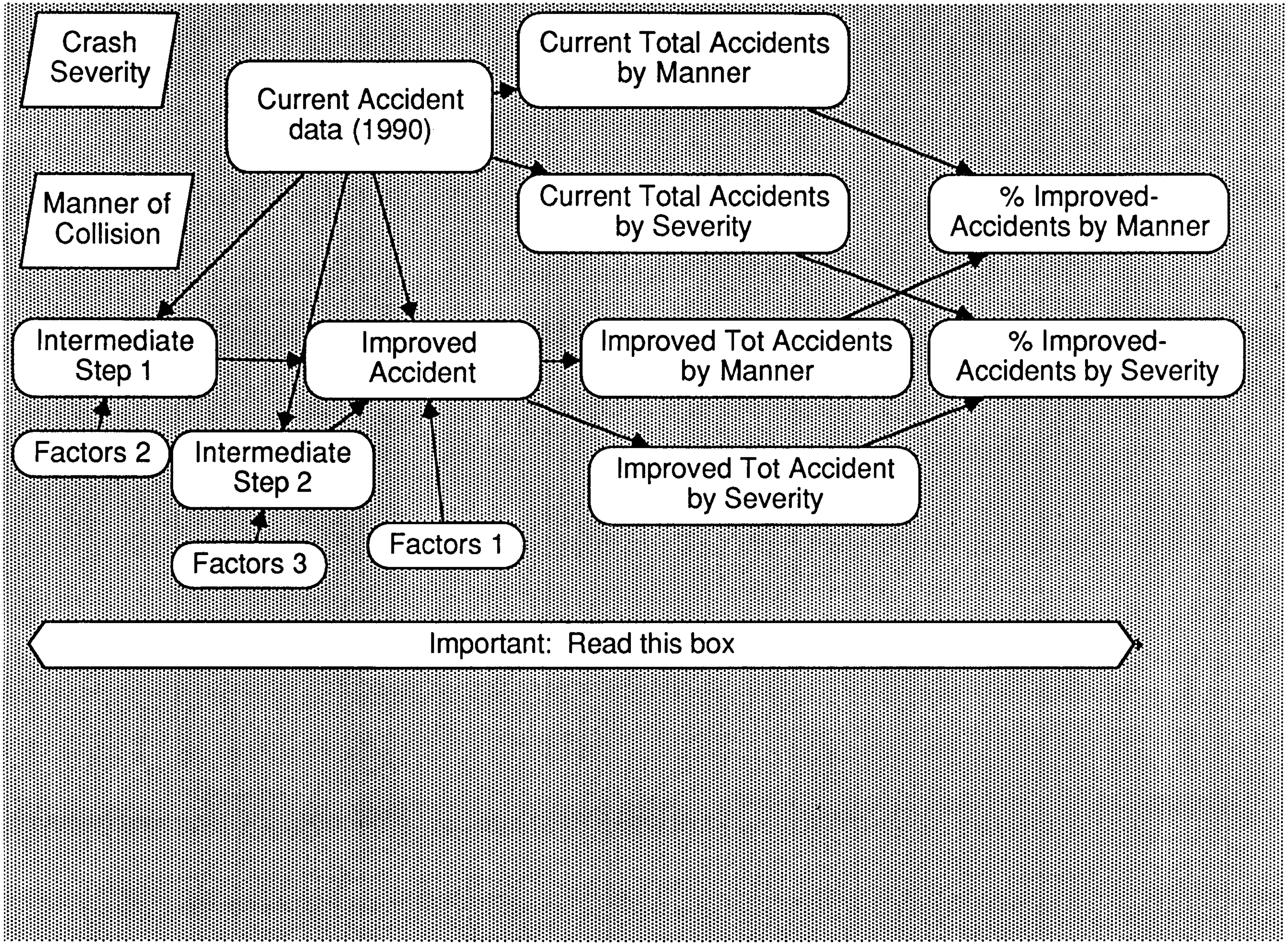
Title: Exert Direct
Veh Control by SS

Description: Refer to the final report regarding any information on this IVHS benefit category.

expr

Definition: 0

outputs: Benefit- Reduce Freq of Accidents


Crash Severity
Manner of Collision
Current Accident data (1990)
Current Total Accidents by Manner
Current Total Accidents by Severity
% Improved-Accidents by Manner
Intermediate Step 1
Improved Accident
Improved Tot Accidents by Manner
% Improved-Accidents by Severity
Factors 2
Intermediate Step 2
Improved Tot Accident by Severity
Factors 3
Factors 1
Important: Read this box

(Objective Benefit-ml   Units:

Title: Benefit-
Mitigate Accidents'
Effects

Description: Assess the benefit of mitigating the effects of accidents.

expr

Definition: Speed-care

Inputs: Speed-care Speed Care for the Inju...

Chance **Speed-care** **Units:**

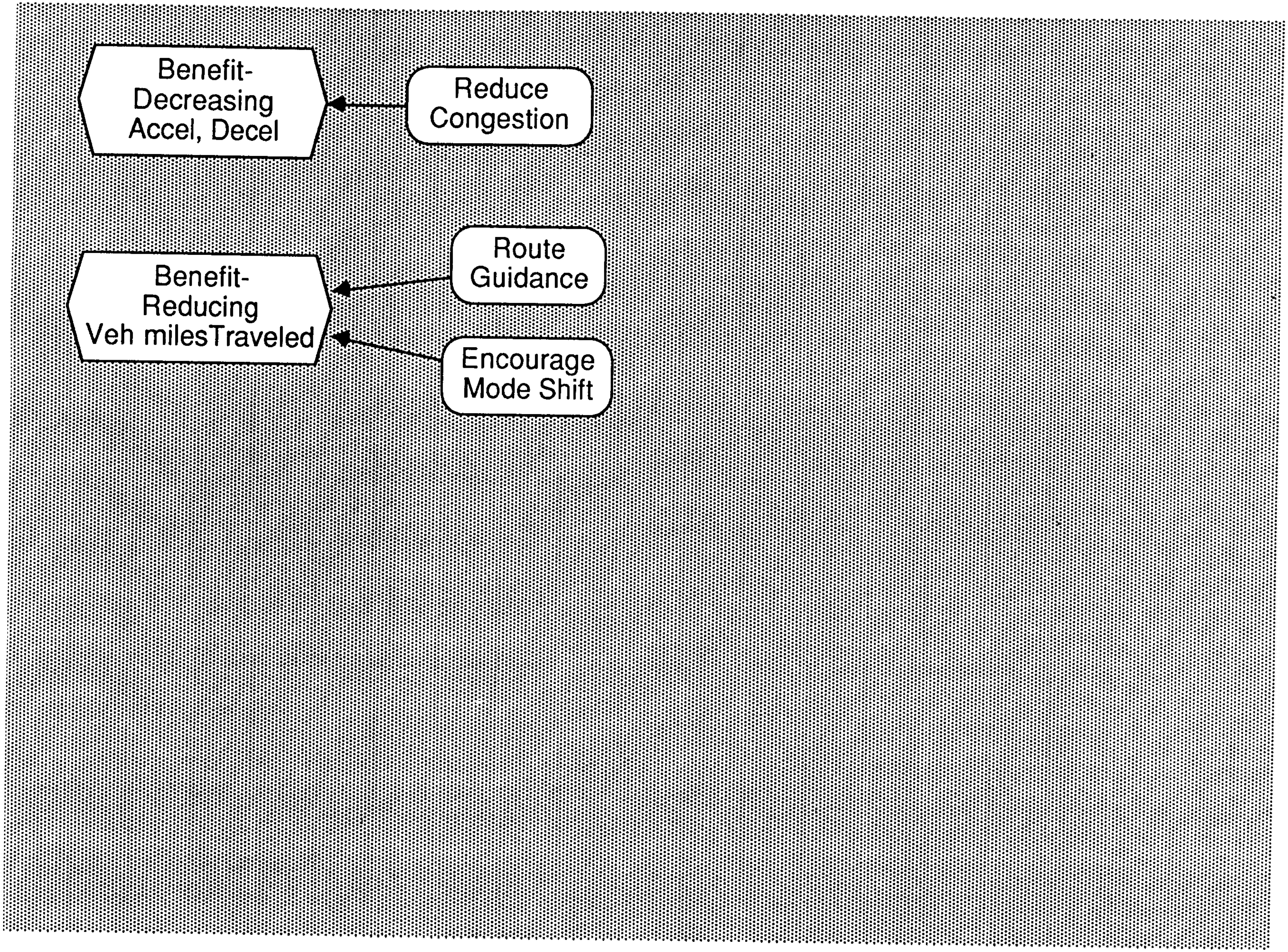
Title: Speed Care for the Injured

Description: Refer to the final report regarding any information on this IVHS benefit category.

expr

Definition: 0

outputs: Benefit- Mitigate Accidents' Effects


Benefit-
Decreasing
Accel, Decel
Reduce
Congestion
Benefit-
Reducing
Veh milesTraveled
Route
Guidance
Encourage
Mode Shift

(Objective Benefit-d

Units:

Title: Benefit-
Decreasing
Accel, Decel

Description: Assess the benefit of decreasing accelerations and decelerations.

expr ▼

Definition: Reduce-con

Inputs : ⬭ Reduce-con Reduce Congestion

Chance Reduce_con Units:

Title: Reduce Congestion

Description: Refer to the final report regarding any information on this IVHS benefit category.

expr

Definition: 0

outputs: Benefit- Decreasing Accel, Decel

(Objective Benefit-r2 Units:

Title: Benefit-
Reducing
Veh milesTraveled

Description: Estimate the benefit of reducing vehicle miles traveled.

Definition:

$$\frac{\text{Encourage-l}}{\text{Route guid}}$$

Inputs: Encourage-l Encourage Mode Shift
Route_guid Route Guidance

Chance Route_guid **Units:**

Title: Route
Guidance

Description: Refer to the final report regarding any information on this IVHS benefit category.

expr

Definition: 0

Outputs: **Benefit- Reducing Veh milesTraveled**

(Chance Encourage-l Units:

Title: Encourage Mode Shift

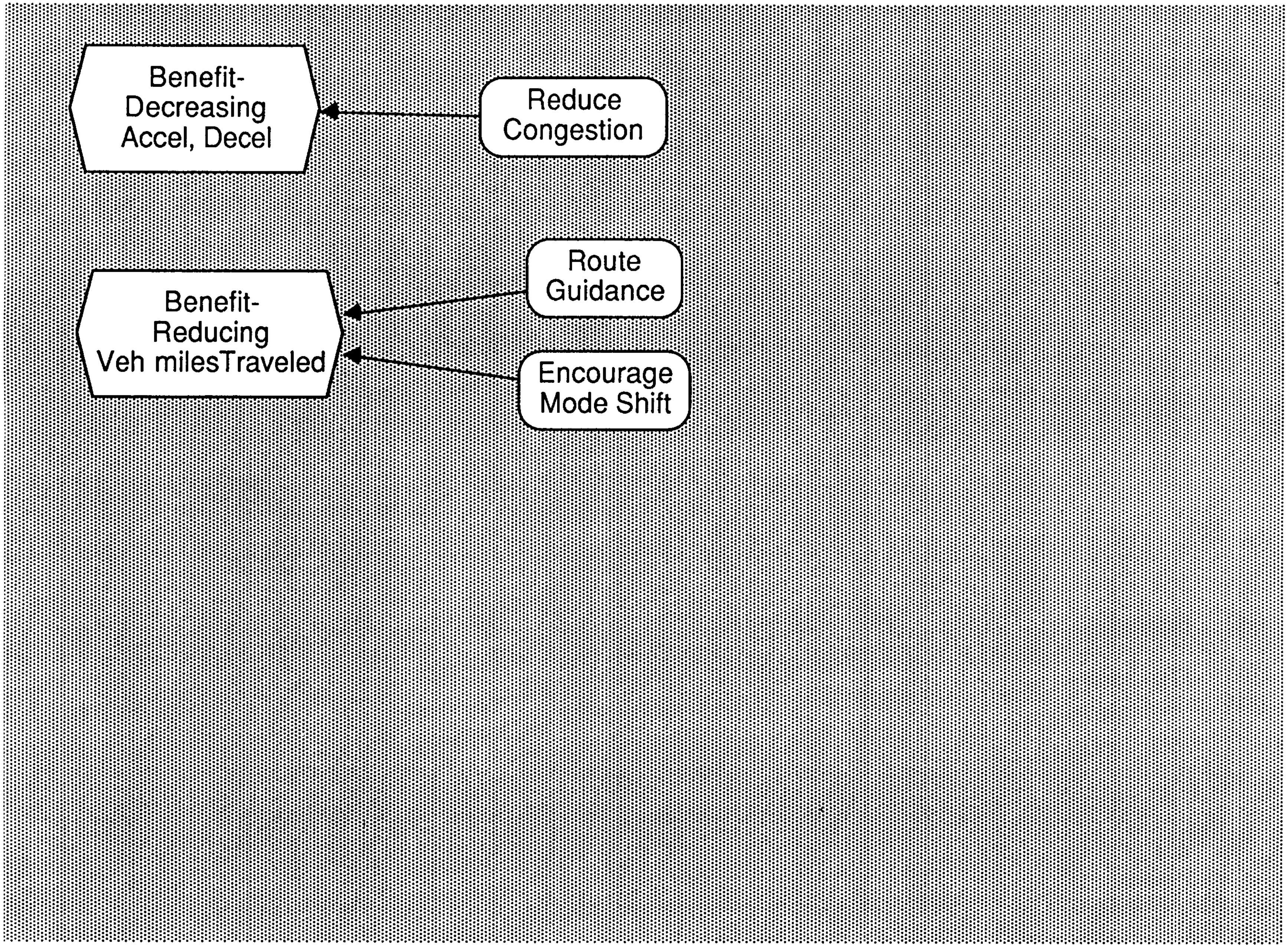
Description: Refer to the final report regarding any information on this IVHS benefit category.

expr

Definition: 0

outputs: Benefit- Reducing Veh milesTraveled

Diagram • Reduce Use of Energy Resources



SECTION 3.0

DEMOS TUTORIAL

Demos Tutorial

An Introduction to Demos

Macintosh Demos version 2.0b2
June, 1992

• • • • • • • • • • • • • •
• • • DRAFT • • •
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Table of Contents

Part 1 Getting started

Welcome to the **Demos** Tutorial. This is a **hands-on** introduction to using Demos. **In this tutorial, you will learn how to install Demos on your hard disk, how to explore an existing Demos project, and how to create a new Demos project using step-by-step instructions. The tutorial is** divided into three **parts,** and you can cover the entire tutorial in under an hour.

- **Getting started** — about 5 minutes

  This part shows you show to install Demos on your computer so you can getstarted.

- Exploring a Demos **project** — about 15 minutes

  This part shows you how to start up an existing Demos project, how to examine the model structure and assumptions, and how to generate tables and graphs showing the **results** of the model. It also shows you how to **generate probability distributions** that **characterize** uncertainty, and how to do sensitivity analysis to see which **uncertainties** are most important. The example mcxiel analyzes total costs of buying and-owning a house.

- Creating a new Demos project — about 25 minutes.

  This **part** shows you how to create a new Demos project from scratch. It shows you how to create variables, define dependencies, add documentary text, and compute results. **The** example model **analyzes** the **costs of owning and running a car.**

This tutorial is designed to familiarize you with the user interface of Demos, and introduce you to some of its basic features. Once you have become familiar with the interface and **features** of Demos, you should **refer** to the Quick Reference for more information about the windows and menus in Demos. The forthcoming Demos **User's** Manual will provide more details about the functionality of Demos to build more complete models.

What you are expected to know

You need to have the basic skills in using a Macintosh computer. These include knowing how to point and click, double-click, and drag the mouse. You also need to know how to use pull-down and popup menus, scroll bars, and the basics of using windows.

If you are unfamiliar the basic skills descrii above, we recommend that you use the Macintosh Tour or Macintosh Basics disk that comes with your Macintosh to learn these techniques, step by step, on your computer. Check your Macintosh Getting Started booklet and Macintosh User's Manual for details.

Demos versions

All versions of Demos require a Macintosh with enough RAM memory (1.5 megabytes). There are three versions of Demos available:

Demos FPU This is the full version of Demos with all capabilities. It requires that your Macintosh have a Floating Point Unit (FPU). It will run on any Macintosh except the Mac Plus, Mac Classic, Mac SE, and Mac LC, PowerBook 100, Mac IIsi without optional Floating Point Unit, or any other Macintosh that does not have a Floating Point Unit.

Demos U This is the full version of Demos, but does not use a Floating Point Unit. It runs about 30% slower than Demos FPU on a machine that has a Floating Point Unit.

Demos demo This demonstration version is available for free, and can be copied and shared freely with other people. It does not require an PPU. It lets you do anything the full version of Demos can do, except it will not save any changes to a model.

You can use this tutorial with any of the Demos versions. If you use the demonstration version, you can wen go through part 3, to learn_how to create a new model. But you won't be able to save the new model you have seated, and so will lose it when you quit Demos.

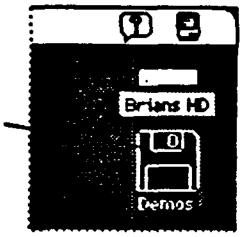
Installing Demos

. **The first thing to do is to copy the Demos program onto your hard drive, if it** isn't then? already. You will need a floppy disk containing Demos and the sample models. The same installation procedure will work with whichever **version** of Demos you have - Demos FPU, Demos U or **Demos** demo. The only **difference** is that the Demos folder and application may have different names from those depicted, e.g., "**Demos** demo" instead of "**Demos**". Follow the instructions in the boxes.

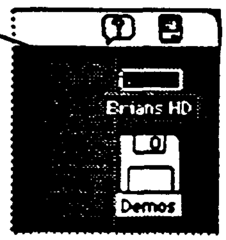
1 **Turn on your Macintosh.**

2 Insert a Demos diskette into the disk drive.

You will now see the Demos disk icon on the right side of your **screen.**



3 Open up your hard disk folder by double-clicking on the hard disk icon.



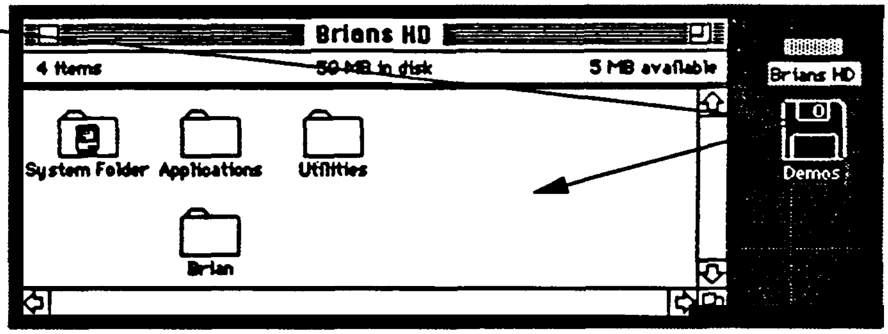
Check if your Macintosh is ***running System 7.*** If it is, **there will be a balloon help ? near the right end of the menu** bar.

If **your** Macintosh is ***not*** running ***system 7,*** skip to **step 5. If it is running** ***System 7,*** continue to step ***4.***

For System 7 users:

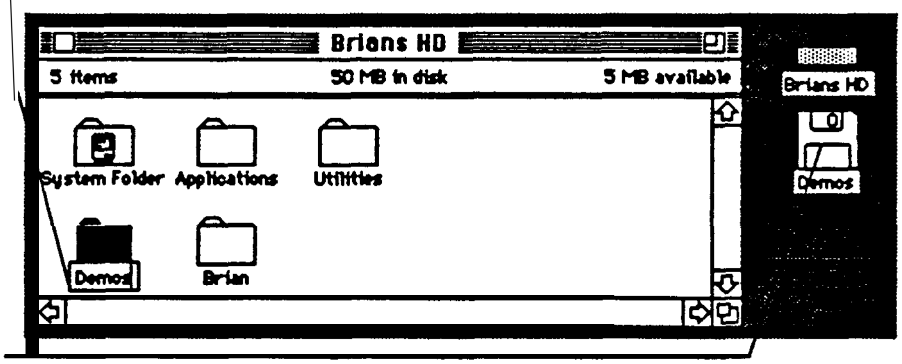
4 **Drag the icon of the** diskette onto your hard disk.

You are now done-Demos is installed onto your hard disk. Tumtothencxt page.



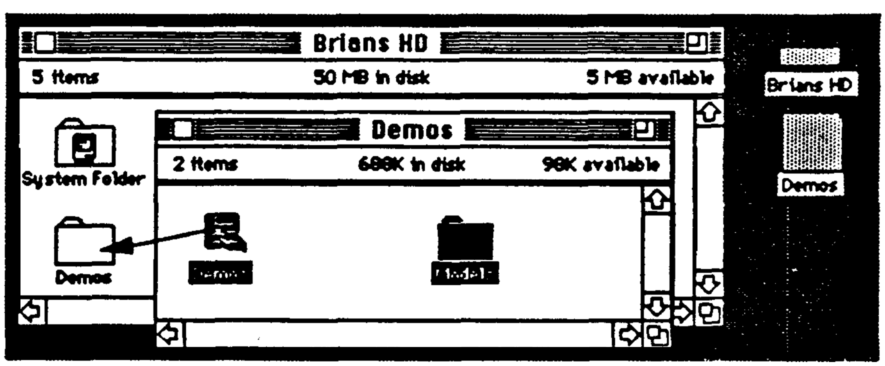
For non-System 7 users:

5 Select New Folder from the File menu to create a folder on your hard disk Label the folder 'Demos".



6 Double-click on the diskette icon to show contents of diskette.

7 Drag each item from the diskette into the empty Demos folder on your hard disk.

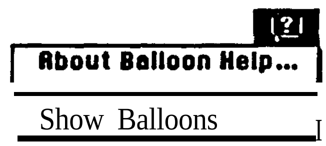


•

Balloon Help

Balloon Help provides text to explain each icon, button, field, menu item or other features of the user interface of a Macintosh program. When you move the mouse cursor over the feature, the explanation text appears in a cartoon-like balloon pointing to the feature. Balloon Help is available on Macintoshes that are running System 7. You can tell whether your Mac is running System 7 by whether there is a ? near the right end of the menu bar:

Press on this ? menu to see the Help Menu. Select Show Balloons if you want to switch on Balloon Help.

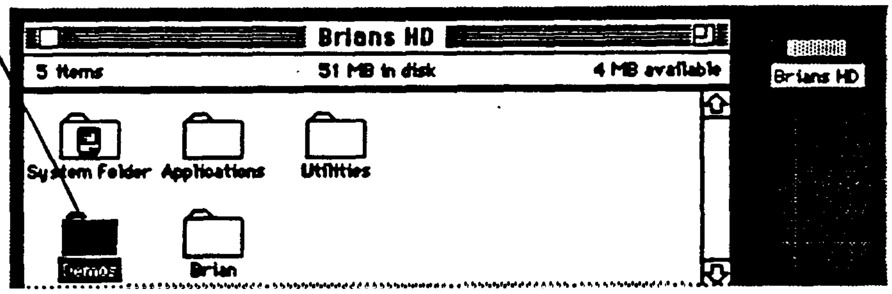


We recommend that you use Balloon Help when you first start using Demos. When you become more familiar with Demos you can turn it off again. To turn it off, press again on the ? menu, and select Hide Balloons;

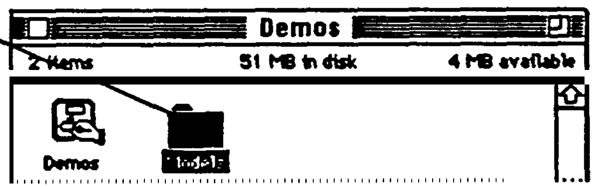
Part 2 Exploring a Demos project

You can explore an existing model by starting the model in the conventional Macintosh way as described below. In this section, you will browse the House model, a Demos project that compares the cost of renting to the cost of buying a house. By examining this project, you should become familiar with how to examine and evaluate a model.

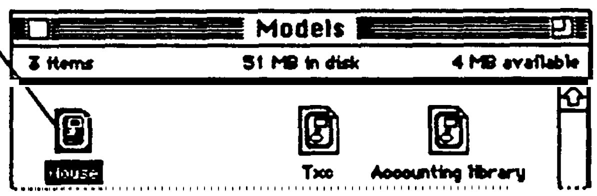
1 Double-click on the Demos folder, to open it up.



2 Double-click on the Models folder, to open it up.

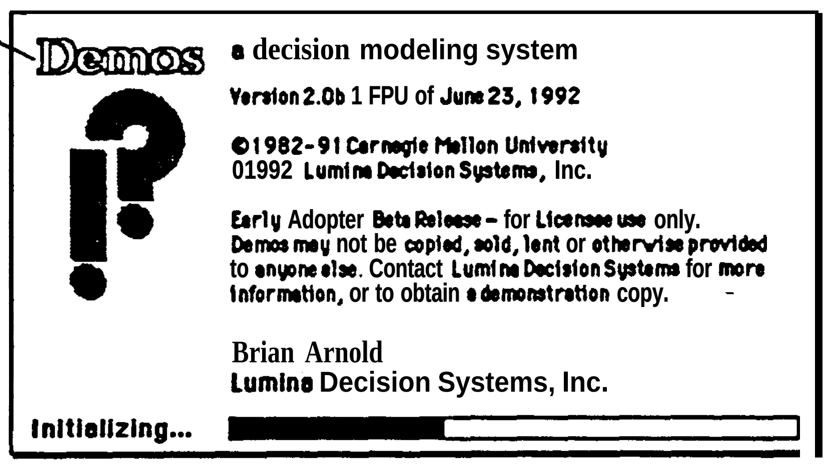


3 Double-click on the icon of the House model to start it up.

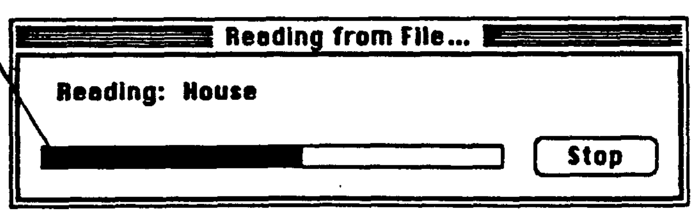


As Demos starts up, you will see this initialization window.

The progress bar shows how far Demos is in initializing.

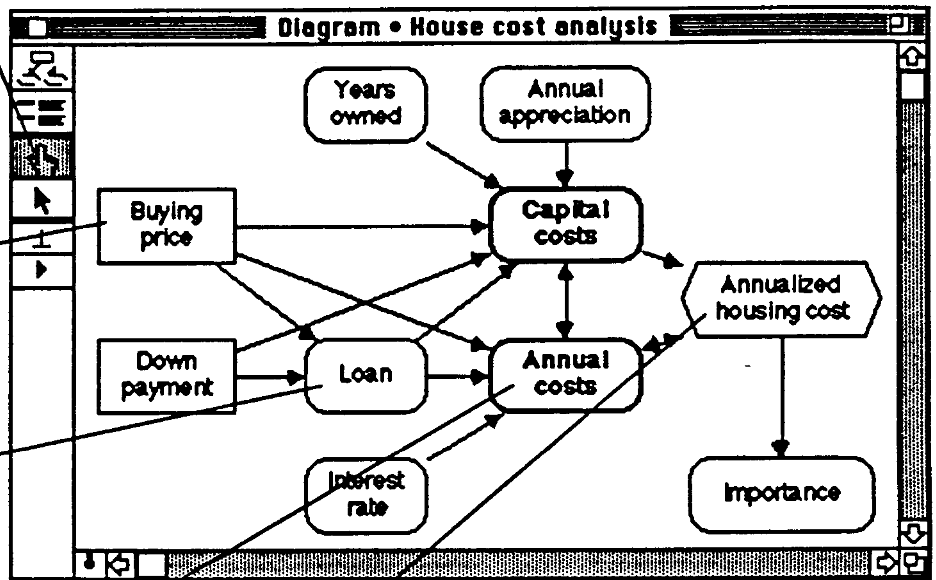


Then, as it starts up the model, you will see this progress bar. This shows how far Demos is in reading in the model.



Recognizing objects on the diagram

When a model is started up, Demos displays the top level of the model in an influence diagram window as shown below. A model contains a number of objects of different classes. Objj classes include decision variables, chance variables and submodels. **The** shape of each node i nthe diagram indicates its object class.



The browser icon is grayed-out, indicating that you **are** inbrowsemode. This **means you can examine the** diagrambutnotchangeit

Dedsion variables **are represented by rectangular nodes. Decisions are** variables that **are directly** under the control of the decision maker.

Chance variables **are represented by nodes with rounded corners.** In general, chance variables **are uncertain. They cannot be controlled directly** by the decision maker.

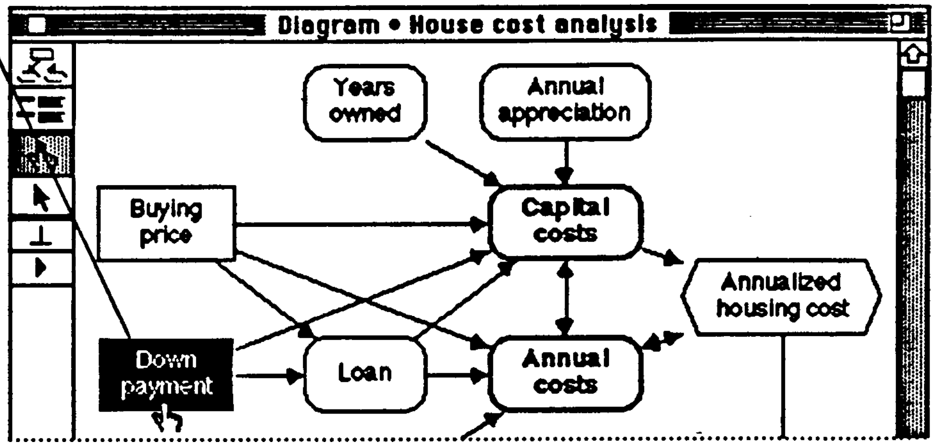
Submodels are represented by thick-lid nodes with rounded **corners. A submodel** contains its own **influence diagram,** showing **more** detail.

The objective variable is **represented** by a hexagonal node. **The** objective is the variable that evaluates the overall value or desirability of **outcomes.** In this one, **the goal is to minimize the** ***Annualized housing cost.*** **Most** ***models contain a*** **single objective node.**

Opening an object window

. Every object has an objj window which shows detailed information about it. You can display the objj window of an **object** simply by **double-clicking ik** nude in the influence diagram. Information about an object is **structured** as a **list** of attributes. The **attributes** of a variable include **ik class, name, title, units,** description, definition, and outputs.

1 Double-click on the Down Payment node to open the object window for Down Payment.



This is the measurement units for the quantity. **The units** here is dollars.

The object's class is **Decision** variable.

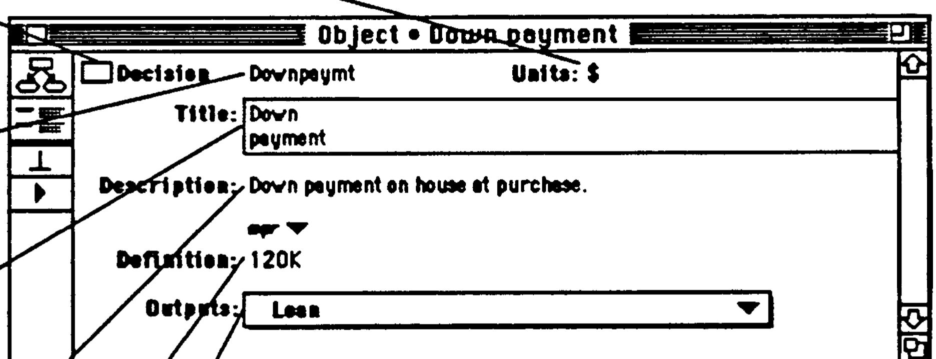
Thenameofthisobjjis Downpaymt. **It** is **used** to refer to this variable in definitions of other variables.

Thetitleofanobjectsays briefly (up **to** 36 characters) what it is. **The** title is **also** shown in the node.

The description provides more **complete** documentation about this variable.

The definition is a simple number. **120K** means 120 thousand. **The** definition may **also** be a **probability** distribution, or other mathematical expression.

Outputs are variables that depend on this variable.

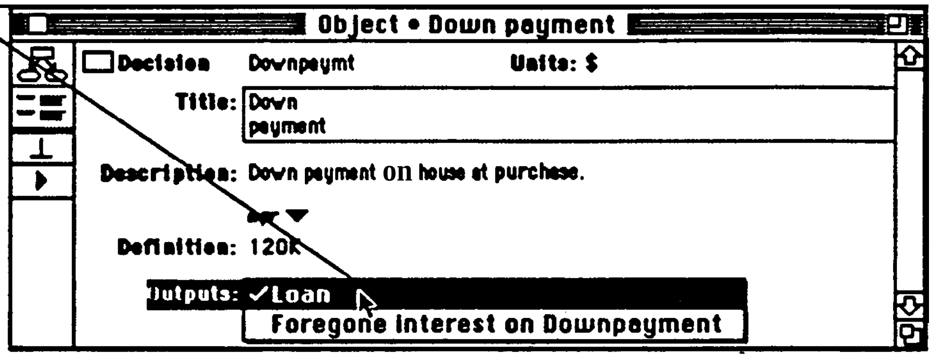


Moving to other object windows

An alternative to displaying an object window by double-clicking ik node on the influence diagram is to explore the inputs or outputs of a displayed object window. The objj window for a variable contains a list of ik inputs, and a popup menu of ik outpuk. You can replace the variable in the object with one of ik inputs or with one of ik outputs.

1 Press here to show a popup menu of the outputs of this variable.

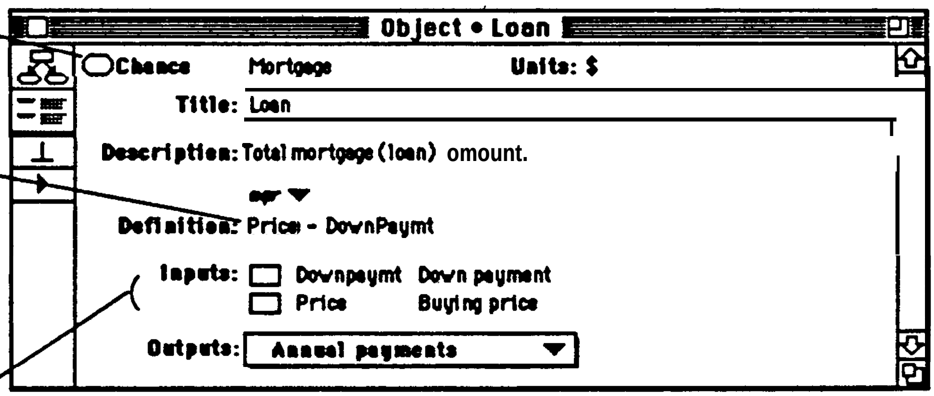
2 Holding the mouse down, slide the cursor to highlight Load, and release it, to select that variable.



Loan is a Chance variable.

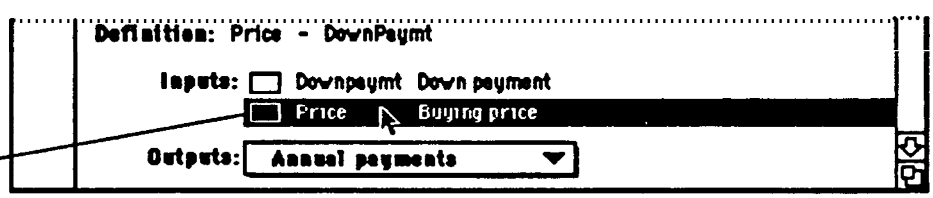
The definition of the Loan amount is the difference between the Price and the Down payment. The definition refers to these variables by their names.

The list of inputs shows the names and titles of the variables in the definition. When the names are brief, the titles help explain what they refer to. Down payment, the variable we cam from, is one of ik inputs.



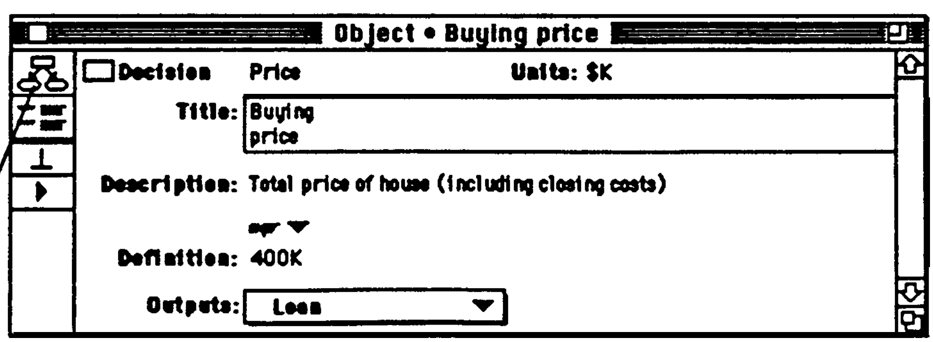
You can examine the object window for any input by double-clicking on it.

3 Double-click on input Price.



The objj window now displays the attributes of Rice.

4 Click on the Diagram icon to return to the influence diagram.

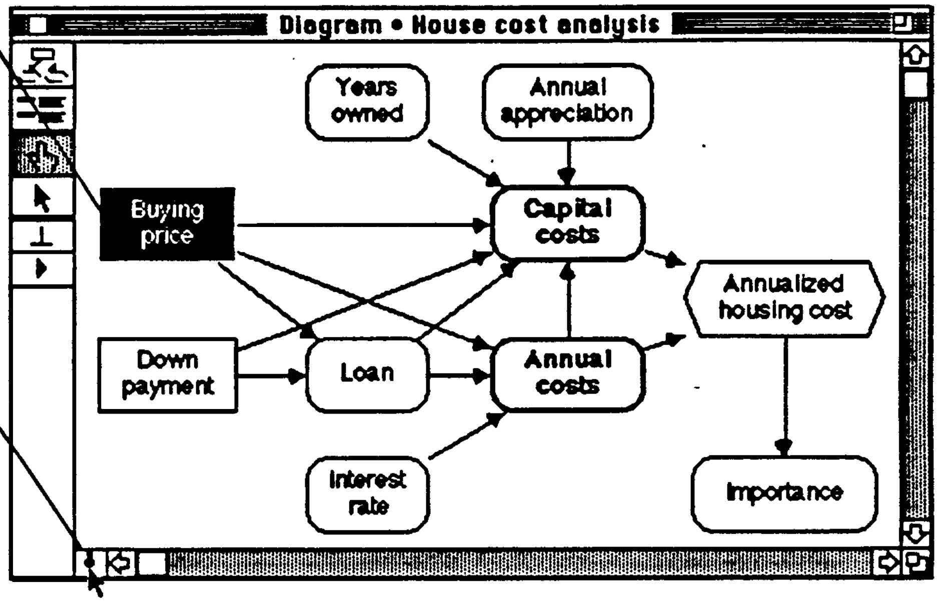


Using the attribute view

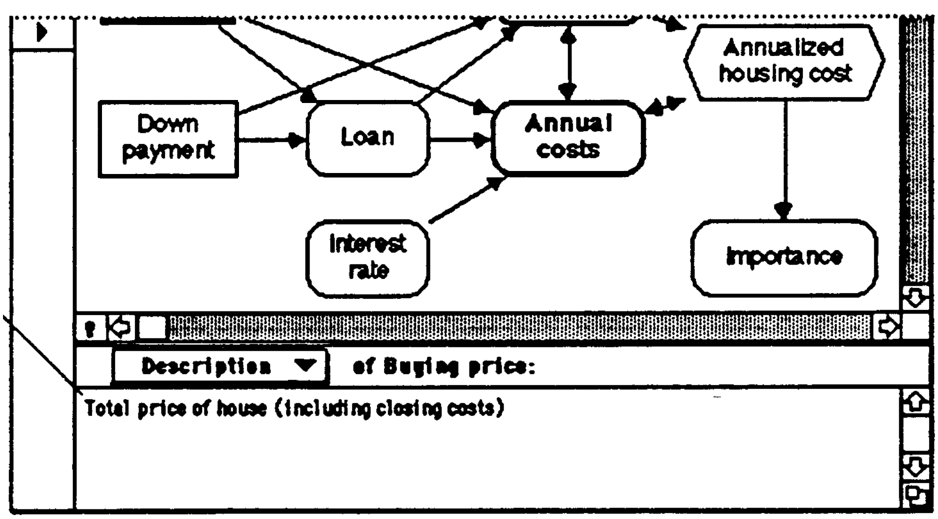
As an alternative to viewing **attributes** of a variable in its **object** window, you can inspect attributes in the attriite view. This is an **auxiliary** window pane that you can open below a diagram window. The **attribute** view lets you rapidly examineoneathibuteatatimeofanyobjectinthediagraxn **You can select which object to view by selecting it in the diagram, and you can select** which attribute you want **from** a **popup** menu of attributes.

The **diagram window** is **frontmost** again. Note that **the** variable Buying price is **highlighted** (in reverse video) to show we were **just examining** it. **(If** it isn't **highlighted** for any reason, **highlight** it by clicking on it **once).**

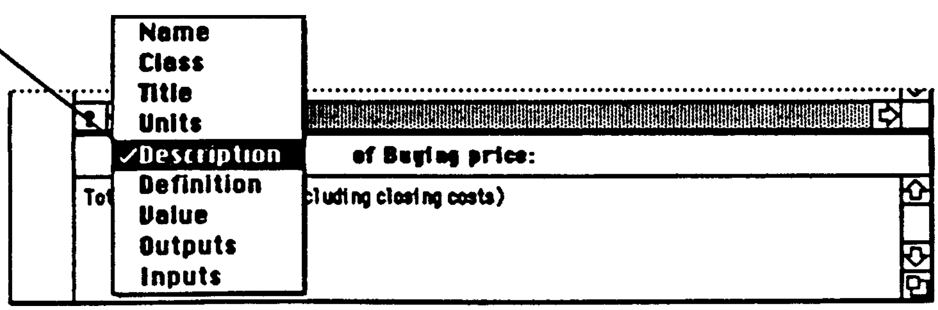
1 Clickontheexpandiconin order to open the attribute view.



Youcannowseethe description of Buying price in the attribute view.



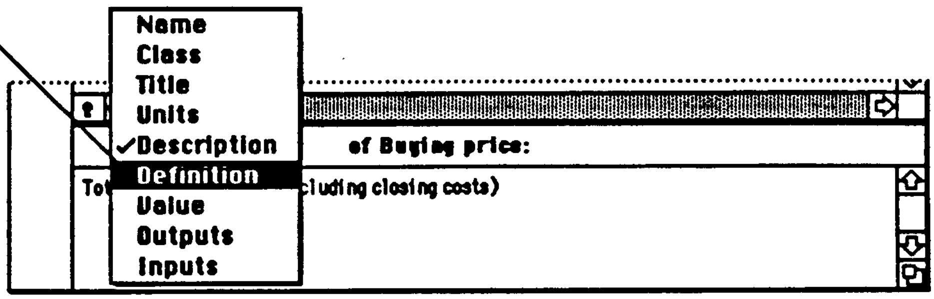
2 Press here to show the pop-up menu of all the attributes of the **selected node.**



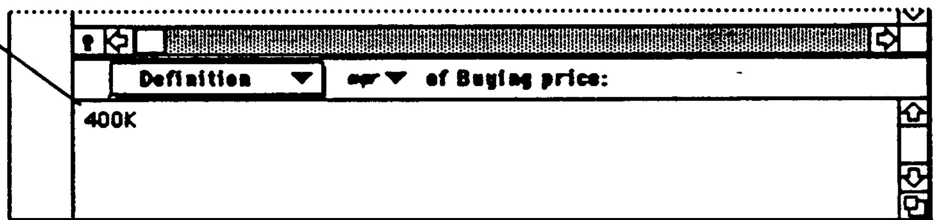
Inspecting definitions in the attribute view

The attribute view allows you to view any attribute of an object For example, you may want to look at the description of each variate, or the definition (as we show here).

1 Press on the **attribute popup menu, drag** to Definition and release to **select it as the new current attribute to** display.

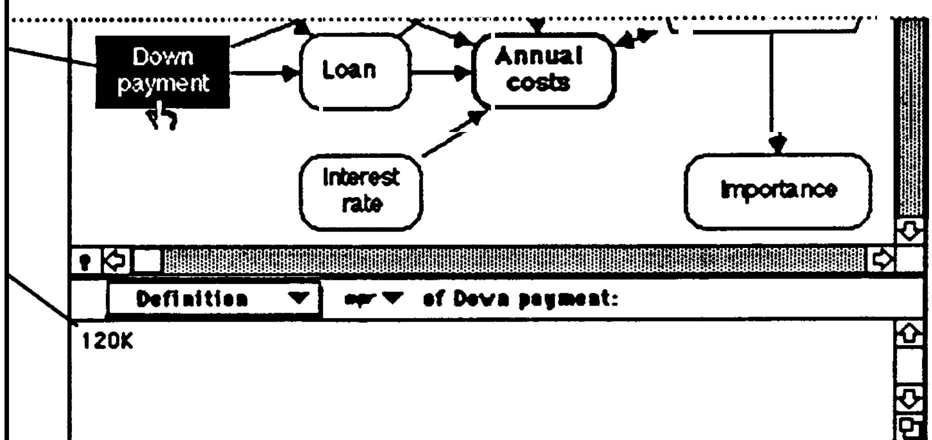


You will **see** the definition of Buying price here. It is a single number, **400K,** that is **400,000.**



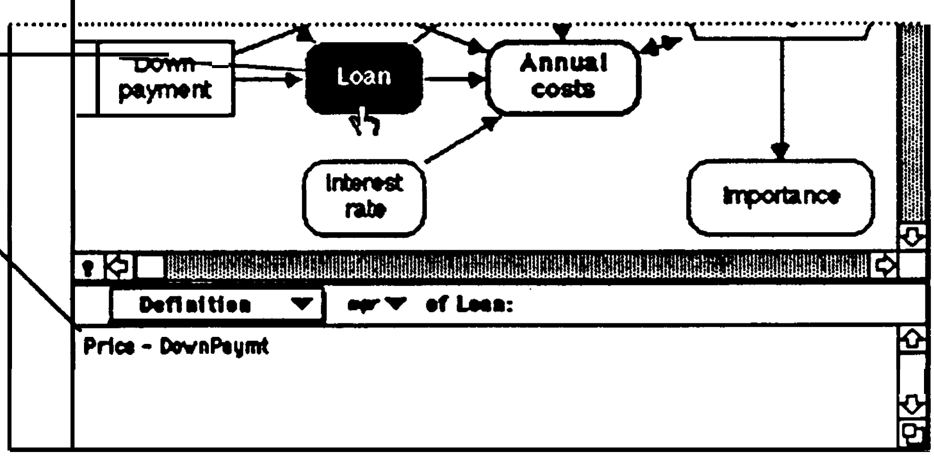
2 **Click on the Down payment** variable to **select it.**

You will see the definition of Down Payment here. It is also a number, **120K,** that is **120,000.**



3 Click on the Loan variable in the diagram to select it.

You will see the definition **of Loan here.** Itisan **expression,** using the **names** of Down payment subtracted **from buying** price. In this way, you can look at the **definition** of any variable in the model.



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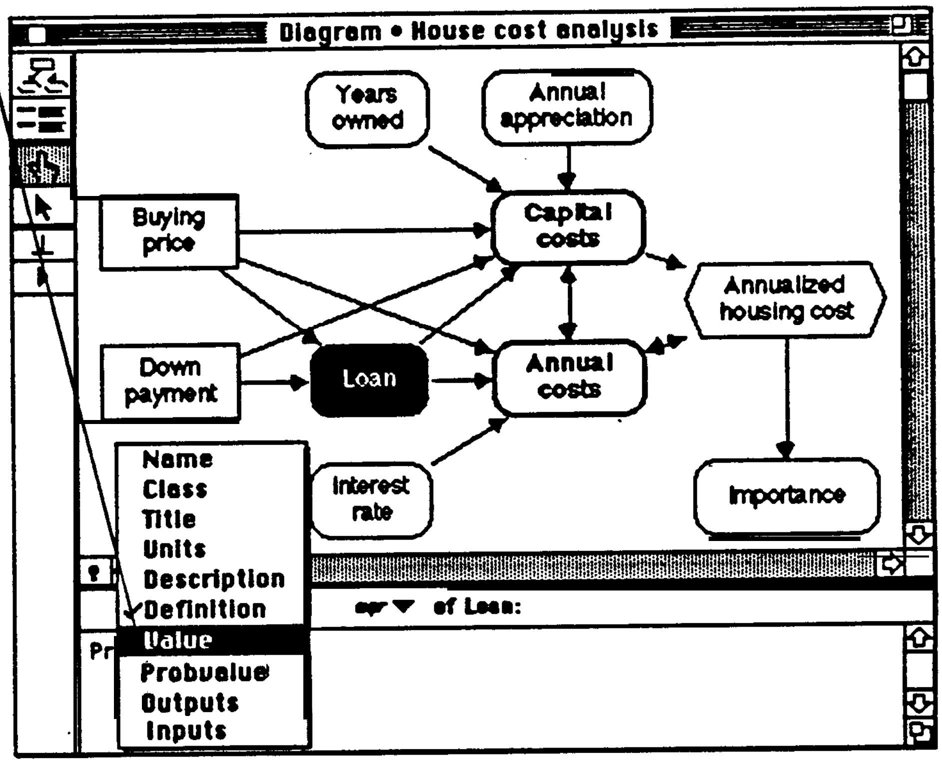
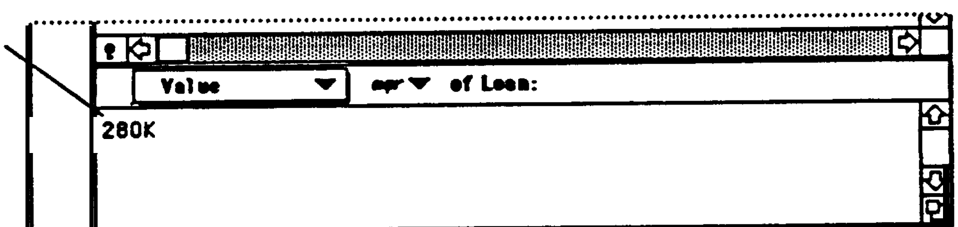
Inspecting values in the attribute view

The attribute view allows you to view some attributes, like the Value, which are not (initially) shown in the object window. When you ask to show the Value attribute of a variable, Demos will first compute it automatically if necessary.

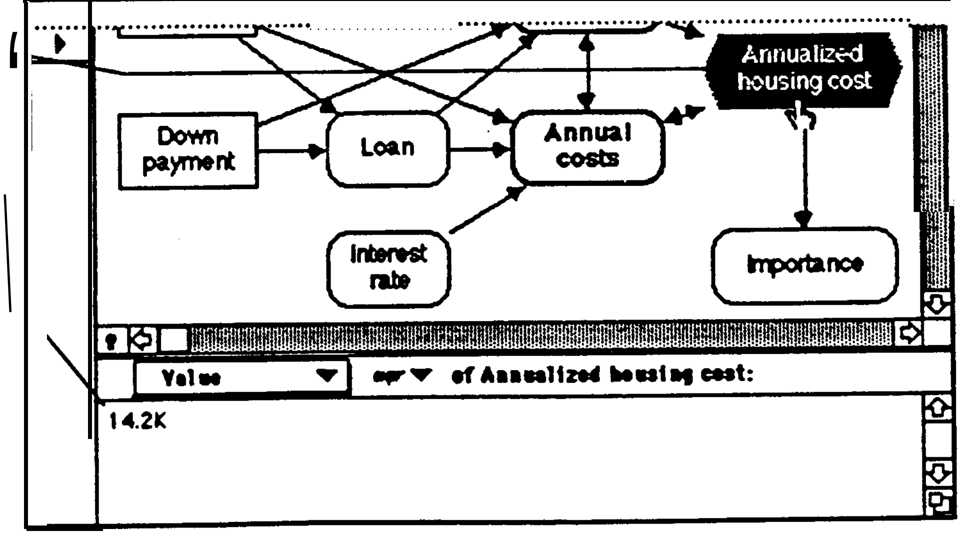
1 Press on the attribute popup menu and select Value.



You will see the value of Loan here (actually the mid or deterministic value).



2 Click on the Annualized housing cost node to select it.



Demoswilltakeamoment to compute the value. Then, you will see the mid value of Annualized housing cost. In this way, youcanlookatthemid value of any variable in the model.

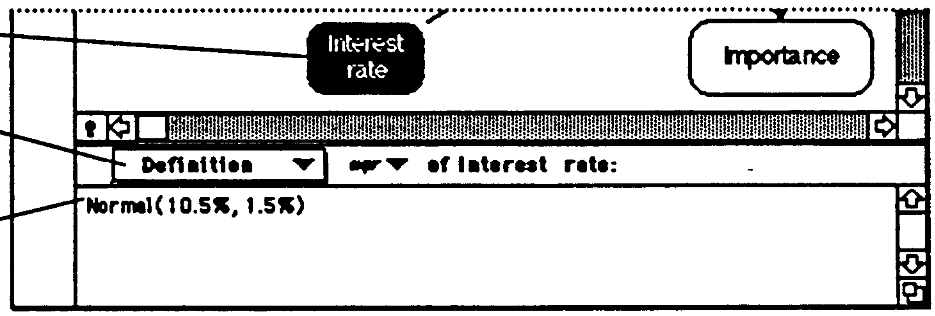
Displaying an uncertain value

You can display the value of a variable in several different ways, some numerical and some graphical. Even if the variable is **uncertain,** you can display its mid **(deterministic)** value. The mid value is computed assuming all **uncertain** variables are fixed at their medians. It is much quicker to compute **than a full probabilistic value, and so it is useful for initial checks of the model. Demos** offers a wide variety of views to display the **uncertainty** in a variable, including selected statistics, probabiity bands, a graph of the probability density function or the cumulative distribution function, or even the table of random numbers from which the distribution is estimated. **Here** you will **use** several of these views for a variable defined as a normal probability distribution.

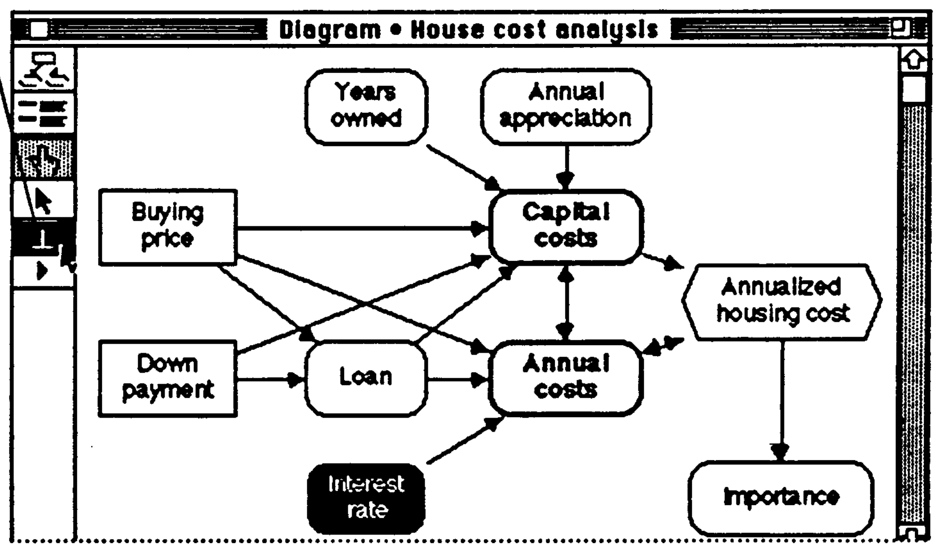
1 Click on the Interest rate node to select it.

2 Change the attribute to view its Definition.

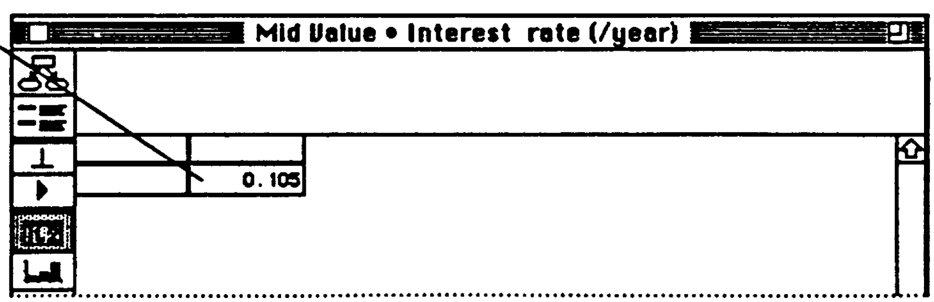
The definition is a Normal distribution, with a mean value of **10.5%,** and a standard deviation of 15%.



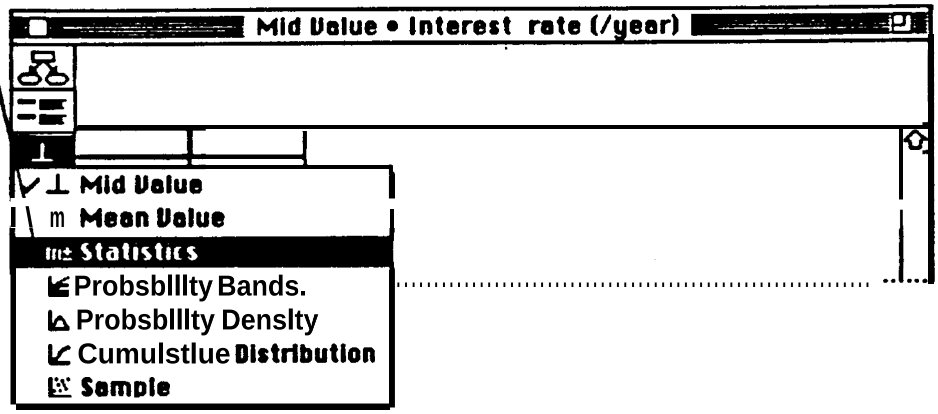
3 **This** icon represents mid **(deterministic)** value **It** is the **current** option for displaying the value of the **selected** variable. **Click** on it to display the mid **value.**



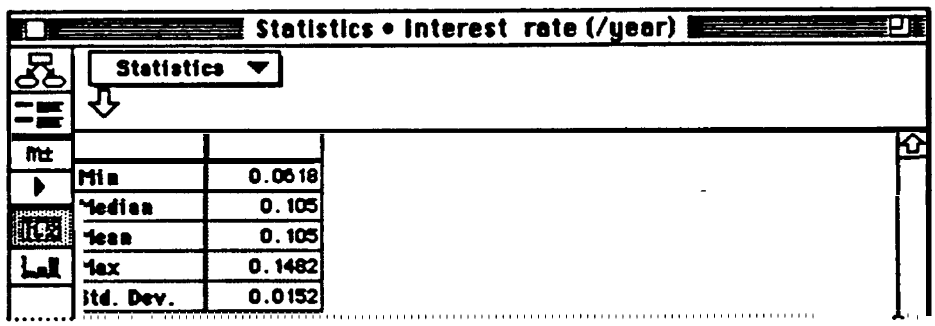
This window appears with **the** mid value shown The mid **value** of a normal distribution is its median whichisthesameasits **mean,** 0.105, or 105%.



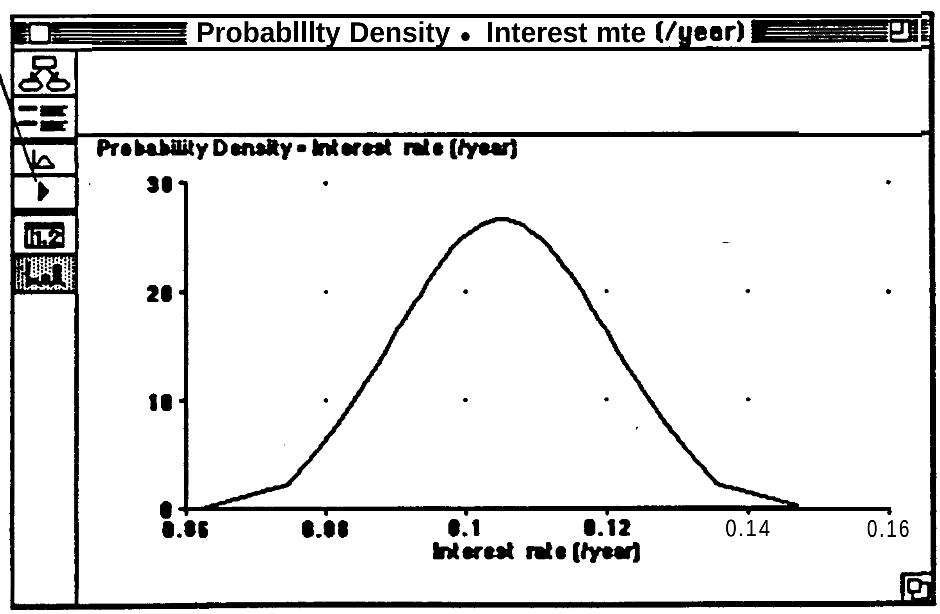
4 **Press on the uncertainty** view selector **popup menu to view the uncertainty** view options, drag the **mouse** to **Statistics**, and release.



Shown are the minimum, **median, mean, maximum** and standard deviation. **They are not exact, since** they are estimated from a sample of values from the distribution. Using Latin **Hypercube sampling, the median and mean are very** close to the true value 0.105. For a **normal** distribution, the true minimum **and maximum is minus** and plus infinity. Demos truncates the distribution at minus and plus 3 standard deviations from the mean.



5 **Use the uncertainty** *view* selector **popup** menu to **change the** current option to Probability Density.

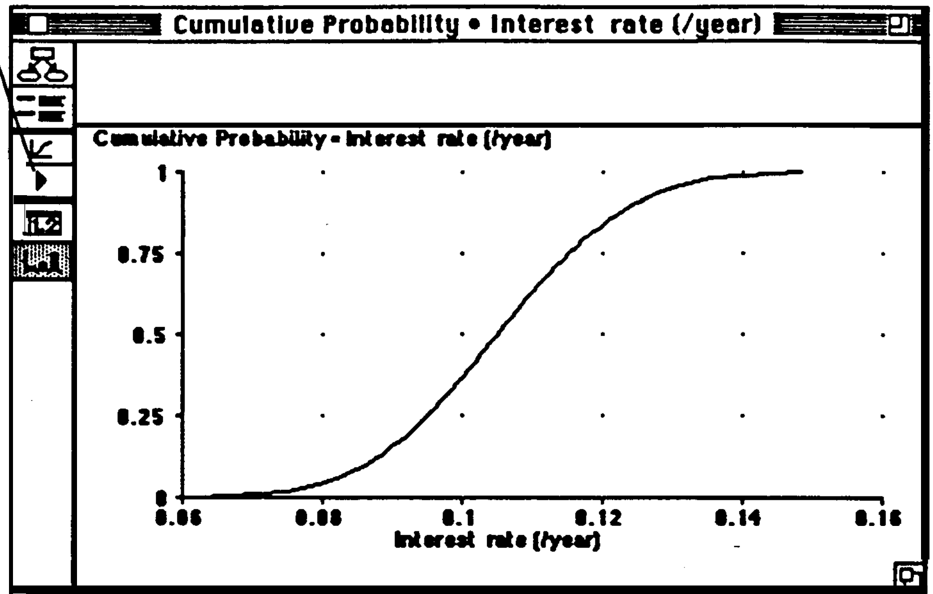


The height of the **curve** at a given value along the horizontal axis denotes the relative probability that the variable has that value. The **units of the vertical scale are chosen so that the total area under the curve is 1.**

A **Note**: the window changes from showing a table to a graph, because the probability density cannot be shown numerically (currently).

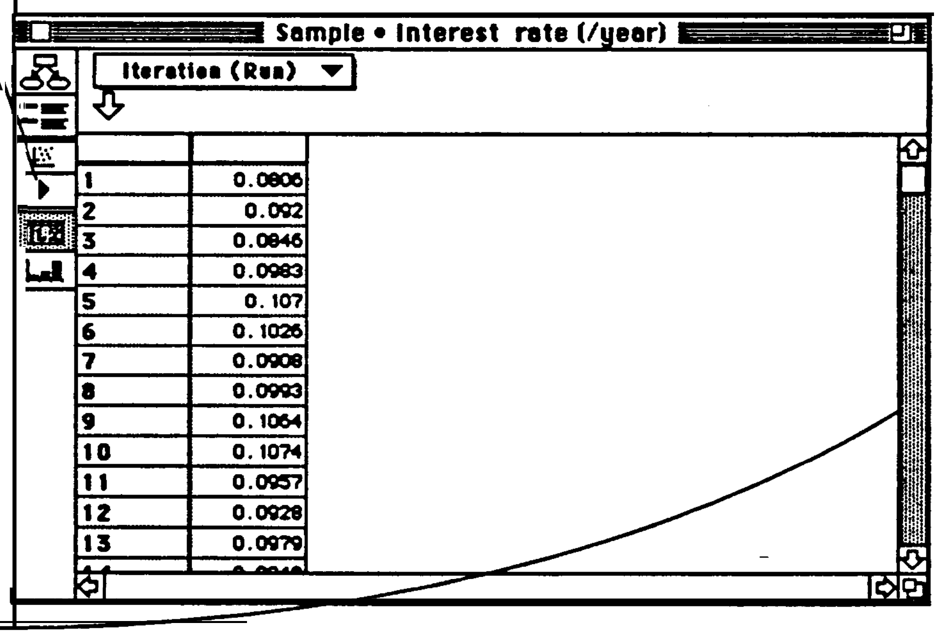
6 Use the uncertainty view selector popup menu to change the view to Cumulative probability.

This the cumulative probability of the specified Normal distributions This curve gives the probability–on the vertical axis–that the Interest rate is less than any given value along the horizontal axis.



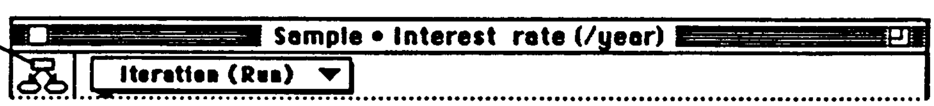
7 Use the uncertainty view selector popup menu to change the view to Sample.

This table lists the 100 sample values which Demos generated at random from the true distribution to estimate the statistics and probability distributions. If you need more precise estimates, you can increase the sample size (see the Quick Reference on how to do this), but a sample size of 100 is fine for this tutorial.



8 To see more values, you can scroll the table by using the scroll bar.

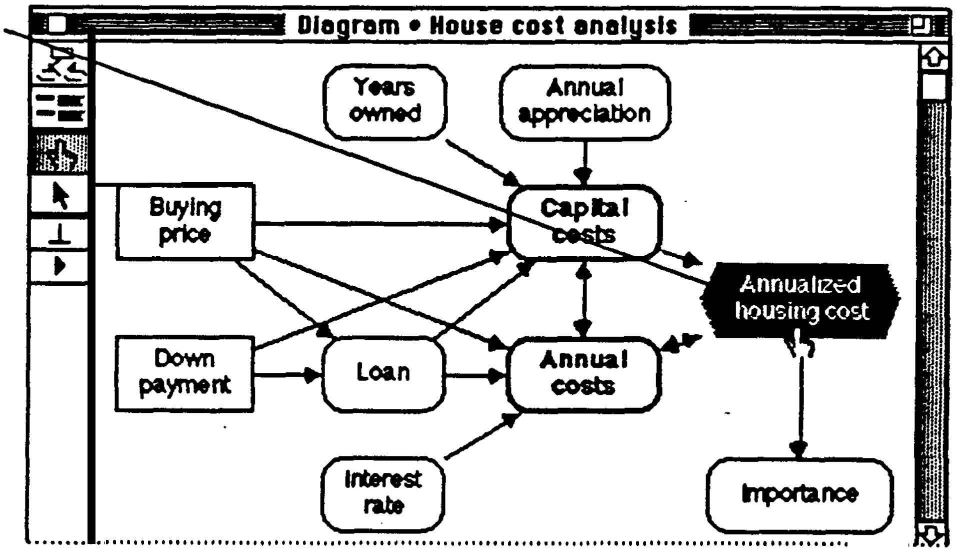
9 Click on the Diagram icon to return to the diagram window.



Displaying uncertain results

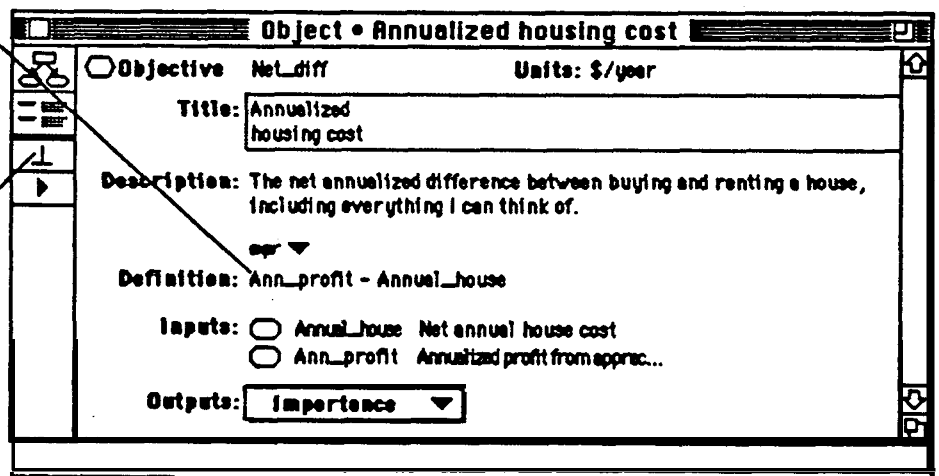
'The Interest rate you just **examined** was an input variable to the model. You **can** use similar methods to look at the probability distribution for an output of **the model–in this case, the Annualized housing cost.** Youcandisplaythevalue of a **variable either** from the Diagram view, as we just did, or from **its** object **window, as we will do here.**

1 **Double-click on the Annualized housing cost node to open its object window.**

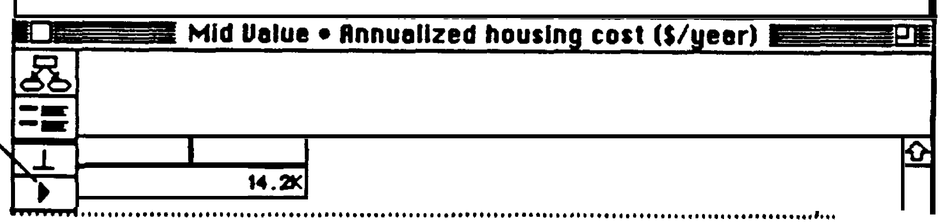


The definition is an **expression. Inputs to the model like Loan are uncertain, and so its value** will be probabilistic.

2 **Click on the mid value uncertainty view selector to view the Mid value.**



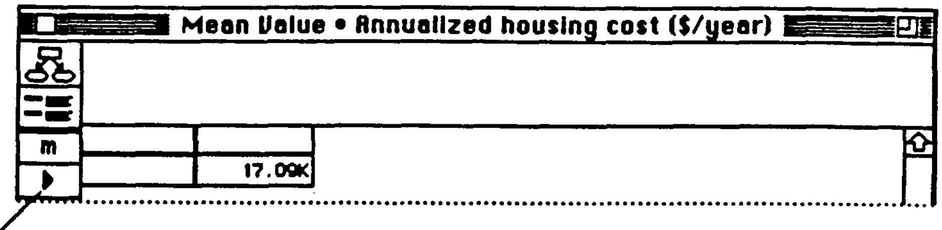
This window appears with the mid value shown.



3 **Use the uncertainty** view selector **popup** menu to Change the **current** option to Mean Value.

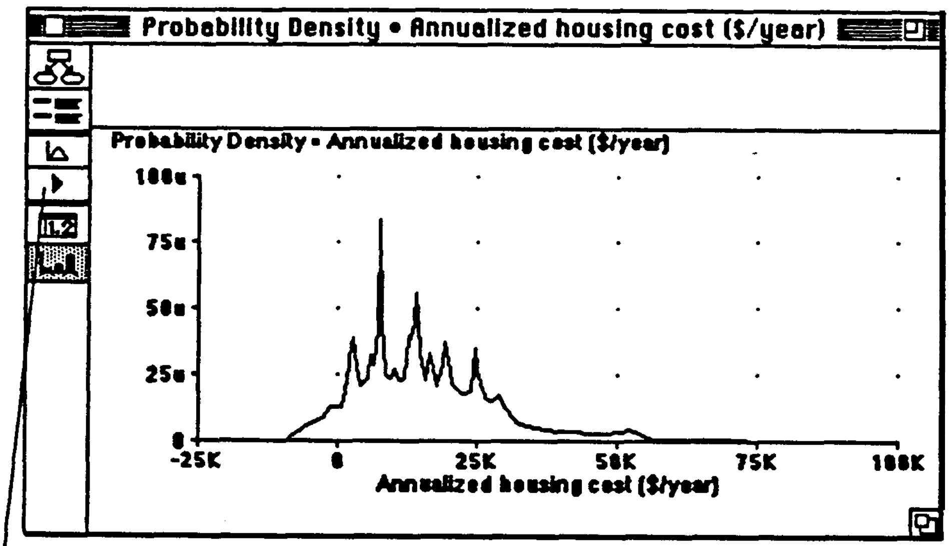
Demos will take a few moments to compute the **mean, since this requires** probabilistic evaluation of **the entire model.**

Note that the mean value of **17.09K is different from the** mid value of **14.2K.** This is **because the mean is esti-** mated **from** the entire distribution.



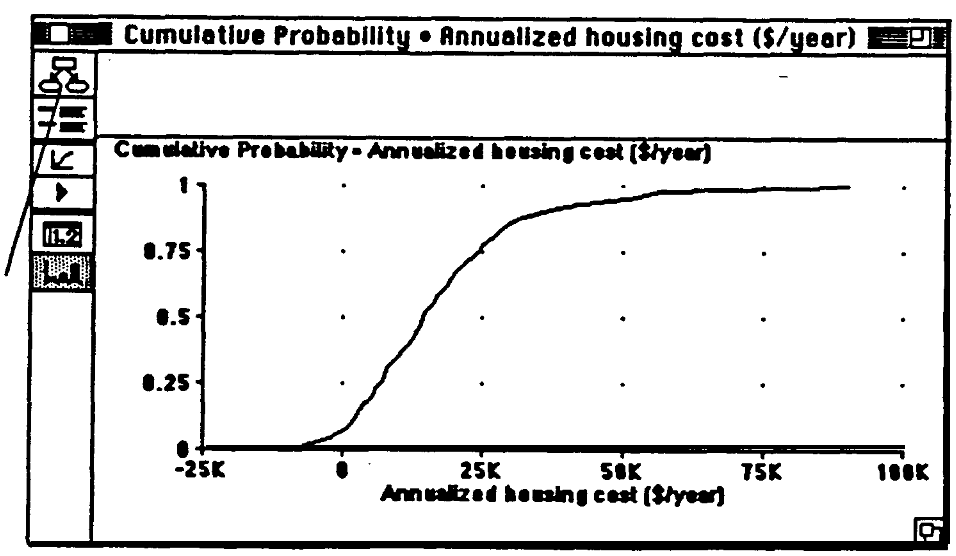
4 Use the uncertainty view selector popup menu to change the current option to Probability Density.

The probability density is displayed fairly quickly. Demos **already** computed the probabilistic value of the variable to estimate the mean. Since it keeps intermediate results, it does not **need to recompute it to** generate the probability density. The graph appears **"noisy"** because we are using a sample **size** of 100. Using a larger sample size would **produce** a smoother curve, but it would take longer to compute.



5 Use the uncertainty view selector popup menu to change the current option to Cumulative probability.

Thecumulatiwprobability distribution looks a lot **smoother** than thedensity **function because it is the** integral of the density.

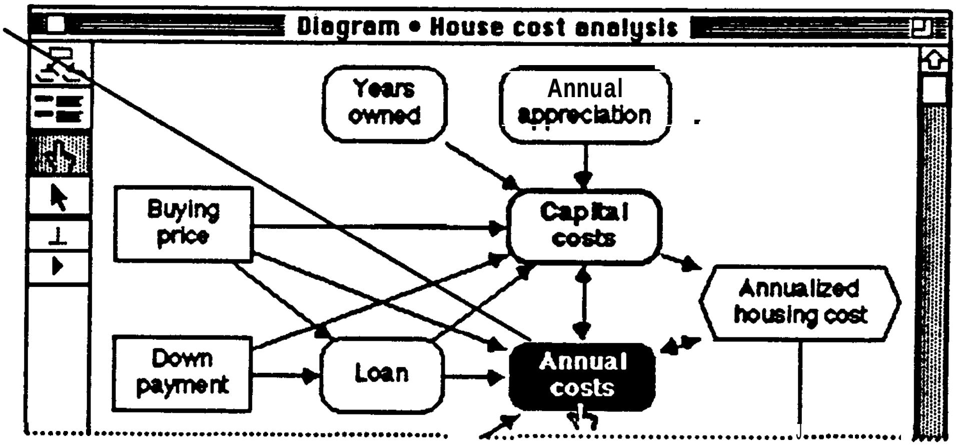


6 Click on the diagram icon to return to the diagram window.

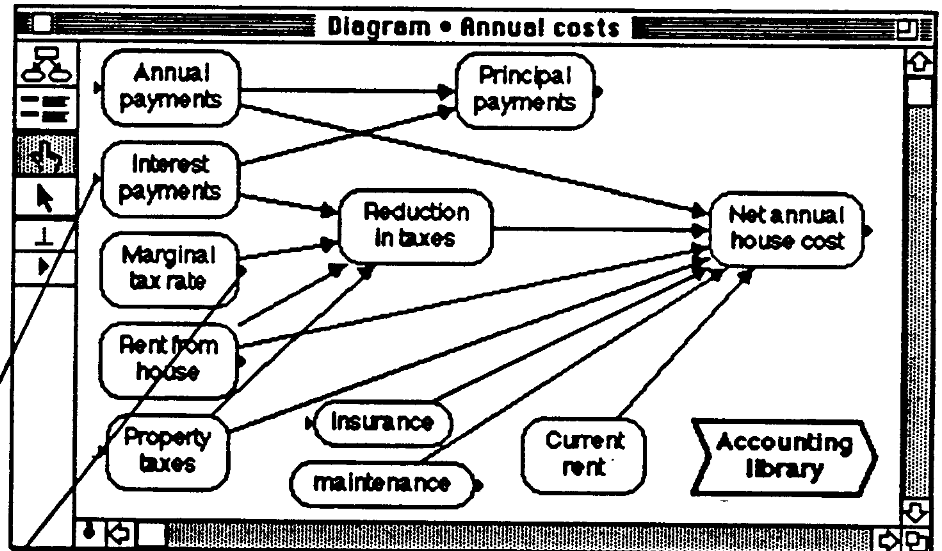
Opening a submodel

Demos models generally contain submodels. Each submodel contains the details of a part of the model, also represented as an influence diagram. In the house example, the capital costs (costs associated with buying and selling the house) and the annual costs (costs associated with owning and maintaining the house) are each in their own submodel. Submodels can also contain submodels. In this way, a large model with hundreds of variables can be organized into a hierarchy of models, each small enough to be comprehensible.

1 To open the submodel, Annual Costs, double-click on the node.



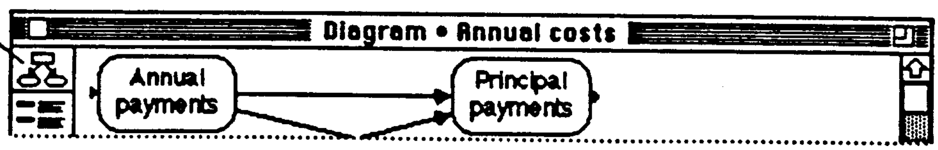
This shows the influence diagram of the Annual costs submodel. This model computes the net annual housing cost, including the principal and interest payments on the mortgage, the reduction in taxes, property taxes, insurance, maintenance, and current rent.



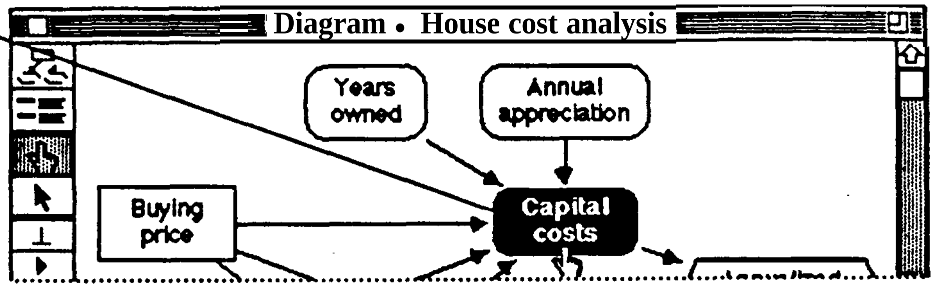
This input arrow head shows that this node has one or more inputs from outside this model.

This output arrow head shows that this node has one or more outputs outside this model.

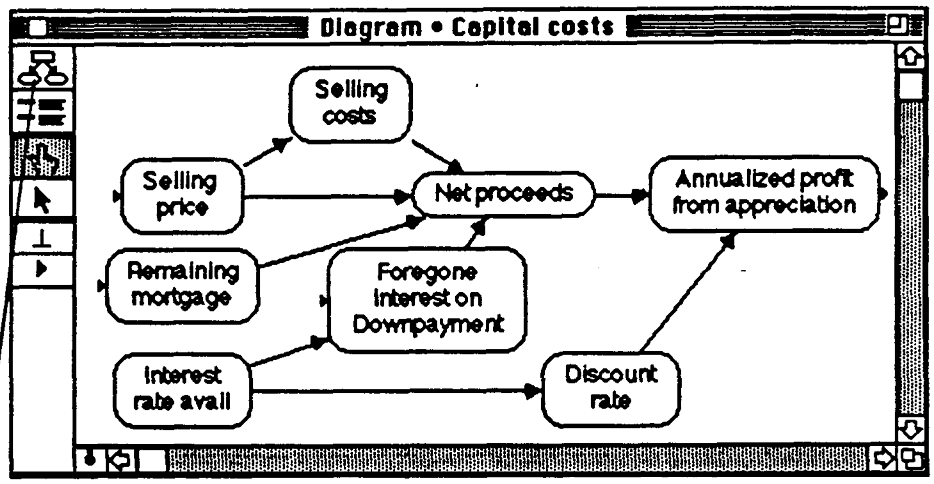
2 Click on the diagram icon to return to the parent diagram, House cost analysis.



3 To open the submodel, **Capital costs, double-click on the node.**

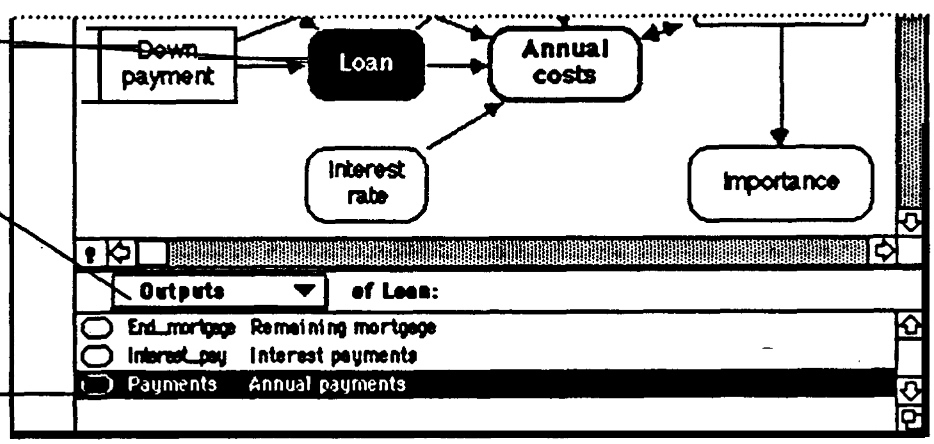


The diagram window for Capital **costs appears** and **replaces** the **Annual costs** diagram. **Demos conserves** the number of windows at each level of the model **hierarchy** to minimize clutter on your desktop. **See the Quick Reference for** tips on how to open more than one **submodel** diagram window at a time.



4 Click on the diagram icon to return to the parent model, House cost analysis.

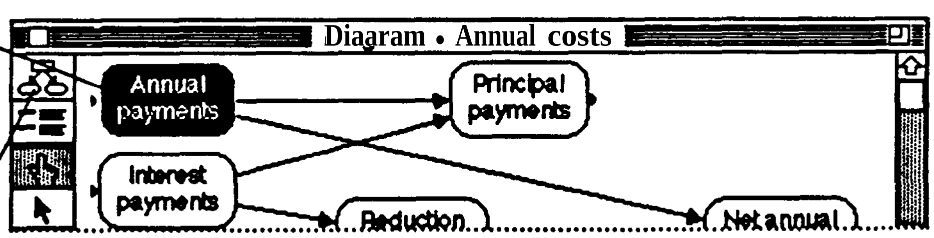
5 **Click on the Loan node to** select it.



6 **Select Outputs** from the attribute **popup** to view a **list** of the **outputs to Loan.**

7 **Double-click** on Annual **payments.**

The Annual costs model diagram is brought **frontmost, and the Annual payments node is selected.**



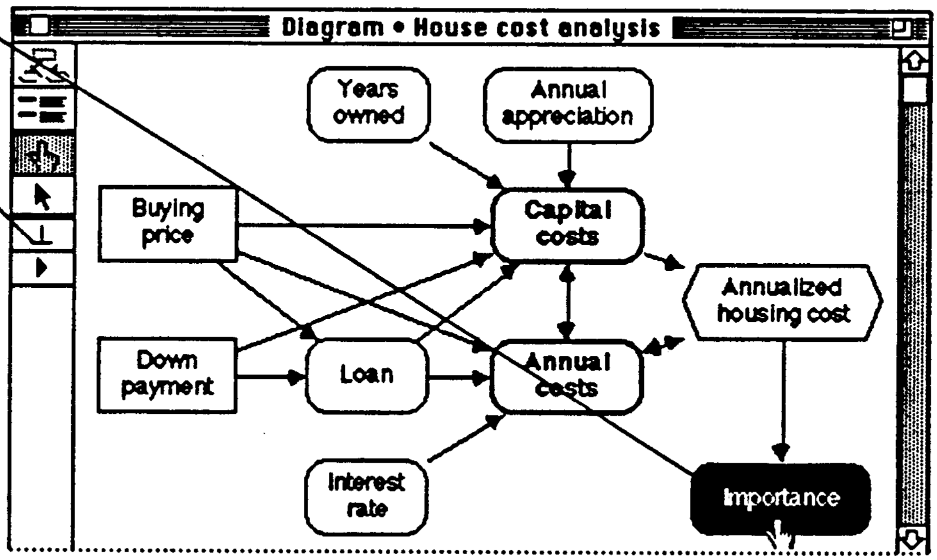
8 **Click on the Diagram icon, to return to the parent** diagram, House **cost** analysis.

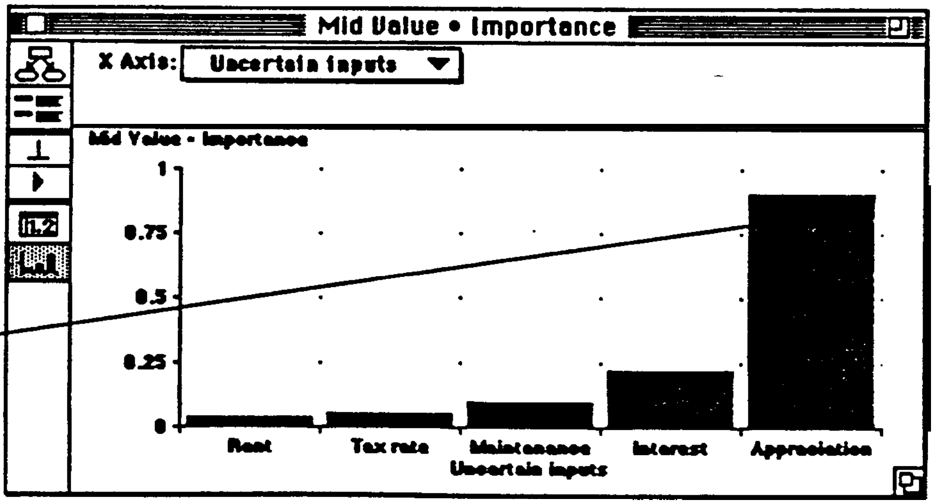
Importance analysis

In this house model, like most Demos models, many of the input variables are uncertain. It is interesting to know how **much** each of **these uncertain** inputs **contributes** to the **uncertainty** in the output. Typically, a few **uncertain** inputs are responsible for the lion's **share** of the uncertainty in the output, and the rest have **little** impact **This "uncertainty** analysis" or **"importance** analysis" tells you **that,** if you want **to reduce** the **overall uncertainty,** it will be most **effective** to concentrate on getting **better** estimates or building a **more** detailed **model** for those one or two **"important"** inputs, **and** you can ignore the rest. Thus, importance analysis can help you **refine** your model much more **efficiently.** It can also ease your **worries** about those **uncertainties** which tum out not to matter very much-typically, most of them Demos defines "importance" as the rank order **correlation** between the sample of output **values** and the sample for each **uncertain** input. It is a robust measure of the **uncertain contribution because it is** insensitive to extreme **values** and skewed **distributions.** Unlike **commonly** used deterministic measures of sensitivity, it averages over the entire joint probability distribution. So it **works** well even for models where the sensitivity to one input depends strongly on the value of **another.**

1 Click on the Importance node to select it.

2 Click on the mid value uncertainty value selector to view the importance.





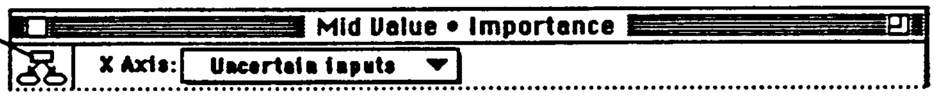
Importance is on a relative scale from 0 to 1. 0 implies **no effect of the uncertain** input 1 implies total **correlation,** so that **all** of the **uncertainty** is due to this input.

It is clear here that the input Appreciation **is** contributing the lion's share **of the uncertainty in the** Annualized **housing cost.**

Parametric analysis

Parametric analysis means varying the value of an input variable to examine its **effect** on a **selected** output. It often gives **useful** insights into what's important, and how **a model behaves. Because the importance analysis revealed** that **the** Appreciation contributes much of the **uncertainty** in Annualized housing cost, we will start the **parametric** analysis with that input variable. We will change its definition from a probabiity distribution to **a** list of alternative values. Demos will then graph the **corresponding values** of the output.

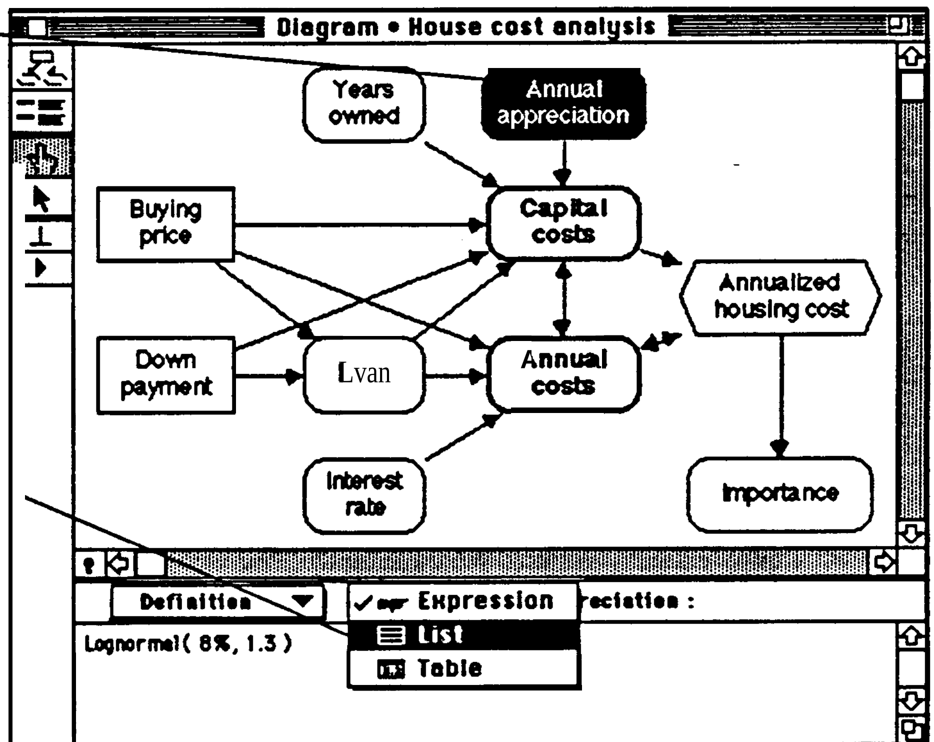
1 Click on the Diagram icon to return to the diagram window.



2 Click on the Annual appreciation node to select it and view its Definition in the attribute view.

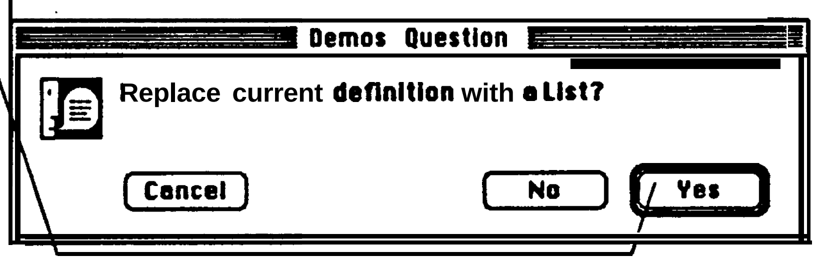
We will now specify Annual appreciation as a **list** of altelnative values, from 0 to 20% **(0.2).**

3 **Press on the expression type popup menu, drag** the **mouse to List, and release.**

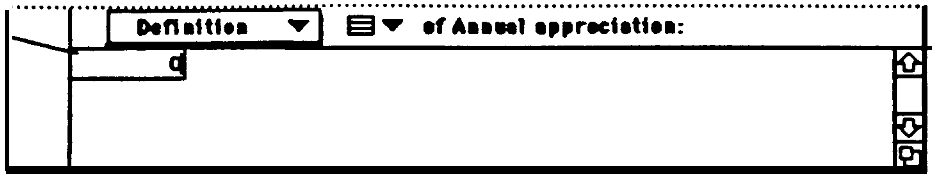


4 Since we want to change the definition from a distribution into a List, we click Yes here.

A **Note: pressing the return key will do the same.**



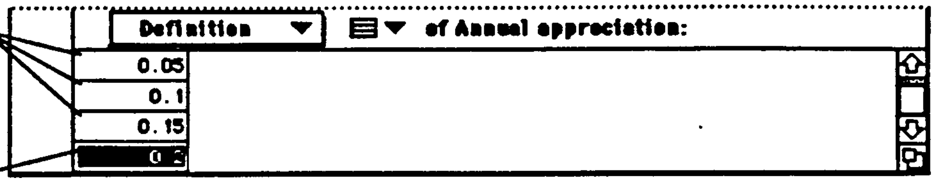
5 Select the cell by clicking in it, type in the number 0, and press the return key.



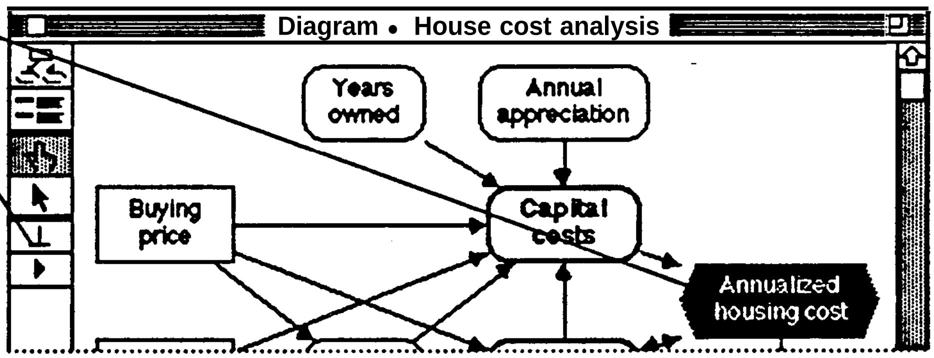
A new cell will appear when you press the return key in the last cell.

6 Repeat the previous step three more times, entering 0.05 (5%), 0.1 (10%), and 0.15 (15%).

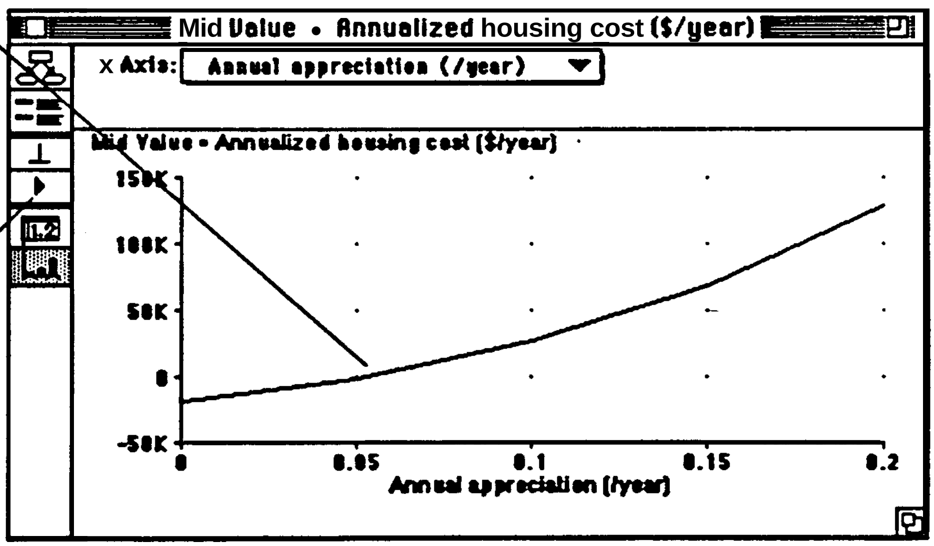
Inthelastcell, type 0.2 (20%) but this time, press the enter key so it won't add an additional cell.



7 Select Annualized housing cost and click on the Mid value uncertainty view option to show the recomputed value.

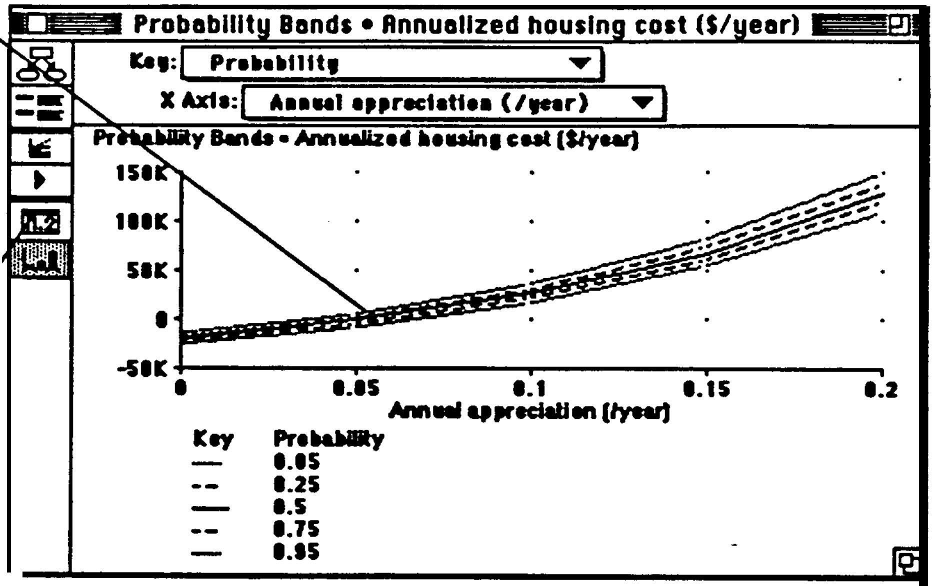


The mid value is no longer asinglenumber! Thereisa computed value for each parameter&d value of Annual appreciation.



8 Use the uncertainty view selector popup menu to view Probability bands.

The break-even point is the Annual appreciation value corresponding to where the probability band of 95% yield!3 an Annualized housing cost of above 0 <S/year), which is at about *8%.*



9 Click on the table icon to view Probability bands as a table of numbers.

Here are the numerical values for the probability bands of housing cost.

Probability Bonds • Annualized housing cost ($/year)

Probability

Annual appreciation (/year)

	0	0.05	0.1	0.15	0.2
0.05	-24.2K	-7320	17.38K	53.26K	109.5K
0.25	-21K	-3773	22.5K	62.1K	121K
0.5	-18.X	-827.5	26.52K	67.79K	128.9K
0.75	-16.6K	2196	30.92K	74.27K	138.8K
0.95	-14.1K	5010.2	35.77K	82.14K	150.5K

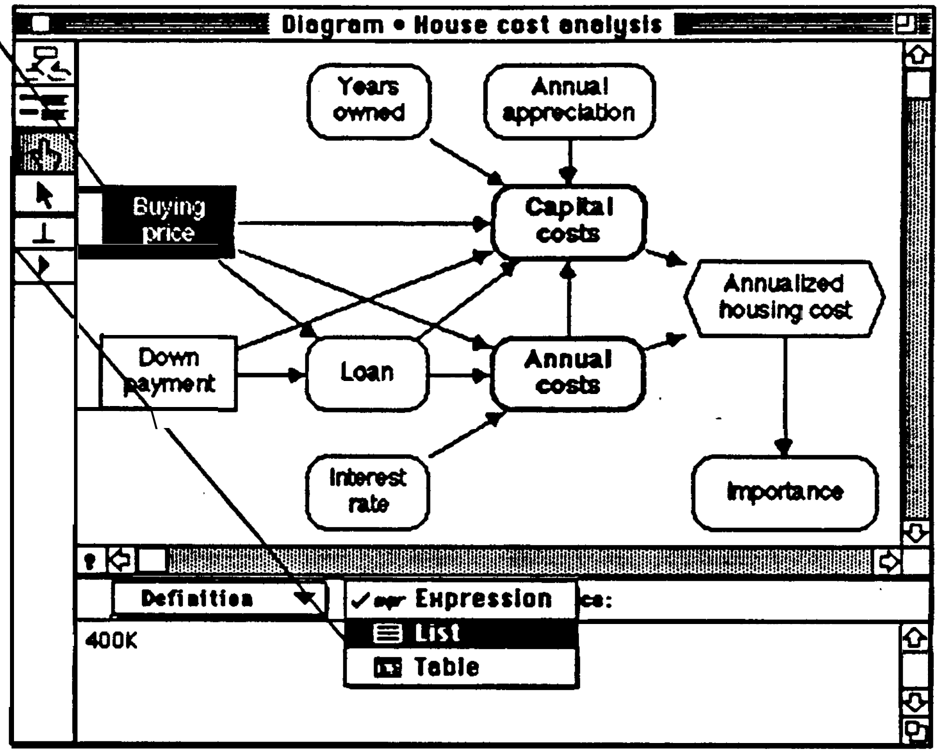
Click on the diagram icon to return to the House diagram window.

Evaluating alternative decisions

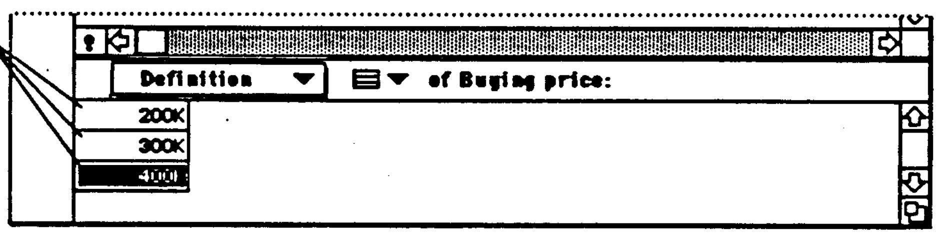
You will learn how to change buying price to view and compare results based on alternative decisions. In doing so, you will learn how to perform **parametric** analysis on two variables, Buying **price and** Annual appreciation, at the same time.

1 **Click on the Buying price** node to **select** it.

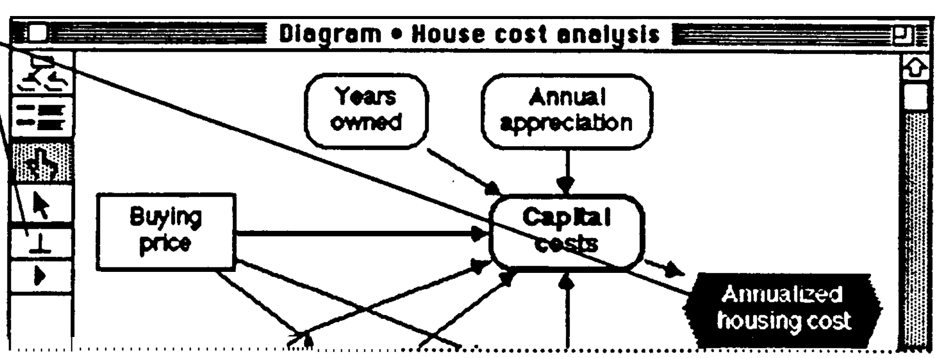
2 **Change its Definition to a List** of values. **Answer Yes** to the dialog that asks if you're sure you want to do this.



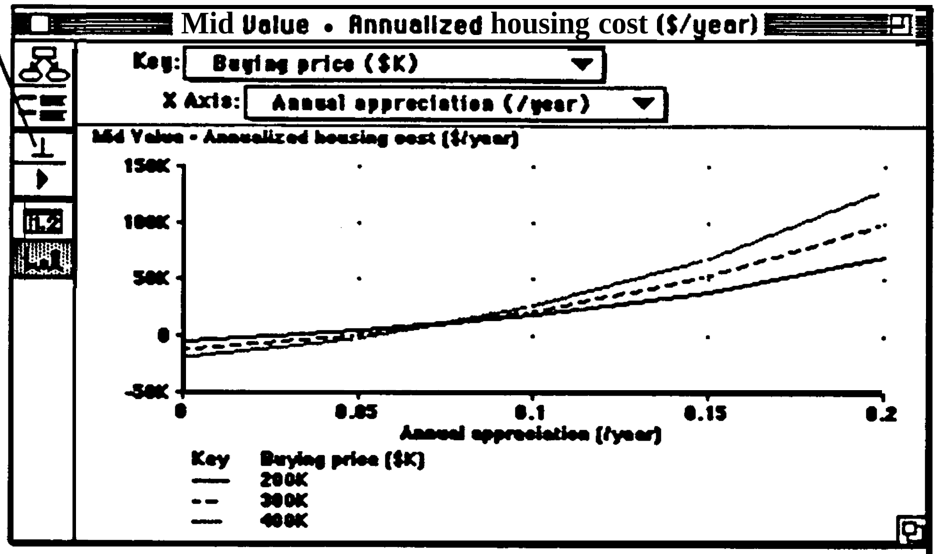
3 **Select the first cell by** clicking in it. Type the first number **200K and** press the return **key.** Type 300K into **the second cell and press** thereturnkey. **Type 400K in the last cell and press the** Enter key.



4 Select Annualized housing **cost and click on the Mid** value uncertainty view selector button to recompute and display its value.

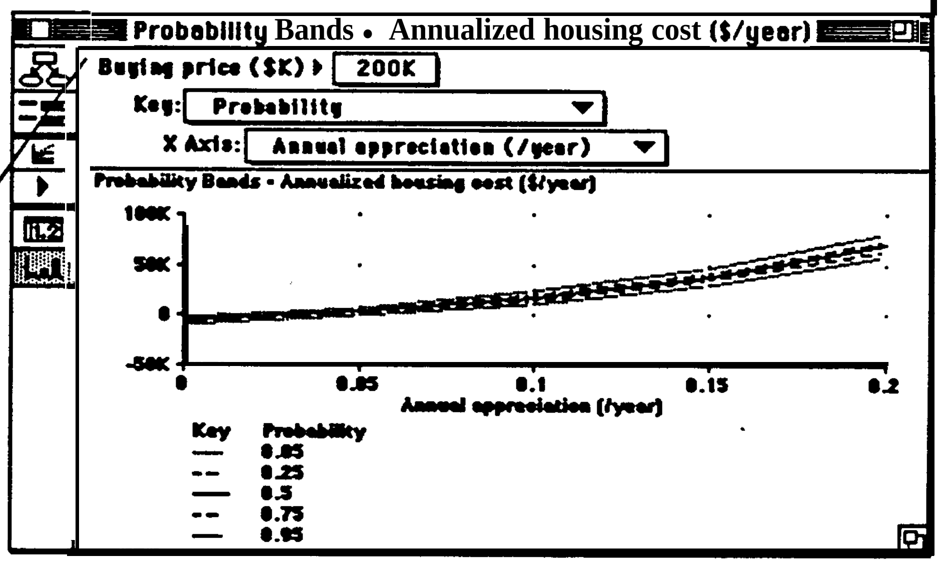


5 Choose probability bands from the uncertainty view selector popup menu.



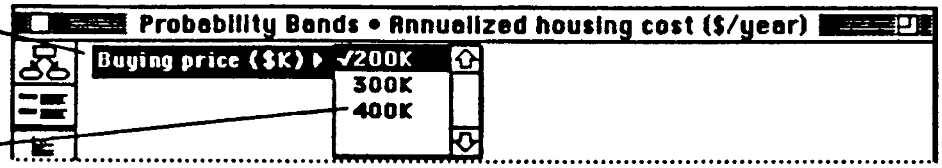
Notice that there are now three dimensions to the result, Probability, Buying price and Annual appreciation.

Because only two dimensions can be shown in the graph, one slice of the third dimension is chosen here.

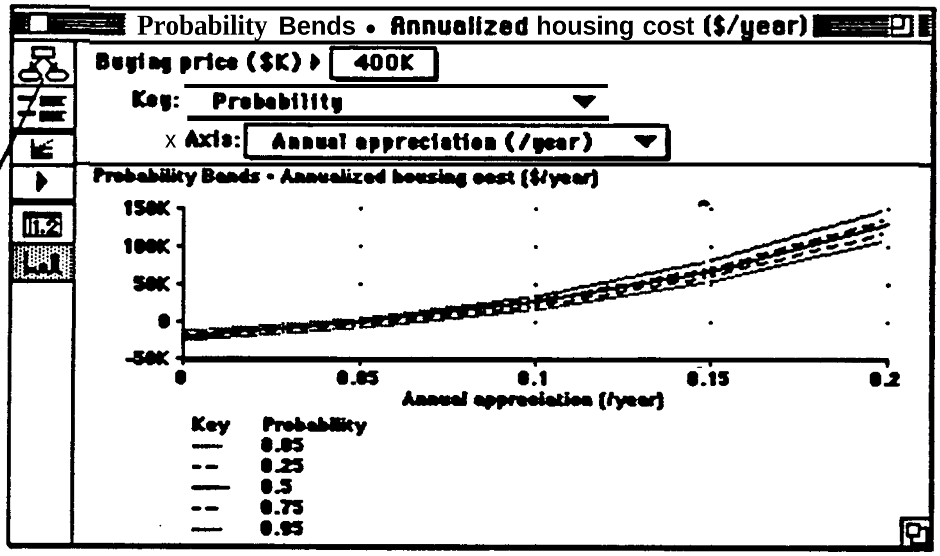


6 Press on this to popup a scrolling list of other values in this dimension.

7 Select 400K by clicking on it once.



The graph changes to show the two dimensions given thethirdindexequalto 400K

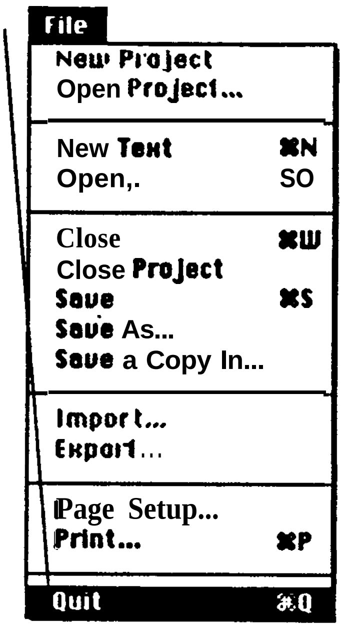


8 Click on the Diagram icon to return to the influence diagram.

Quitting a model without saving

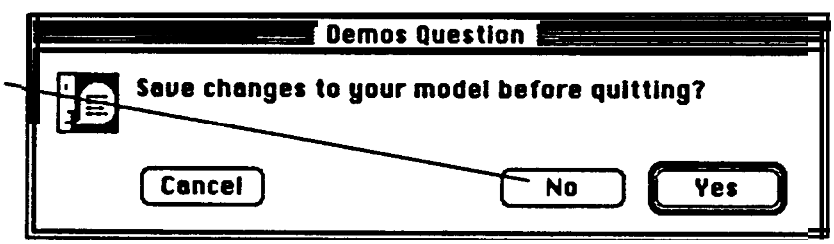
When you have finished examining a model, you may want to quit. It is best to quit without saving changes, unless you meant to edit and save. Here, you will find out how to quit without saving. Later, in the section on creating a new project, you will learn how to save your changes.

1 Select **Quit** from the File menu.



Because you have made changes to the model, Demos will ask if you want to save those changes before quitting.

2 Click on No to indicate that you would like to quit without saving.

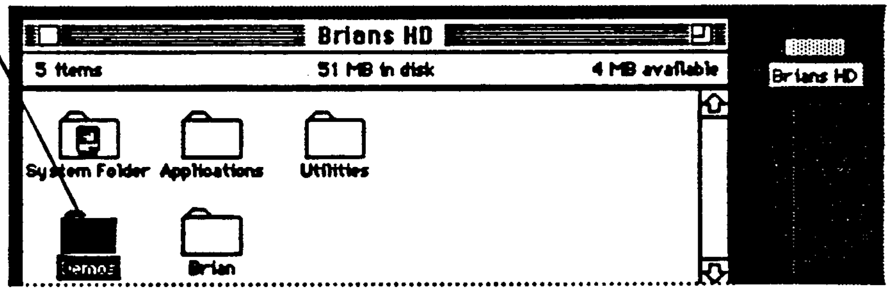


▲ **Note:** The Demos application is now closed. To open it again refer to the beginning of this section. To learn how to create your own model, continue with the tutorial.

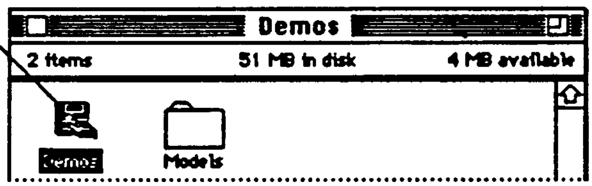
Part 3 Creating a new Demos project

You cm start up Demos in the conventional Macintosh way by double-clicking on the Demos icon. You can then open an existing project or create a new one, as described here.

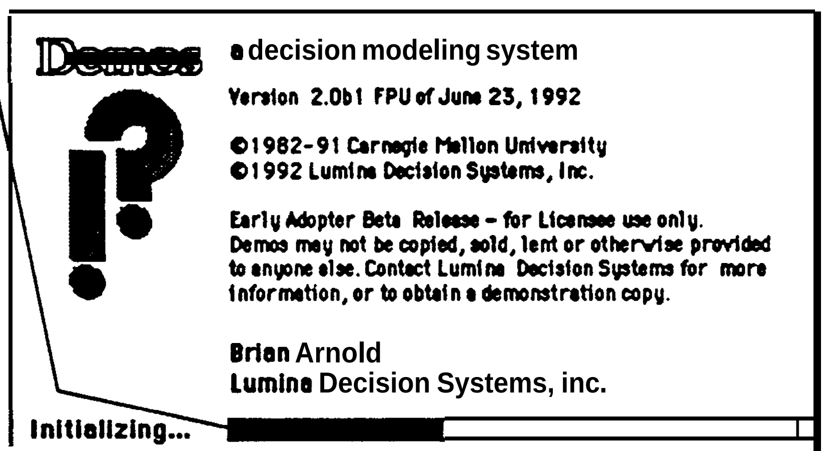
1 Double-click on the Demos folder, to open it up.



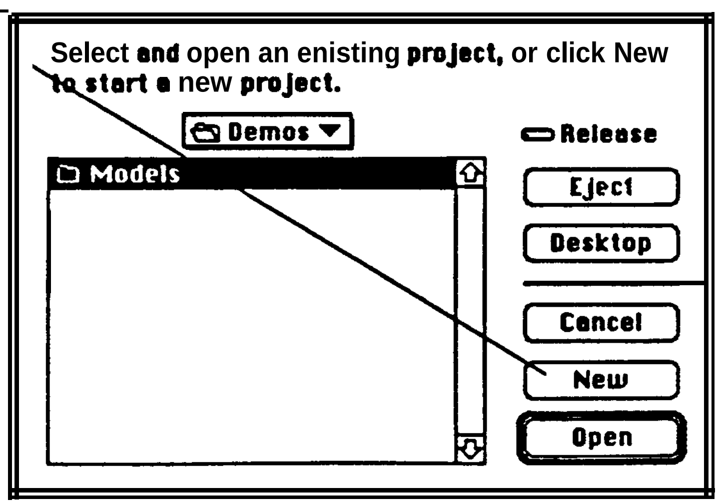
2 Double-click on the Demos icon, to start up Demos.



The Demos start-up graphic will then appear, withabarshowingits progress at initialization.



Click here to create a new project.



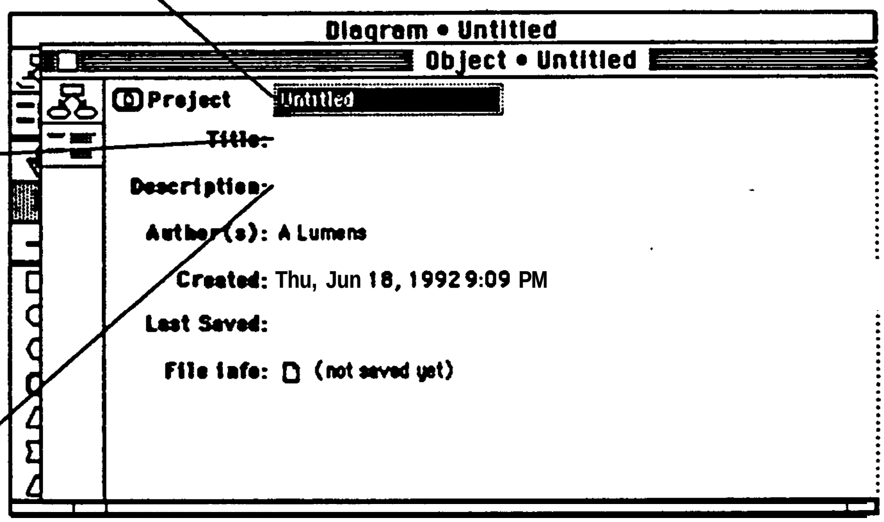
Documenting the Model

This object window appears after starting a new project. A project consists of one or more models. The project itself is the main model. It will contain text attriites, including name, title, description and author. These attributes will identify and describe the Model.

1 Type "Carcosts" in the box tonameyourmodel. If you begin typing, the text will automatically appear in the box. The name will hold up to 20 characters. Press the Enter key.

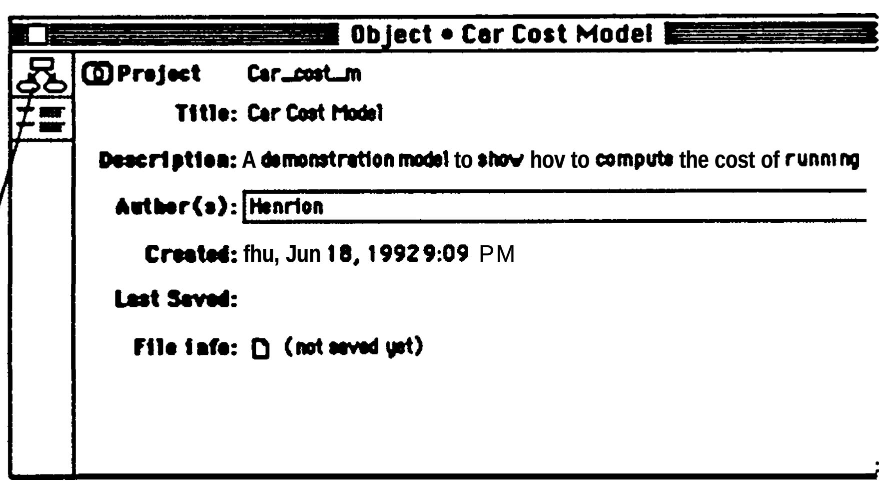
2 Clickheretolabelthetitle more descriptively. Type "Car Cost Model" Press Enter. Demos will accept up to 36 characters on up to 3linesoftext.

3 Clickkretoprovidea description of the model. Type "A demonstration model to show how to compute the cost of running a car." Press Enter. Demos will accept any amount of text for thedescription. Note that pressing Return adds a new line of text.



Repeat this procedure to add your name as author if your computer does not automatically register your name.

4 Click here to tell Demos that you'd like to see this model's diagram.



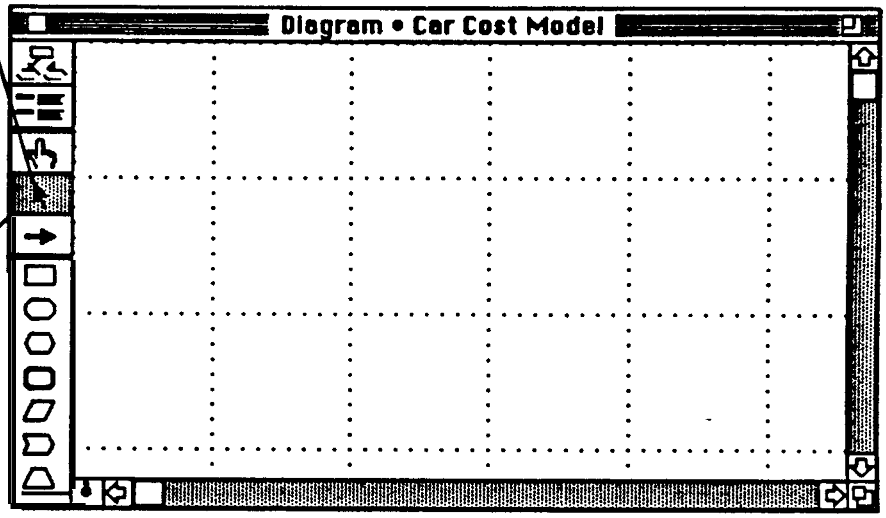
Browsing or editing a diagram

The browse mode is used to view an existing model, without changing it. The edit mode is used in model creation or to change an existing model. Besureto note which mode is activated throughout this tutorial. When a mode is selected, the icon is grayed-out. When you create a new model, its diagram is initially in edit mode.

1 If you did not follow the tutorial from the previous page, select the edit icon by single-clicking here.

Initially, you will see a blank diagram window. This is where you will create an influence diagram showing variables and their dependencies.

You should see the command icons associated with the edit mode. These command icons allow you to create nodes in the diagram and connect them with influence arrows.

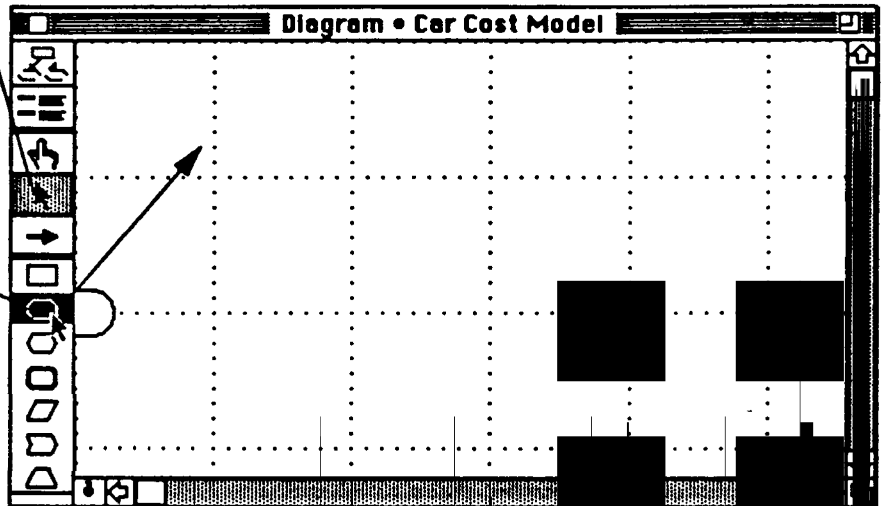


Creating a variable

In this example, you will begin a model of expenses for operating a car for one year. When building a model, it is important to select descriptive titles for your variables. You will start by creating the variable *Fuel Cost.*

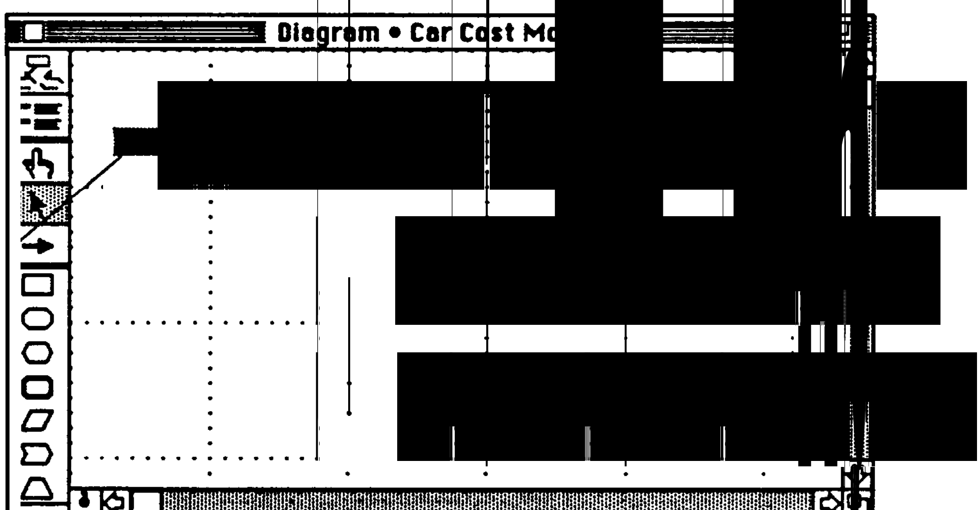
1 Clickheretoselecttheedit kon. If you have continued from the previous page, the icon should already be grayed-out.

2 Click here, on the chance kon, and drag the outline of it to a position on the diagram.



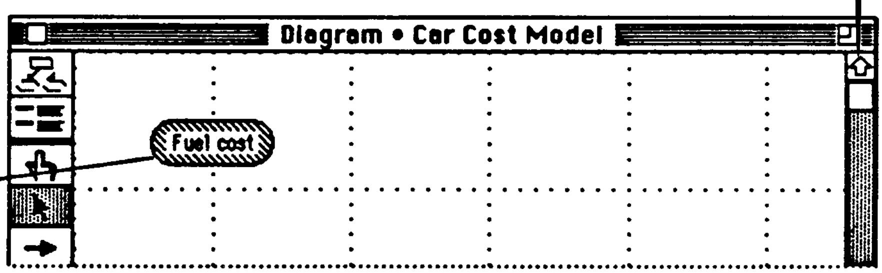
A new chance variable will appear where you release the mouse in the diagram. Its text will automatically be selected for you to specify its title.

3 Type "Fuel Cost" to title the variable. Press Enter or single-click anywhere else withinthediagramto indicate that you have finished the title. (Demos will interpret Return as a newlineinthetitle).



Your diagram should now look like this.

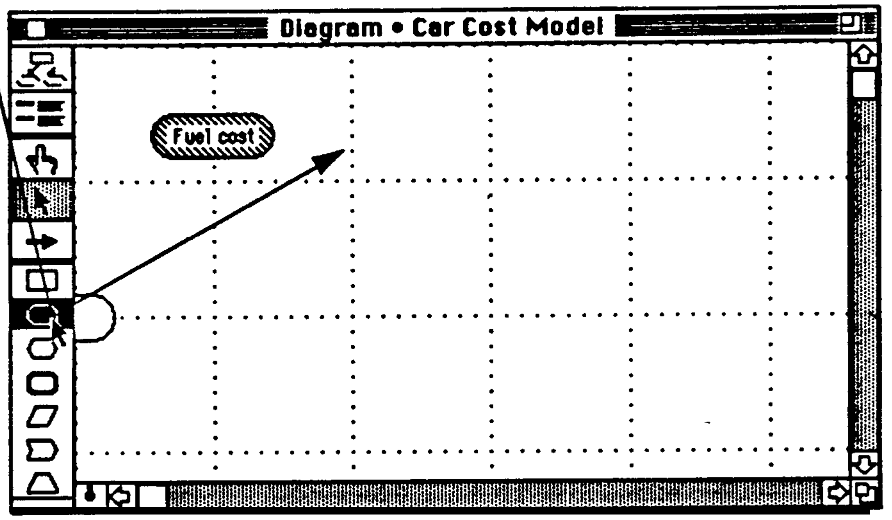
Note that the Fuel cost node is filled with diagonal line pattern around its text. This indicates to you that the its definition has not been explicitly defined yet.



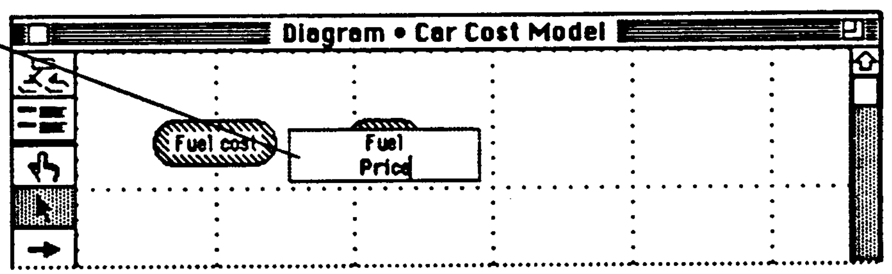
Creating more variables

Repeating the steps from the previous page, you will create four more variables on the diagram. Four variables affect fuel cost. You will also create and title these variables: ***Fuel Price*** (price per gallon of gasoline), ***Annual Miles*** (number of miles driven each year), Age (driver's age), and ***Mpg*** (miles per gallon of gasoline).

1 To make another variable, **single-click on the chance icon again and drag the outline** to a position on the diagram.



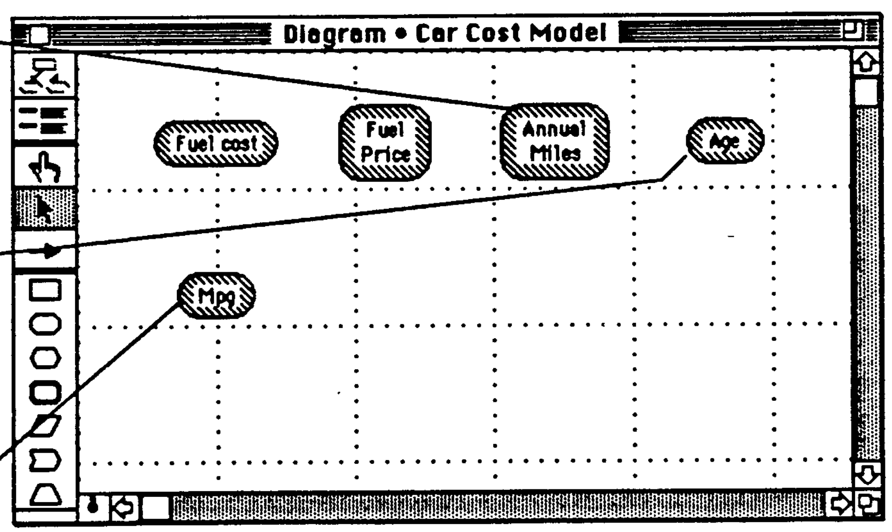
2 Type "Fuel". **Press Return** to enter part of the title on the **second** line. Type **"Price"** to finish the title. **Press** Enter.



3 Clickonthechanceicon again and drag **the** outline to a position on the diagram. Title this variable **"Annual Miles".** Press Enter.

4 Cickonthechanceicon again and drag the outline to a position on the diagram. Title this variable 'Age". Press Enter.

5 **Click on the chance icon again and drag the outline** to a position on the diagram. Title this variable **"Mpg". Press** Enter.

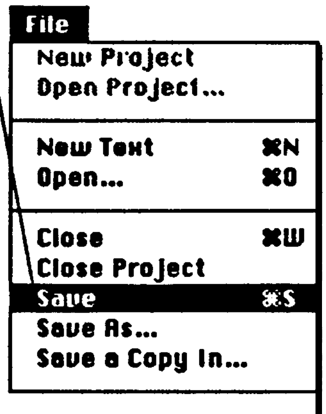


Saving your model without quitting

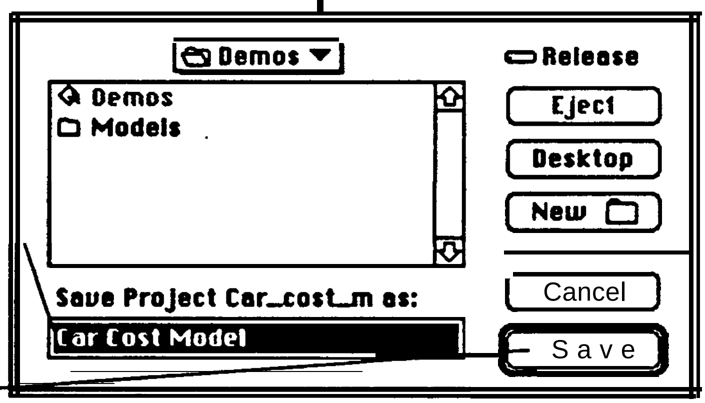
After you have created part or all of a model, you may want to save it. You will learn to save your model without quitting. Saving periodically during model creation is recommended, so you won't lose too much if the program or machine crashes unexpectedly.

1 To save your model, select Save from the File menu.

▲ Note: You can also type ⌘S onthekeyboadasa shortcut.



Demos initially uses the title of your model, Car Cost Model, to name the file. If you want to name it differently, Press the delete key to erase the default title given to the file and type something else.



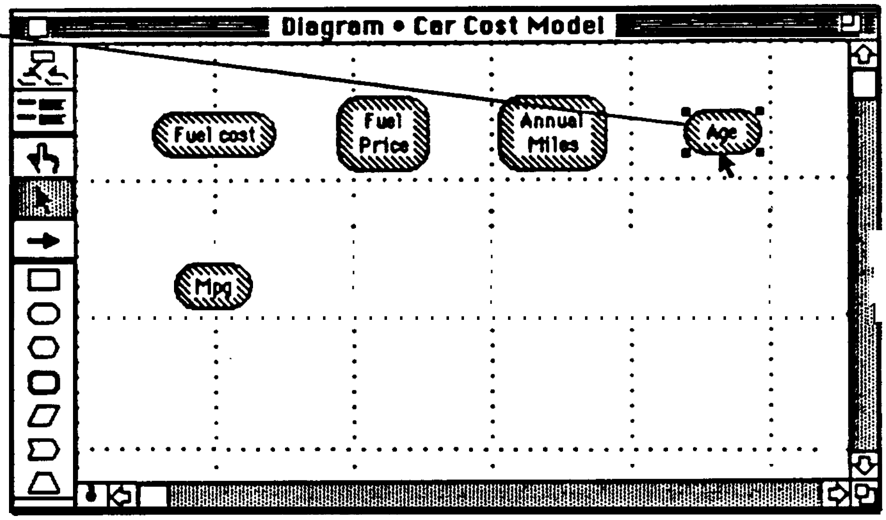
2 Click on the Save button.

Yourrmdelwillnowbe saved in a file called "Car Cost Model".

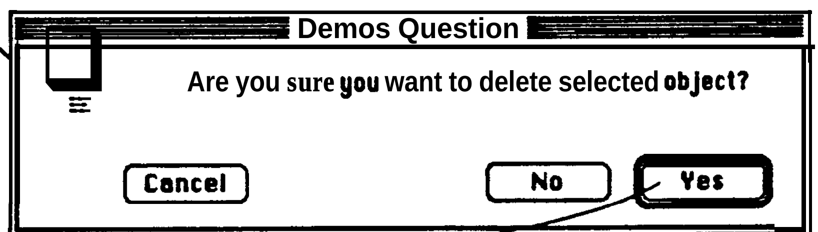
Deleting objects

Sometimes, you will want to delete objects that you had once wanted to include. In this example, you realize that the driver's age is not critical to your understanding of fuelcost. Therefore, you want to delete the *Age* variable.

1 Select the *Age* variable by clicking on the node. Select Delete from the **Object** menu (or press the delete key).



A **Note: Demos cannot undo** a delete command. So, to make sure you want to delete the selected object, it asks you **before continuing.**

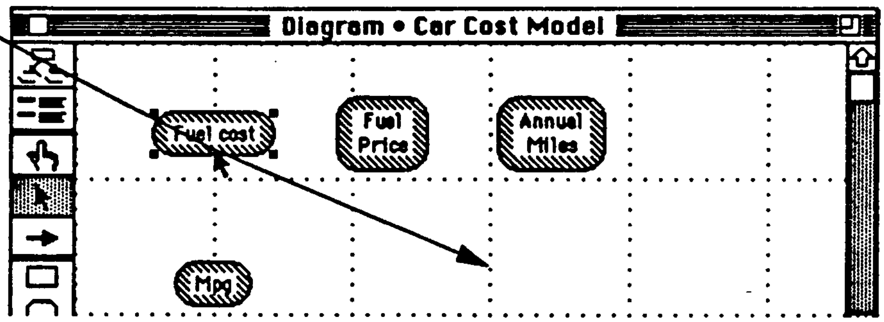


2 Click **Yes** to indicate that you would like to delete theobject.

Selecting and moving object nodes

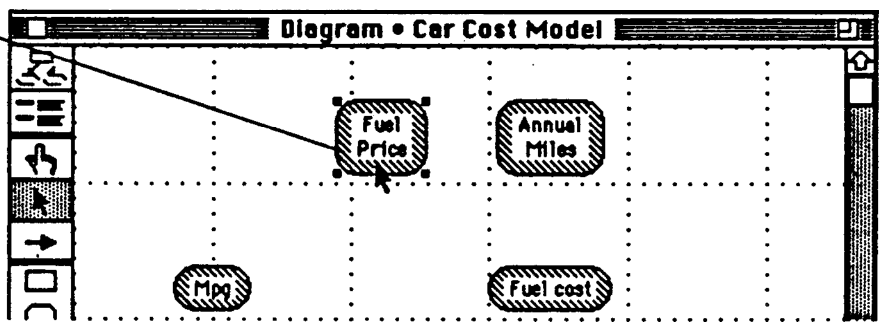
You would like to move the variables so that the three variables contributing to **fuel** cost **surround the Fuel** Cost variable You begin by learning to move a variable node in the diagram. It can be more convenient to apply commands to more than one objj node at **a** time. **Most** commands applied to one selected **node (or** variable) can also be **applied** to other nodes at the same time. You **will learn to select two nodes and move both nodes to another location on the diagram.**

1 **To move *Fuel Cost*, press the mouse on the *Fuel Cost* node and drag it to the** position shown in the second diagram **on this page.**



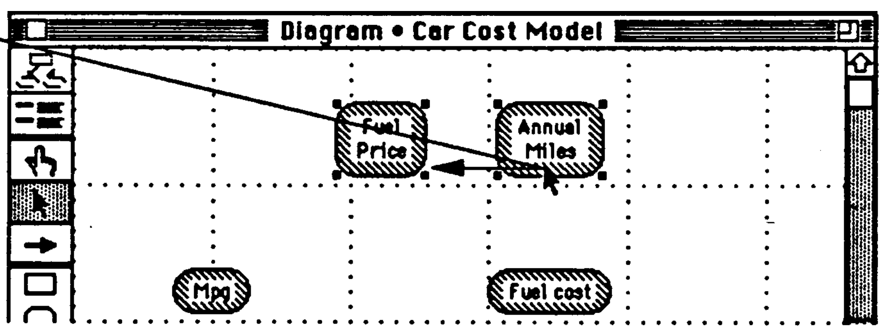
2 **In order to move the *Fuel Price* node and the *Annual Miles* node at the same** time, click on the ***Fuel Price* *node to* select it.**

A Note: Another way to select more than one node **is to drag a box around the** nodes you want to **select.**



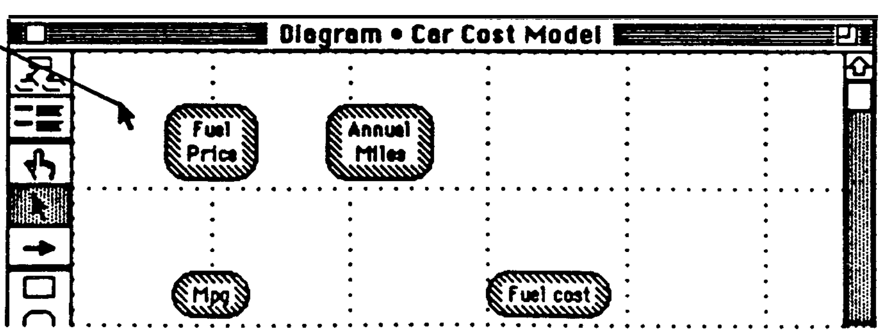
3 Hold the shift key down and simultaneously click on the Annual ***Miles*** node. Now, both nodes are selected.

4 **Press the mouse inside the *Annual miles node*** and drag **the two nodes to the** position noted in the **diagram** below.



5 **Click anywhere else within the diagram to deselect these two nodes.**

A **Note: you can undo or redo a drag operation using Undo/Redo in the Edit menu, or by typing ⌘Z.**



Editing the title of an object

Each object in the model is represented by a node on the diagram. You may decide that you would like to change the title of an object to make the model easier to understand. For example, suppose you want to change the title of the object *Mpg* to *Miles per Gallon.*

1 **Suppose** you would like to **change the title of the *Mpg* object. First, click on the node, to select it. The black squares surrounding the** node indicate that it is selected.

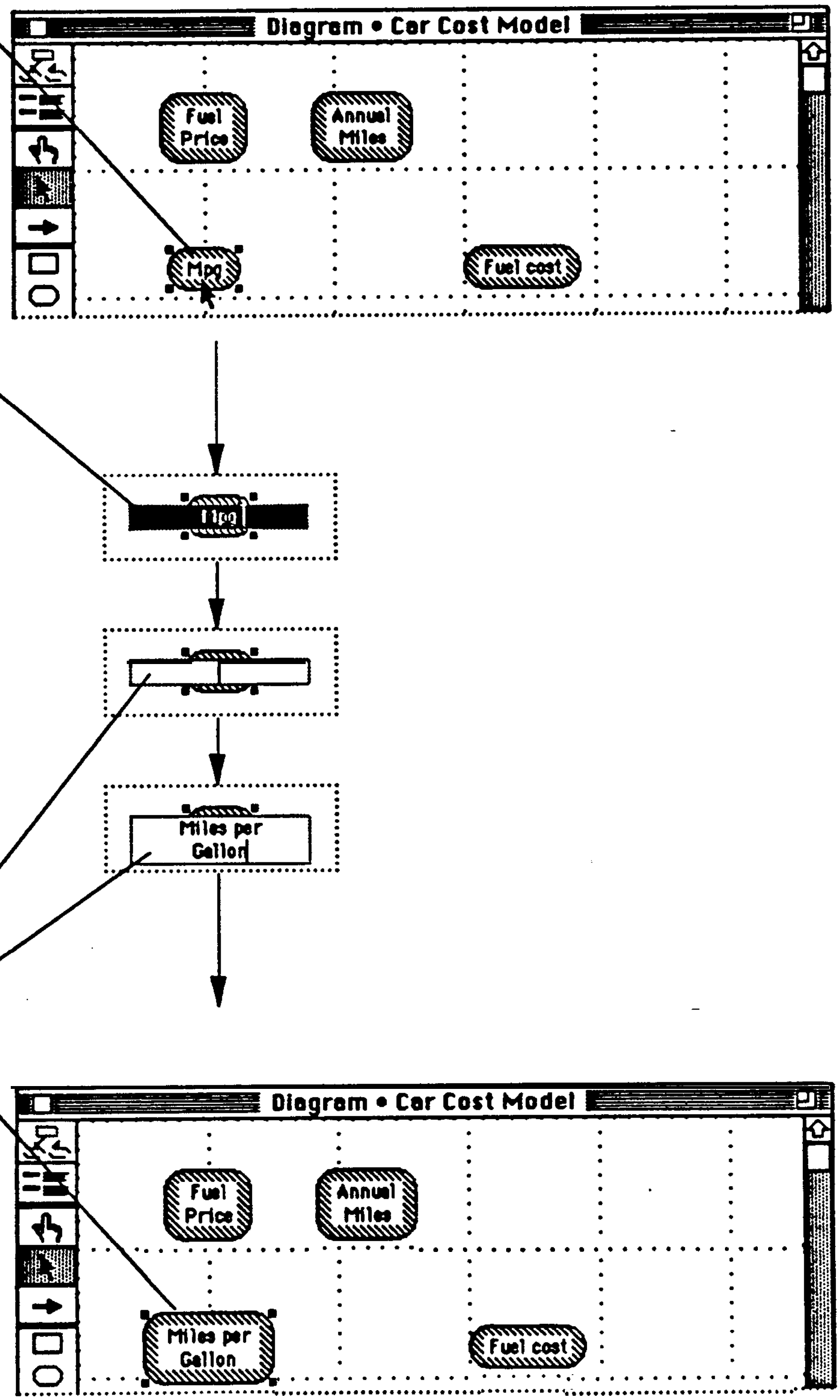
2 **Click again within the title box to select the title for editing.**

▲ Note: **Leave a brief pause between the click to select the node and the click to select the text in it. If you** complete two **single-clicks too quickly, Demos will** interpret it as a **double-**click and an object window **will open. If you** accidentally open the object **window,** simply return to the diagram by clicking on **the diagram** icon.

3 **Press delete to remove the unwanted title.**

4 **Type "Miles per", and the return key, and "Gallon", to retitle the object.**

5 **Press Enter and you should have a newly titled object as shown here.**

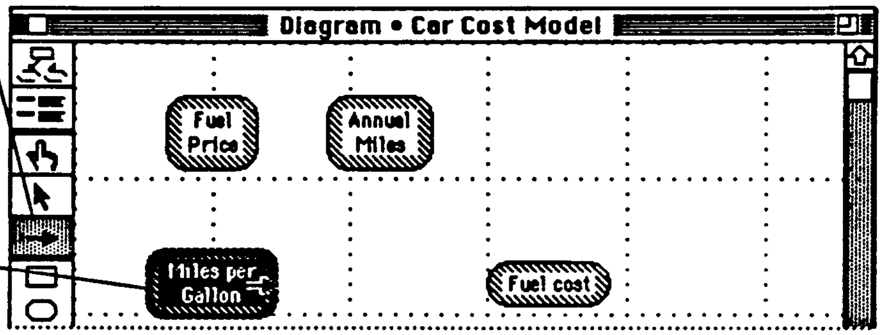


Drawing arrows between nodes

One powerful element of Demos is the ability to show relationships among variables through the **creation** of the **influence** diagram. Arrows are used to **specify the dependencies between and among objects. The** ***Miles per Gallon*** variable influences the ***Fuel Cost*** variable. You will **learn** to draw an arrow from one nude to another.

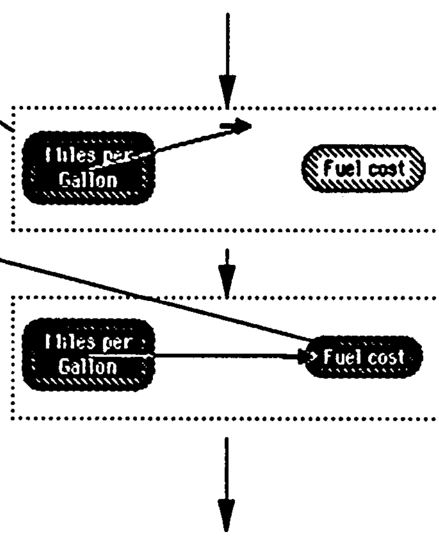
1 In the edit mode, you will notice an influence arrow icon. Click on this icon to begin drawing arrows.

2 **Press down on the** ***Miles per Gallon*** node to highlight it, **if it is not already** highlight&.

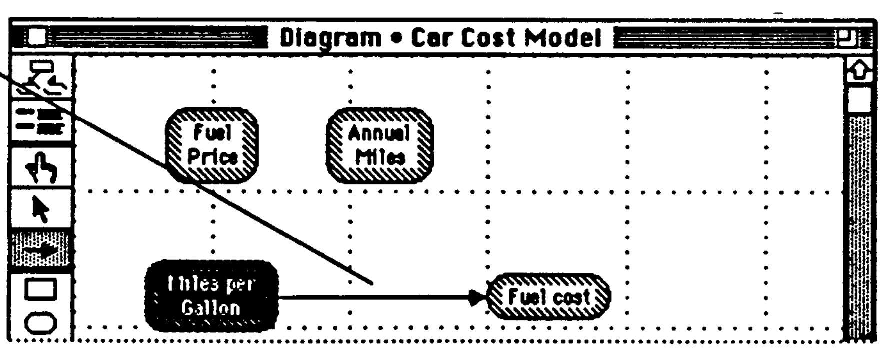


3 Then, drag the arrow from ***Miles per Gallon*** **to** ***Fuel Cost*** **as shown.**

4 **Release the button.**



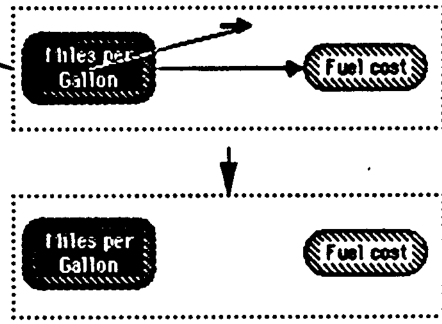
The nodes should now be **connected.**



Deleting arrows and connecting multiple arrows

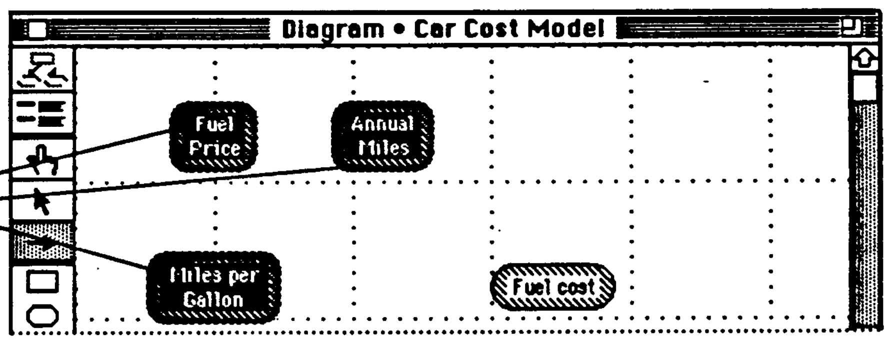
Sometimes, it will be essential to delete an arrow due to a change in your understanding of the model or other factors. In this example, you will delete the arrow connecting Miles per Gallon with Fuel Cost. You will then connect the three variables contributing to Fuel Cost to the Fuel Cost node with arrows.

1 To delete an arrow, repeat the procedure for creating an arrow. Click on *Miles per Gallon*. Drag the arrow from *Miles per Gallon* to *Fuel Cost*.



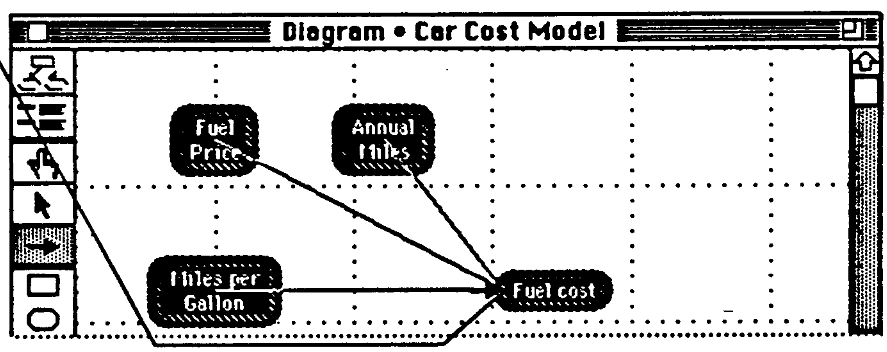
The arrow should disappear.

To draw more than one MOW at a time, you can select more nodes using the shift key.



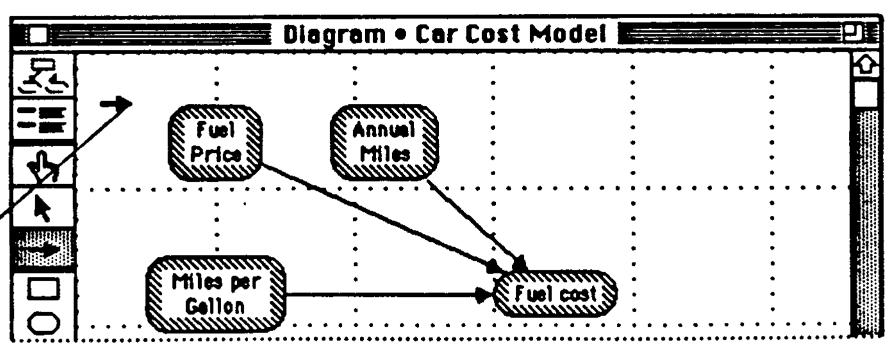
2 Ress down on the shift key and click on *Fuel price*. Similarly, shift-click on *Annual miles*. All three variables shown should now be selected.

3 Press on one of these three selected nodes and drag the arrows to the *Fuel Cost* node.



4 Release the button. You should now see three *arrows pointing to the **Fuel** Cast node.*

5 Click anywhere in the diagram not in a node to deselect all nodes.

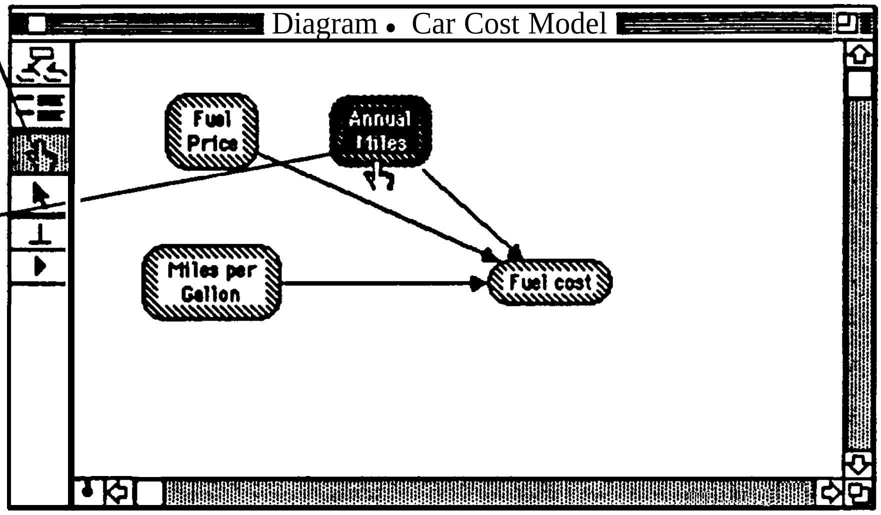


Opening an object window

Each objj has its own objj window containing text attributes describing and defining it. You can open the object window to enter or edit this information.

1 Click on the Browse icon to switch off arrow drawing.

2 To open the object window for the *Annual Miles* variable, **double-click** on its node.



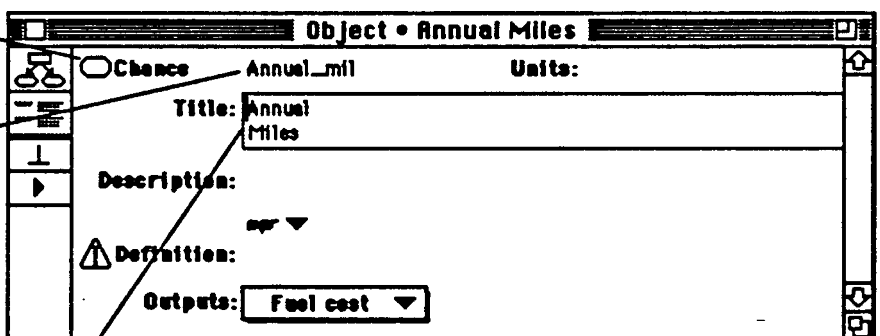
A Note: **You can also double-click on a node in Edit mode, to open an object** window. However, if you **double-click** too slowly, Demos will interpret your request as two **single-clicks. Thus, you will be in a** position to edit the title as shown previously. To **return to the step above,** simply click somewhere **else** in the **diagram** space.

The object class is Chance variable.

The name is ***Annual_mil.*** Demosassignsthename **when** the title is created. It **uses the first 10 characters** ofthetitlewiththe **exception of spaces** which **are replaced by** underscores. Demosdoes not differentiate between upper and **lowercase letters.**

The title is ***Annual*** Miles.

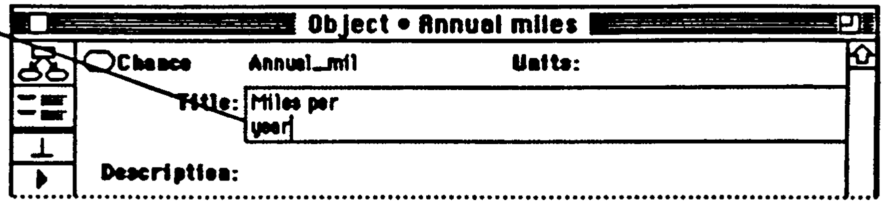
Boththenameand **title can be edited directly.**



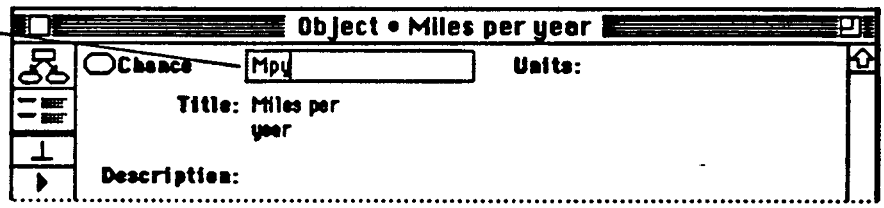
Entering object attributes through the . object window

An important characteristic of Demos is that documentation of the model and its variables can be added as the model is being created. Objectattributescan be entered or edited through the object window.

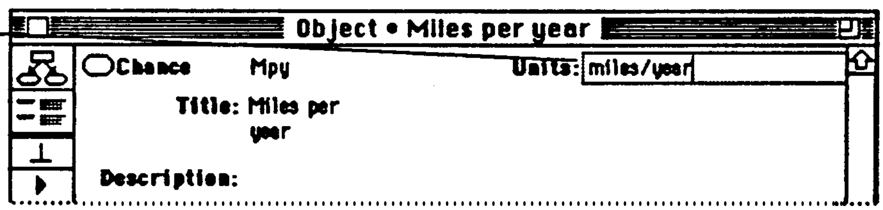
1 To change the, title, click in the title field, use the cursor to select text and use the delete key to erase "Annual Miles". Type "Miles per", and the return key, and "year". Press Enter.



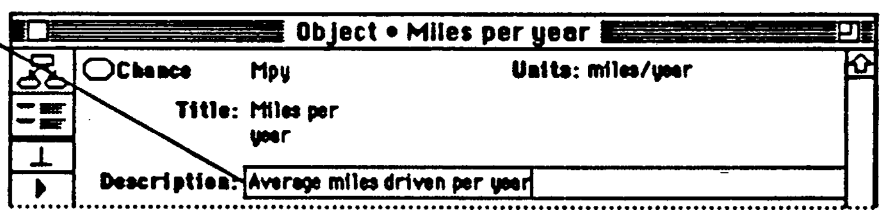
2 Tochangethename into an abbreviated shorthand for miles per year, click in the name field, use the cursortoselecttextanduse the delete key to erase "Annual_mil". Type "Mpy" Press Enter.



3 Click here to specify the *unitsbox. Type* "miles/year" Press Enter. Demos will use this information when it labels graphs or tables that involve *Miles per Year*. It is not used as part of a mathematicalfunction.



4 Click here and type "Average miles driven per year" as the description Press Enter.

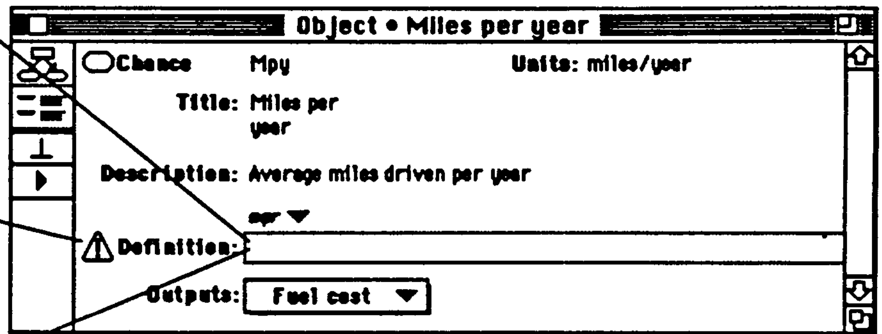


Explicitly defining a variable

Nowthatwehavedocumented the variable *Miles* per *year,* we wish to give it a mathematical expression for how to compute its value. We will define *Miles per year* as a single number.

1 Click here. Demos is ready to accept a mathematical expression for the variable.

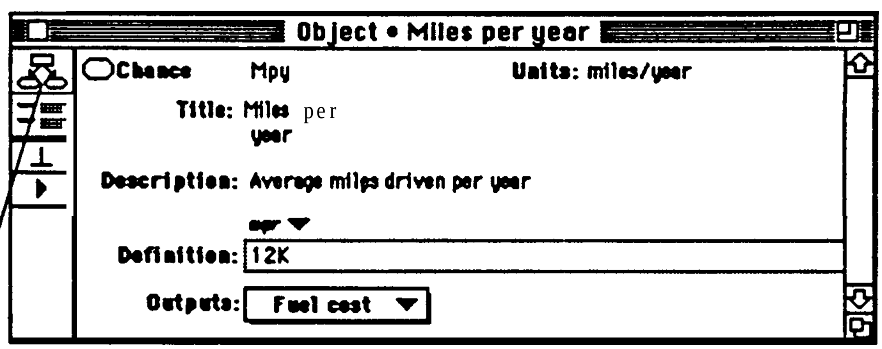
Demos shows a warning icon next to the definition to indicate that this variable's definition hasn't been explicitly defined yet.



2 For this example, let's assume that the average number of miles driven annually is 12,000. Type "12K". Press Enter.

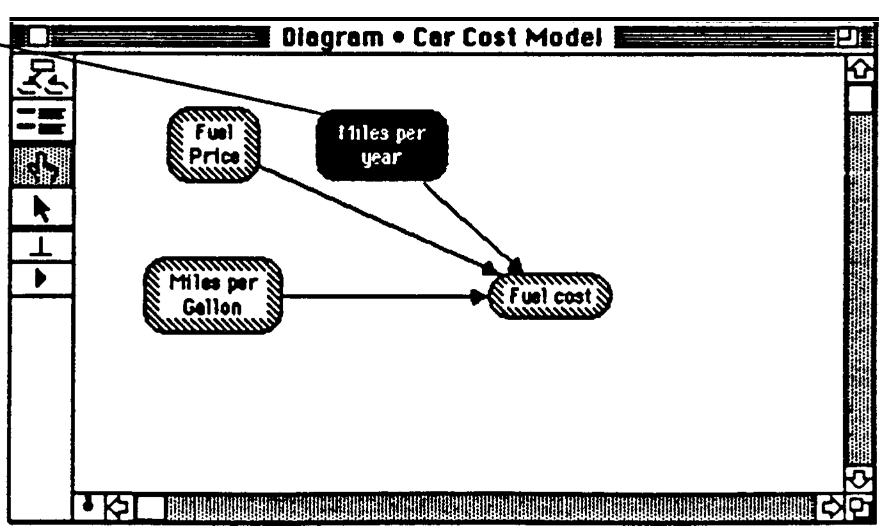
The warning icon will disappear.

A **Note: Any time we use** *the name-tedwiththe* Miles *per Year* variable in the definition of another variable, Demos will automatically uses its value, **12K.**



3 Single-click on the diagram **icon to return to the diagram.**

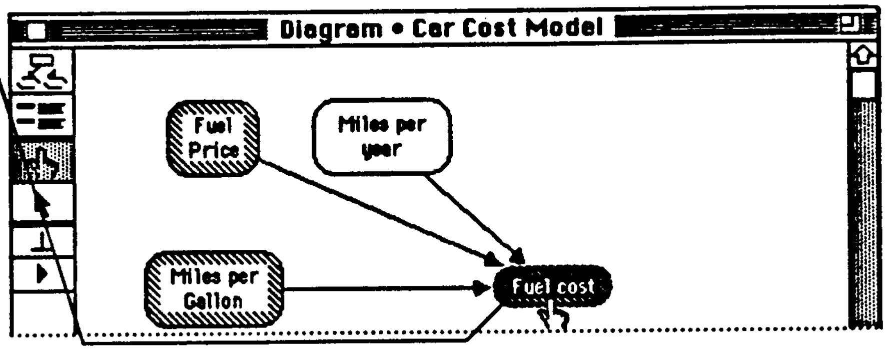
Note that the ***Miles per year*** **node is no longer filled** with a diagonal **line** pattern **around its text. This is because** ***Miles per year*** **now** has a computable **definition.**



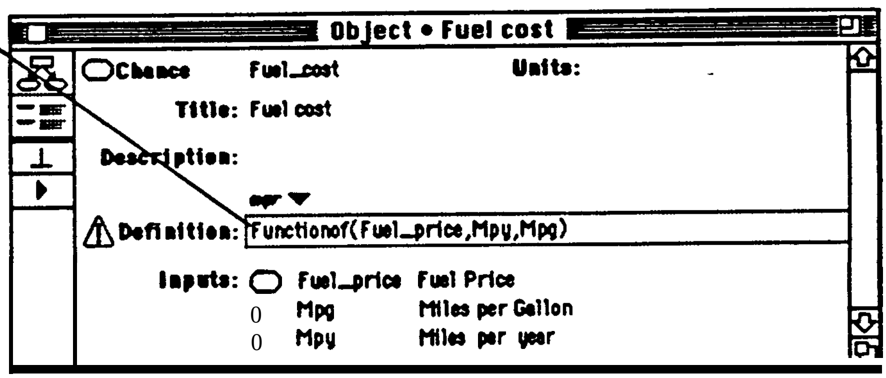
Defining variables that are influenced by other variables

The “Fuel Cost" node has arrows pointing to it, indicating that it is influenced by other variables. We will leam how to specify the dependance with a mathematical expression of those other variables.

1 **Double-click on Fuel Cost** to **open** its **object** window.



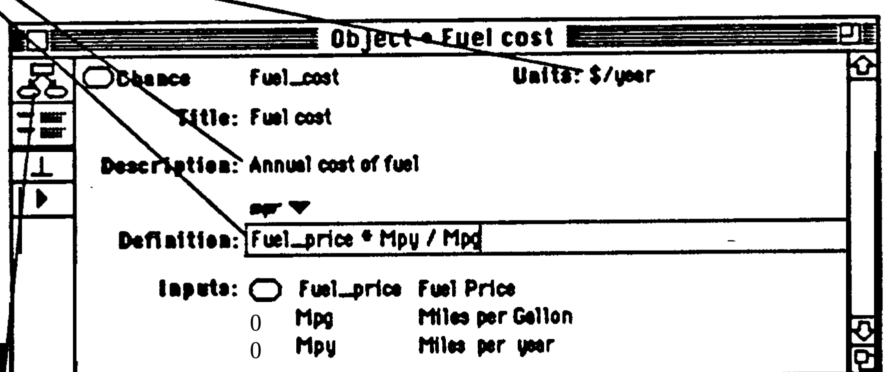
The names of **the** input **variables will appear in the** defmition for “Fuel **Cost". But since the form of the dependance** hasn’t yet been specified, it is just **"FunctionOf(...)".**



2 **Specify the units,** description, and definition, . as shown.

The definition must appear exactly as shown. Delete **all extraneous parts such as "FunctionOf" and all commas.** Cut and Paste **commands in the Edit** menucanbeusedtoavoid retyping the variable **names.**

Notice that multiplication is **"*"** and division is **"/".**

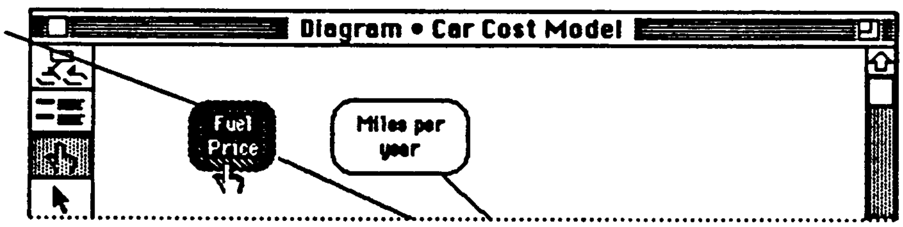


3 Click on the diagram icon **to return to the diagram.**

Probabilistic definitions and distribution display

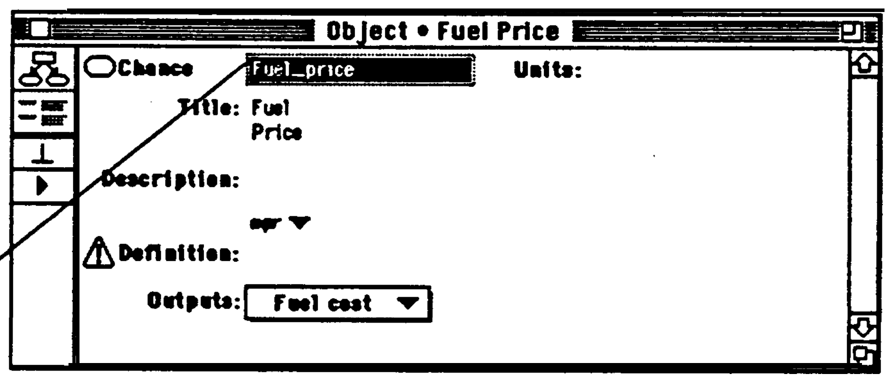
Demos excels at analyzing models with **uncertain** inputs. We **will** document the variable Fuel price and give it a probabilistic definition. **Let's** assume that **the Price per Gallon of gas is not known for sure, and uncertainty about it is** expressed as a normal distribution with a mean of 1.19 and a standard deviation of **.10.** You will learn to enter this definition and request a display of **the** distribution computed automatically by Demos.

1 **Double-click** on the "Fuel **Price" node to see its object** window.



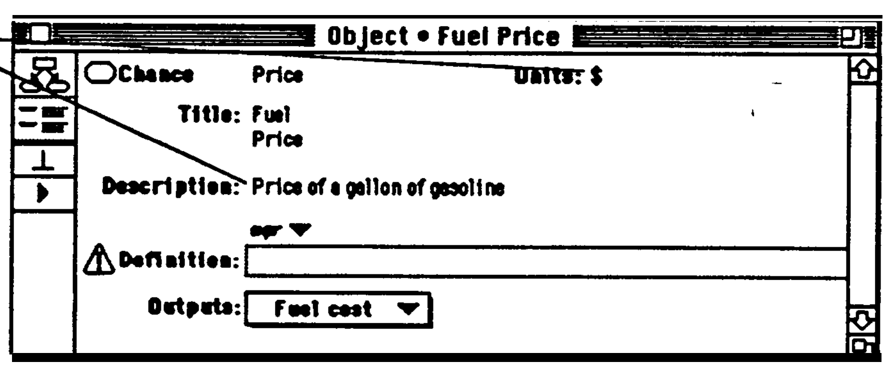
Demos automatically gives a new variable a default **name based on the first 10 characters** of its title, when you **first** title the variable. We **will change** this first.

2 **Change the name to "Price".**



A Note: the definition of variable Fuel cost refers to variable **Fuel_price.** Demos will automatically update the definition of Fuel cost **when you change the name to Price.**

3 To complete the documentation for this variable, enter the units and **description as** shown.



We **will** edit this **variable's definition next.**

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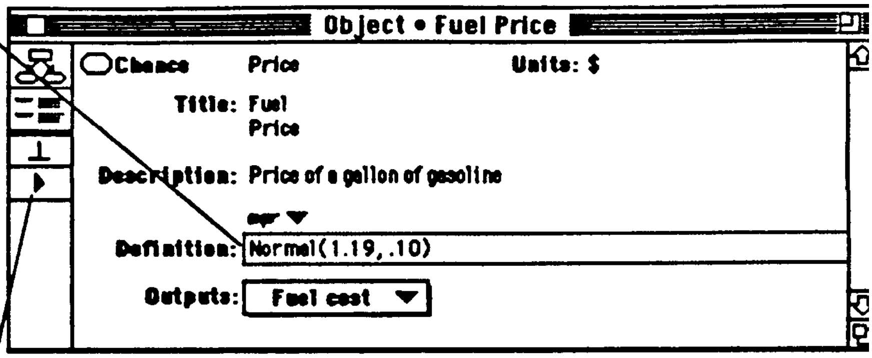
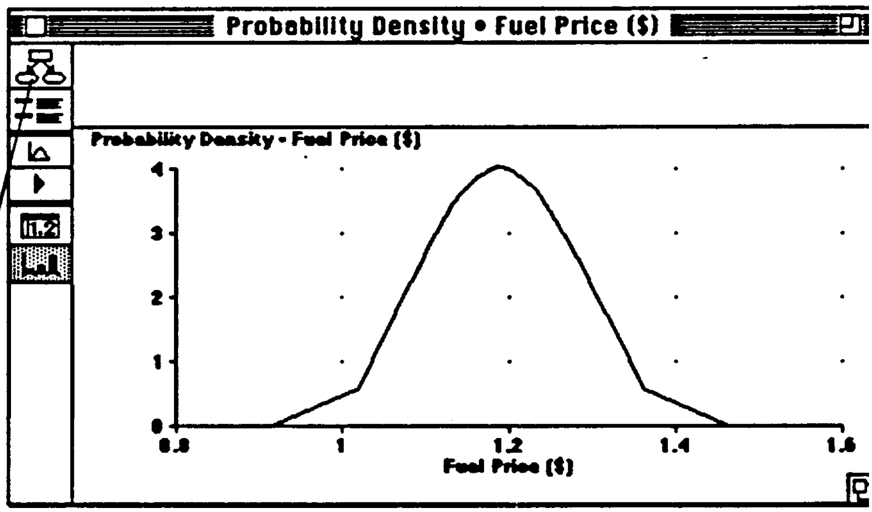
4 It is important to enter definitions correctly so that Demos knows how to interpret them. To learn more about the proper syntax for a definition, refer to the Demos Quick Reference. For now, type the normal distribution as shown, using parentheses. Press Enter.

5 To display the distribution of "Fuel Rice", select Probability Density from the uncertainty view selector popup menu.



The distribution of Fuel Rice should look like the graph shown on the right.

6 Click on the diagram icon to return to the original diagram.

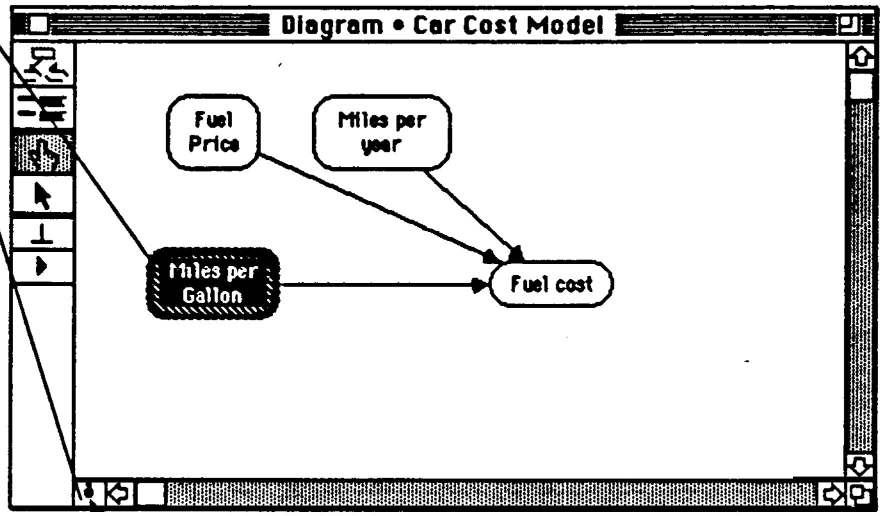


Entering attributes through the attribute view

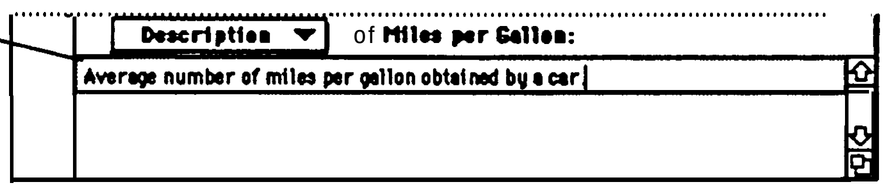
You may prefer to see the attributes and the diagram in the same window. **The** attribute view (appearing under the diagram) allows you to edit attributes. You will learn to enter data through the attribute view.

1 **Click on the "MPG"** variable, to select it.

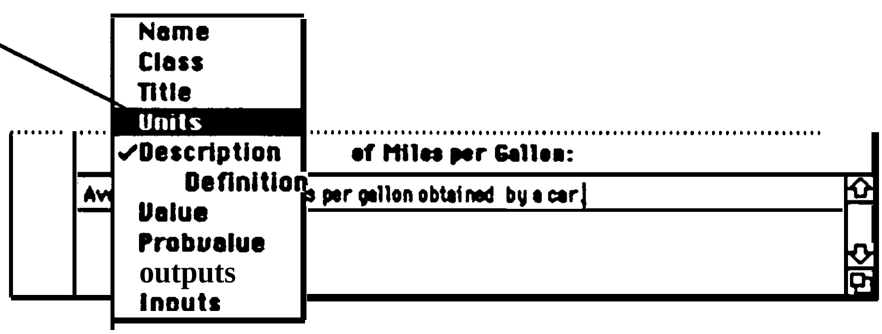
2 Inordertodesaibethe **attributes of the Miles per** Gallon variable, we will open the attribute view. Click on the expand icon. Notice the attriite view **appears below the diagram. This view can be used to** enter or edit data.



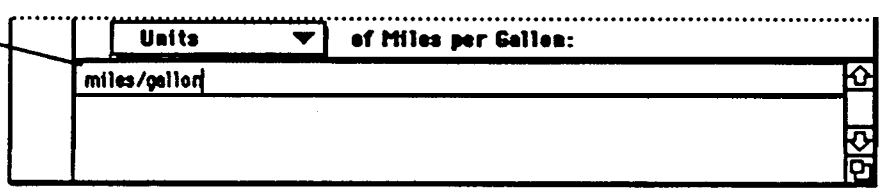
3 **Single-click** here to enter **the description.** Type "Average number of miles **per gallon obtained by car." Press Enter.**



4 **Press here to see the** attriite **pop-up menu.** Dragthemousetotheunits attribute and release.



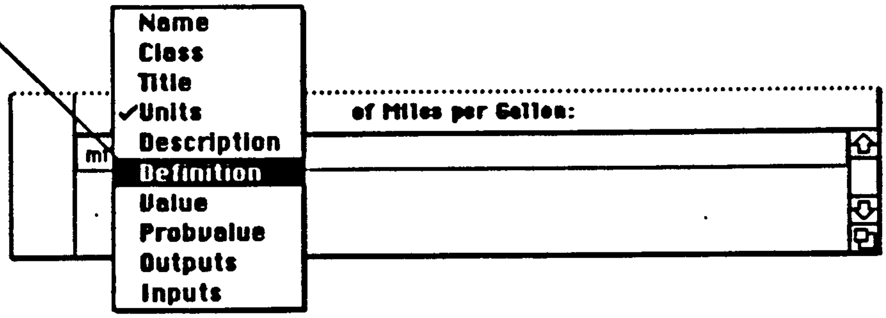
5 **Type "miles/gallon". Press Enter.**



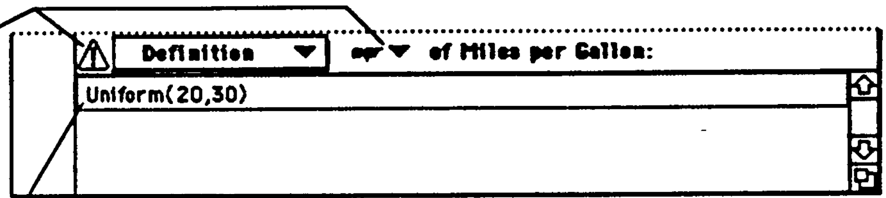
Entering a definition in the attribute view

Entering a definition in the attribute view is exactly the same as entering it in theobestwindow. We will define Miles per gallon as an uncertainty distribution, where we believe it is equally likely to be any value between 20 and 30. You can use a Uniform distribution to characterize this.

1 Use the attribute pop-up menu to select definition.

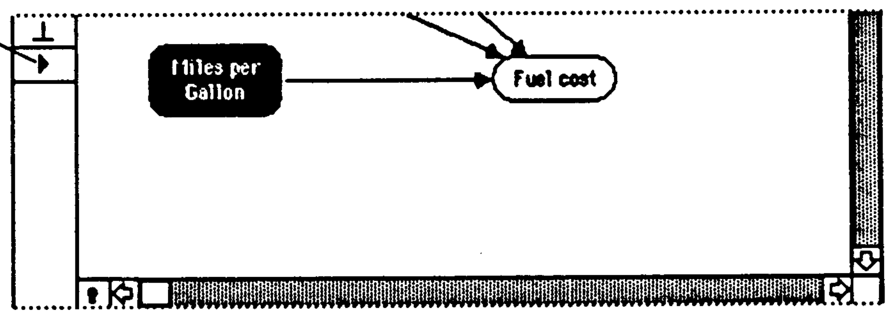


The warning icon and expression type popup menu are available here when showing the Definition



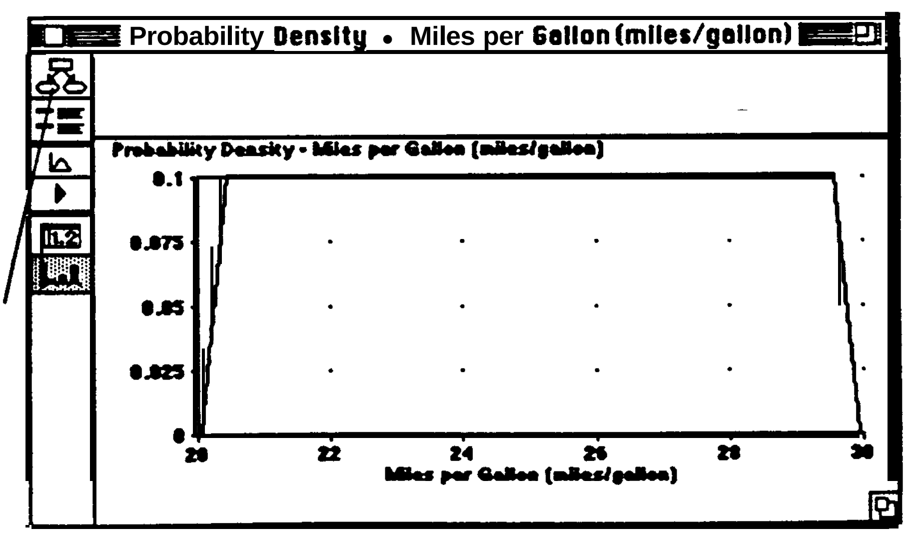
2 Click here to type in the distribution as shown. Press Enter.

3 Select Probability density from the uncertainty view selector popup menu to view the uniform distribution.



The uniform distribution increases sharply at 20 miles per gallon, then is flat (has equal probability across this range), and thenfalls back to zero probability at 30 miles per gallon

4 Click on the diagram icon to return to the diagram window.

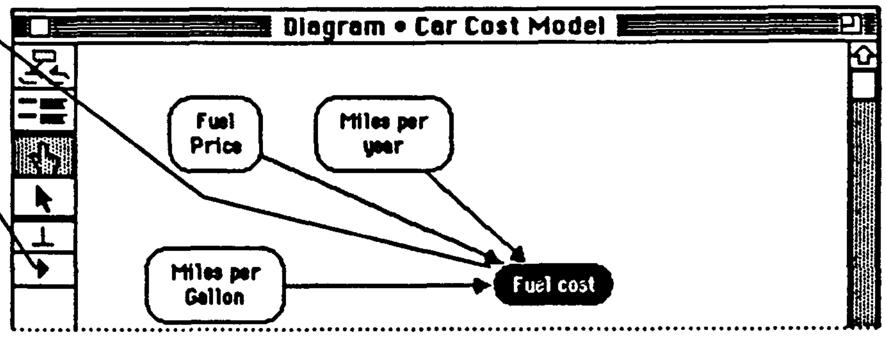


Probabilistic results

Demos can display the results of **probabilistic** inputs in several ways. These **include** probability density distributions and cumulative probability **distributions.**

1 Click on the **fuelcost node** to **select** it.

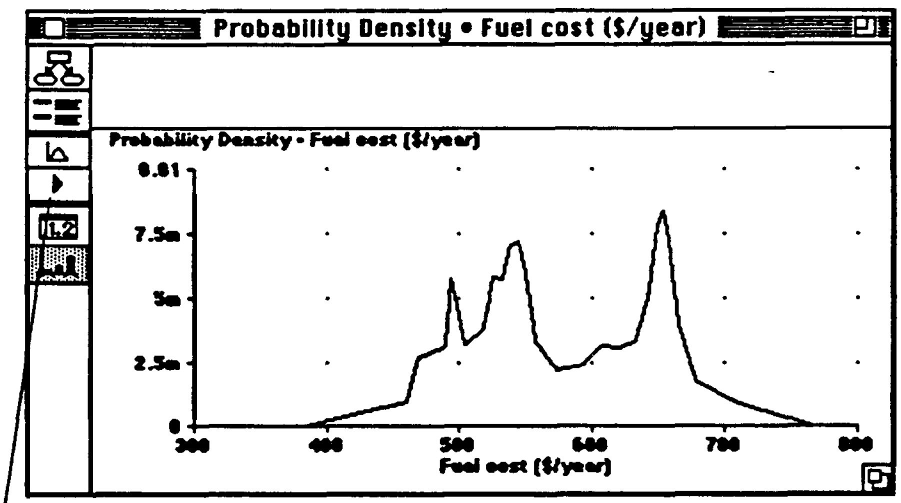
2 Select probability Density **from the uncertainty** view selector **popup menu.**



Demoswill take a moment to compute the results and display them in a graph.

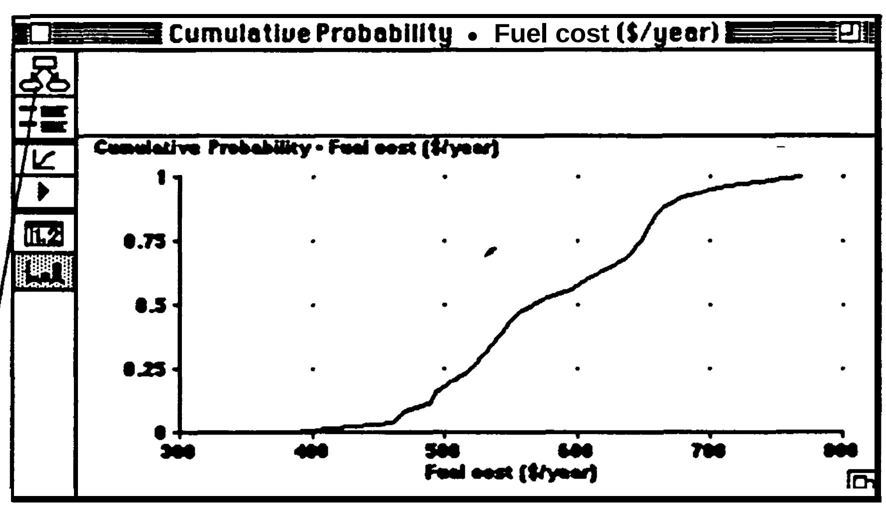
This graph shows the probability density of the value of Fuel cost.

The graph appears "noisy" **because we are using a** sample size of 100. Using a larger sample size would produce a smoother cum, but it would take longer to compute.



3 select cumulative **Dis-**triiution from the uncertainty view selector **popup menu.**

This graph shows the cumulative probability of the value of Fuel cost.



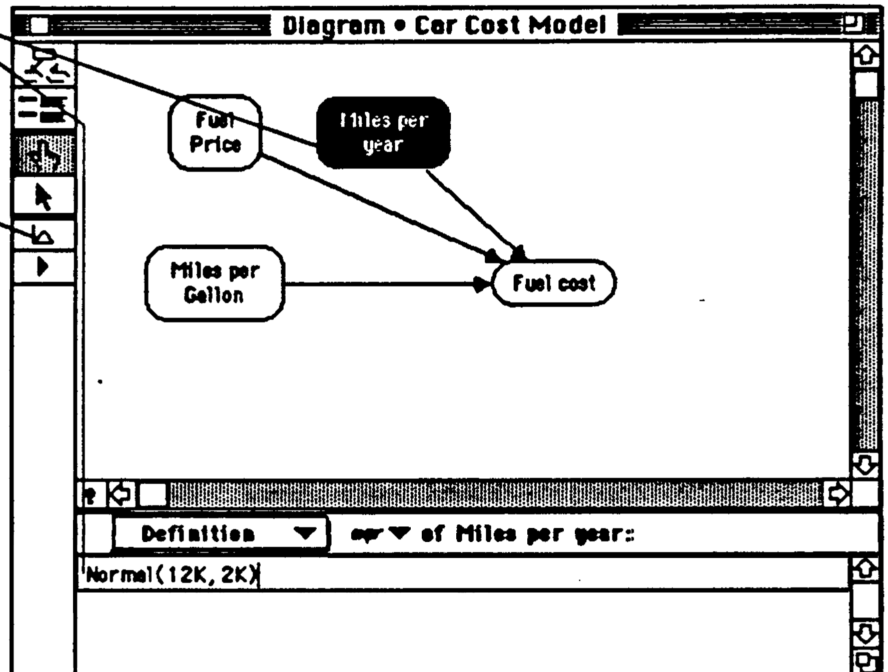
4 Click on the diagram icon to return to the influence diagram.

Refining the model

. **In Demos, you will find it easy to refine your model. You can change a** definition, add **new** variables and dependendes without having to change **other** parts of your model. Demos **will autmatically** update the **necessary variables** whose definitions **or dependencies** have changed, and will automatically recompute them when you display their **values.** In the **Car cost model, we realize that we don't really know how many miles per year that we drive, but we believe that it is most likely to be our earlier single-number** estimate of **12K,** and we believe that a normal distriition with **standard** deviation of **2K, or 2000** miles **represents** our **uncertainty** about its value

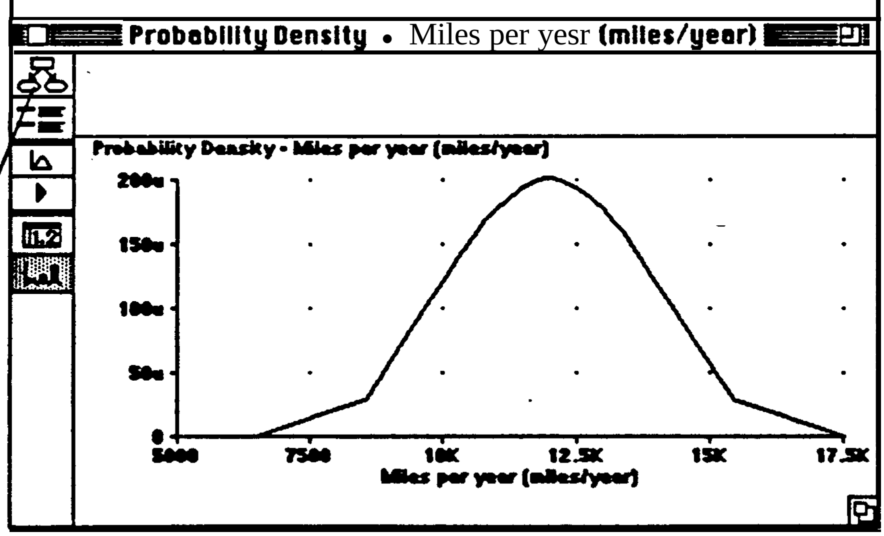
1 **Select Miles per year in the diagram, and change i definition from 12K to Normal(12K, 2K).** Press Enter.

2 **The Probability density** option in the **uncertainty** view **selector popup** menu should **already** be **selected. Click on the icon here to** compute the probability density for Miles per year. If Probability density is not already selected, select it from the **popup** menu.



The probability density of **Miles per year is shown** here.

3 **Click on the diagram icon to return to the diagram.**

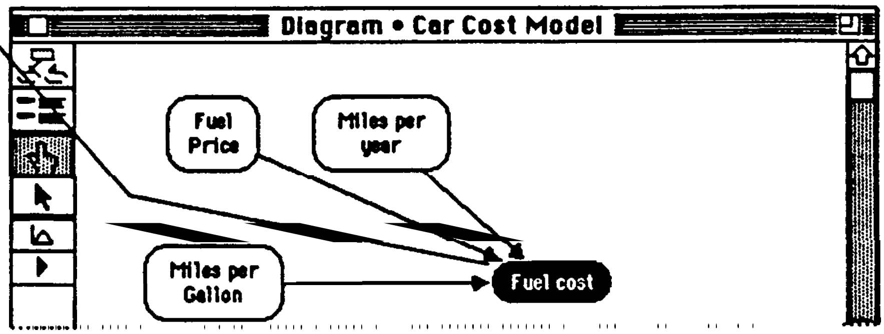


Importance analysis

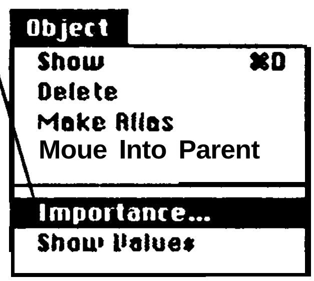
In this car cost model, **like** most Demos models, we have defined several input variables as **uncertain.** It is interesting to know how much each of **these uncertain** inputs contributes to **the uncertainty** in the output. **Importance analysis is described on page 21 in Part 2 of this tutorial.** Wewilllearnhowto set up a simple importance analysis on our output variable Fuel **cost.**

1 Select Fuel cost in the diagram.

Wewillnowusethe **Importance feature of Demos** to automatically **generate an importance** analysis.



2 Select Importance from the Object menu.

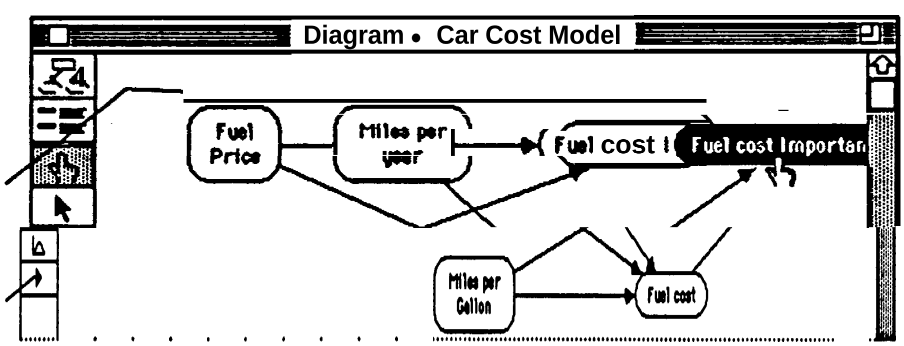


Demos will take a few moments to figure out which inputs are **uncertain. Then, it will create a** variable, Fuel cost inputs, that lists **these** inputs, and another variable, Fuel cost **importance,** that computes the absolute value of the rank-order correlation **between each input and the** value of Fuel cost

Thenewnodesappear toward the upper right part of the diagram window.

3 Click on Fuel cost **importance** to **select** it.

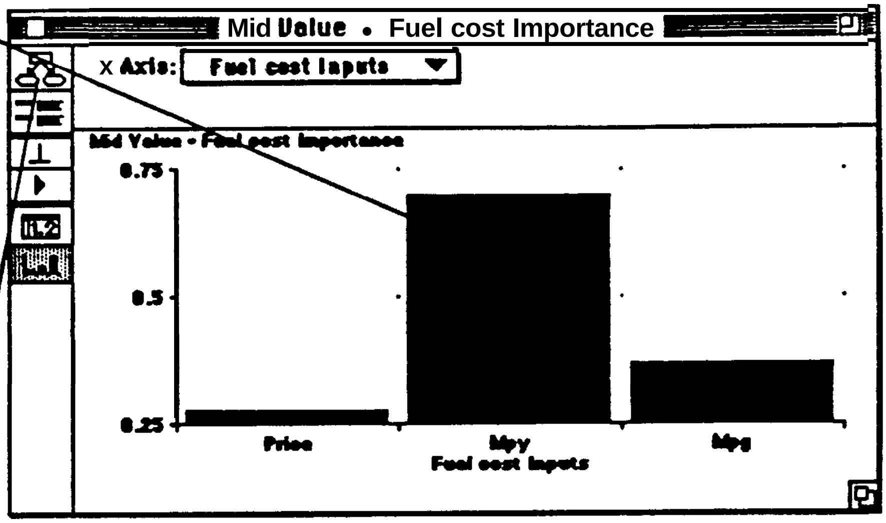
4 Select **Mid** value **from** the **uncertainty** view selector **popup menu.**



This graph shows that **Mpy, Miles per year, is the** variable **contributing most of the uncertainty in the** output **Fuel cost.**

We will now perform parametric analysis on Miles per year.

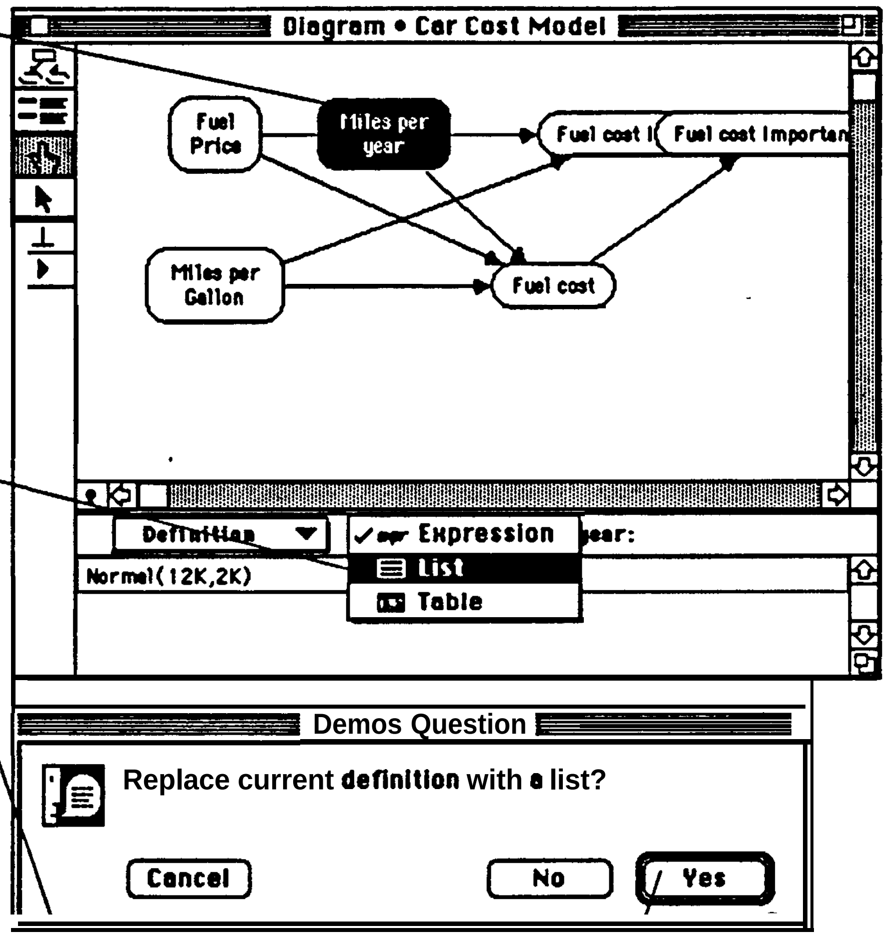
5 **Click on the diagram icon to return to the diagram.**



Parametric analysis

Parametric analysis **means** varying **the** value of an input **variable** to **examine** its **effect on a selected** output. it often gives useful insights into what's important, and how a **model** behaves. Because the **importance** analysis revealed that the Miles per year **contributes** much of the **uncertainty** in Fuel cost, we will start the **parametric** analysis with that input variable. We **will** change its definition from **a probability** distribution to **a list** of alternative values. Demos **will** then graph the corresponding values of the output.

1 **Click on the Miles per year node to select it and view** its Defmition in **the attribute view.**



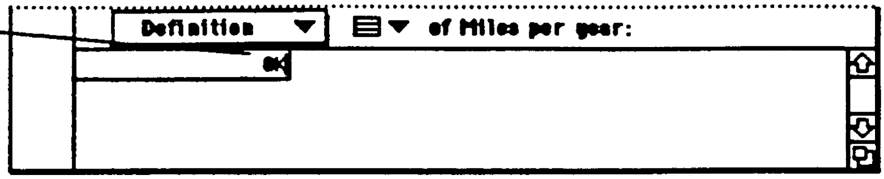
We will now specify Miles peryearasalistof altemative values, of **8K, 12K** and 16K.

2 Press on the expression **type popup menu, drag the mouse to List, and release.**

3 Since we want to change the definition from a distribution into a List, we click Yes here.

▲ **Note: pressing the return key will do the same.**

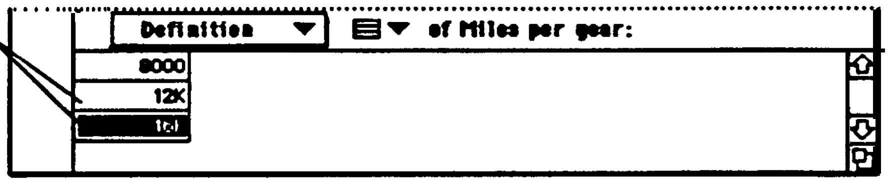
4 Select the cell by clicking in it, type in the number 8K, or 8000, and press the return key.



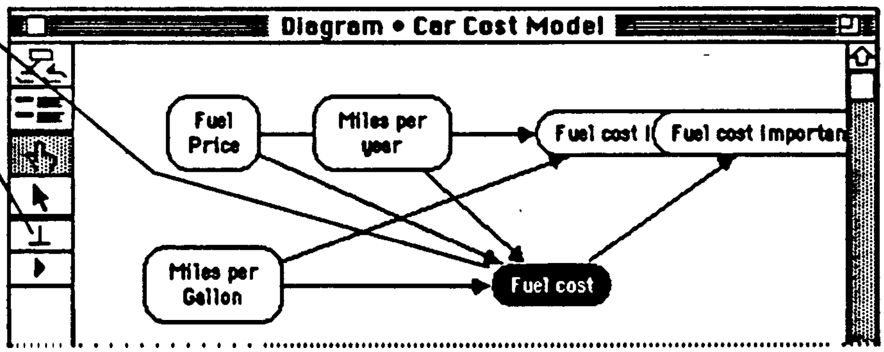
A new cell will appear when you press the return key in the last cell.

5 Repeat the previous step, entering 12K.

In the last cell, type 16K, but this time, press the enter key so it won't add an additional cell.

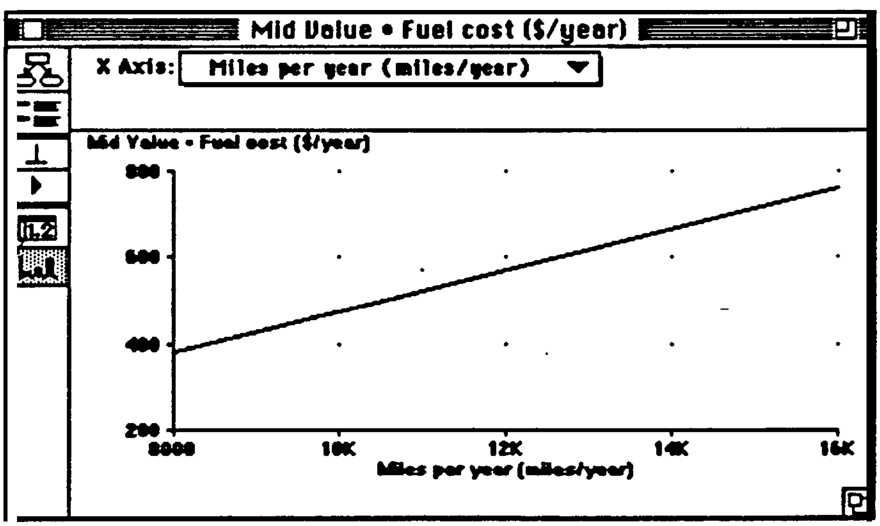


6 Select Annualized housing cost and click on the Mid value uncertainty view option to show the recomputed value.



The mid value shows the linear relationship between miles per year and the fuel cost. There is a computed value for each parameterized value of Miles per year.

7 Click on the Table icon to view the table of values for Fuel cost.

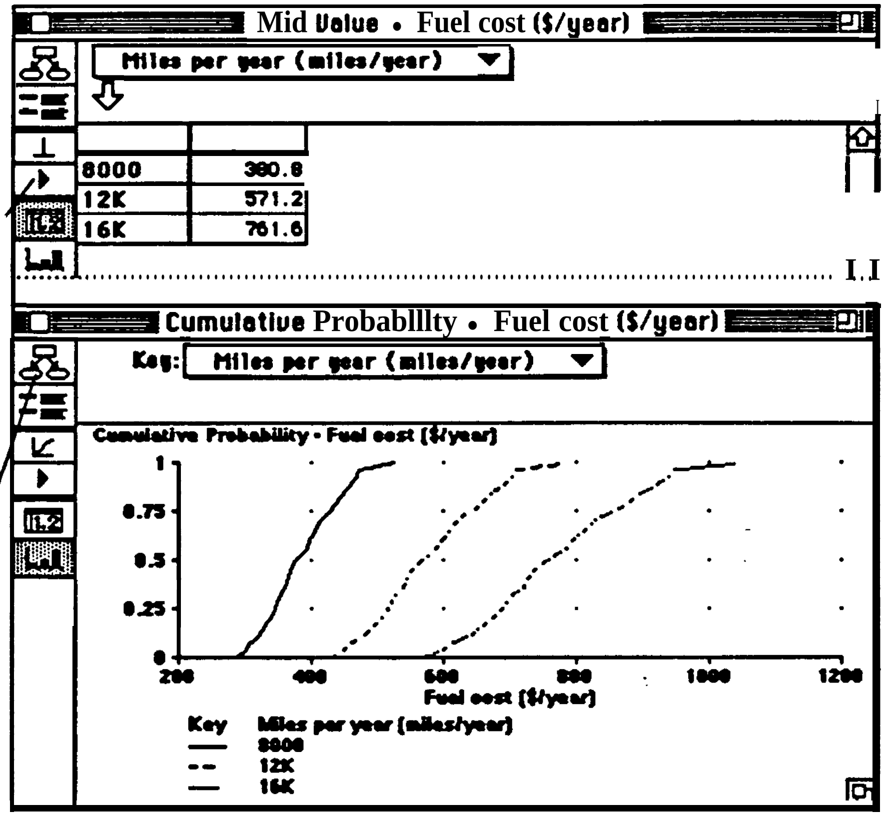


Here are the individual mid values of fuel cost, for each parameterized value of Miles per year.

8 Select Cumulative density from the uncertainty view selector popup menu.

This graph shows a cumulative distribution of Fuel cost for each parameterized value of Miles per year.

9 Click on the diagram icon to return to the diagram window..

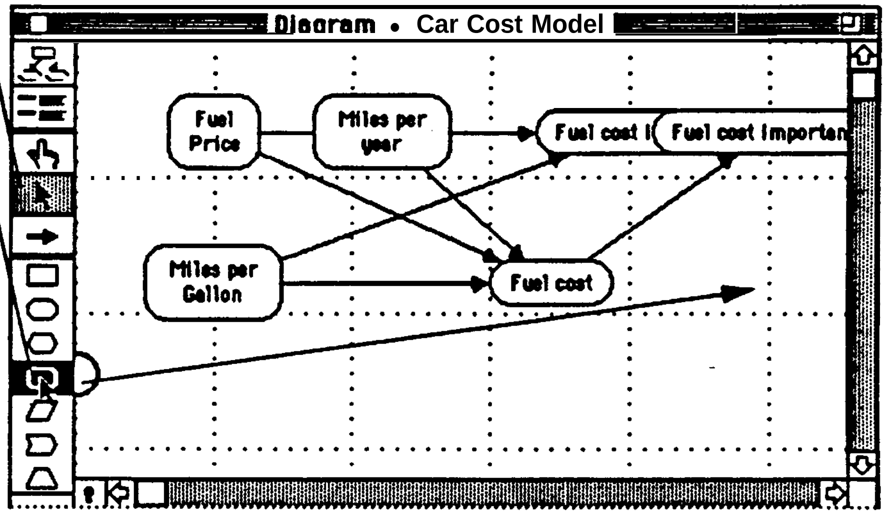


Creating a submodel

in order to simplify **complicated diagrams, submodels can** be **created.** Perhaps we would like to **create** a **submodel that contains** variables used for analysis, and include the Importance variables that we **previously** created. We might also create **submodels** if we decide that our **Fuelcost determination** is **a** small **part of a larger model. You will learn to create a submodel and place nodes in it.**

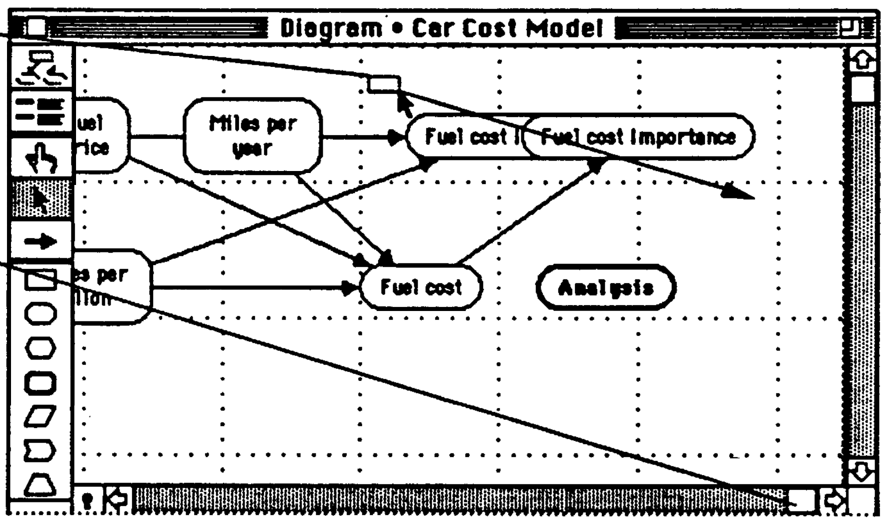
1 You must be **in edit mode** to **create** a submodel. Click **here if necessary.**

2 Click on the **Submodel** icon anddragtheoutlineofitto **the position shown in the** diagram **Notice that Submodel nodes** have **thick** outlines. **Title the Submodel "Fuel Cost** Inputs". Press Enter.

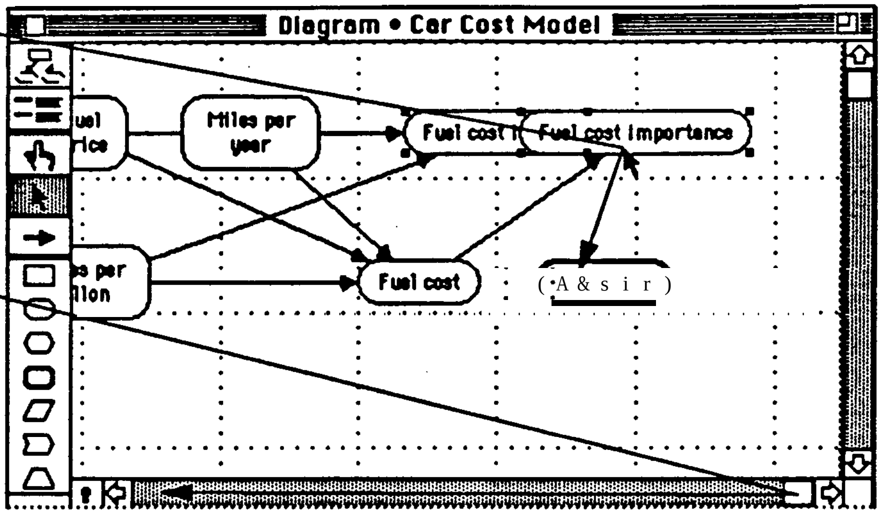


3 **To move the importance** variables into the submodel, select both of their **nodes. Press** and drag the **mouse** to surround all three input variables.

As you drag the mouse to the right to surround these variables, your diagram **will scroll to the left, and the scroll bar thumb will** move toward the right.

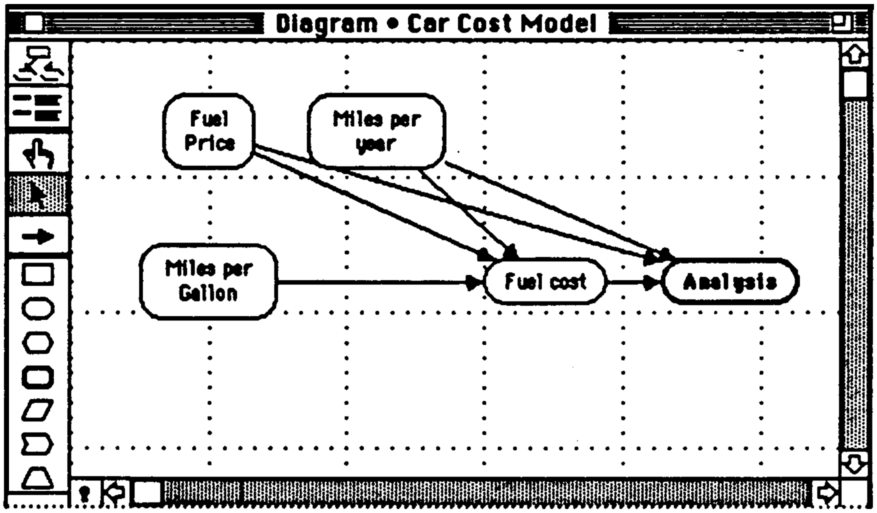


4 Press on one of these nodes and drag it into the submodel.



Scroll the diagram back toward the right by pressing on the scroll bar thumb and dragging it all the way to the left.

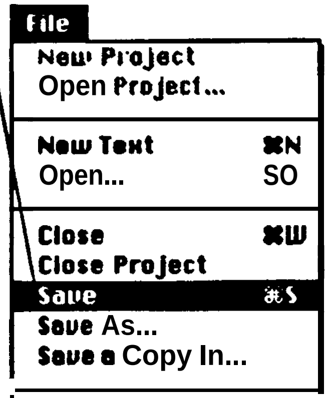
The final appearance is as shown here.



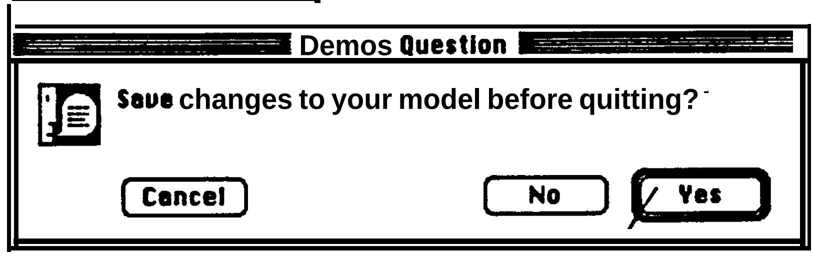
Saving your model and quitting

After you have created part or all of a model, you may want to save it. When you have finished a session with Demos you may want to save and quit.

1 To save your model, select **Save** from the **File** menu.



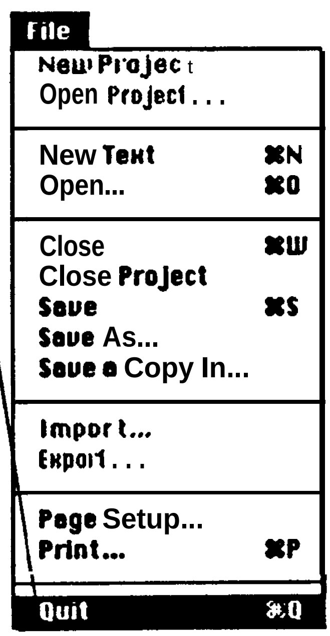
A Note: You may also select **Quit** from the **File** menu before remembering to save changes. If you do this and changes have been made to the model, Demos gives you this dialog box.



2 Click Yes to save changes.

You have previously saved your model under the name Tar Cost Model" (see page 34), so Demos now automatically saves your changes in that same file.

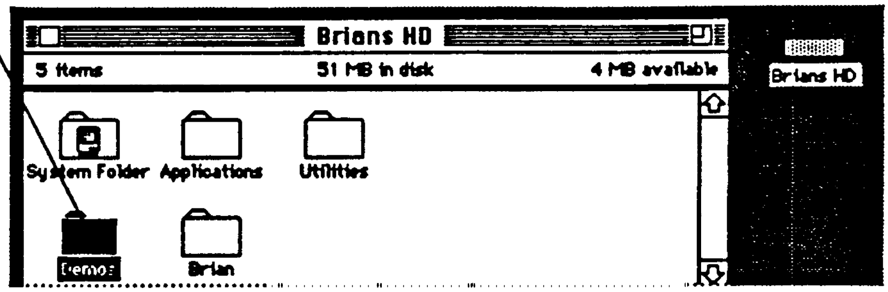
3 To quit Demos, select **Quit** from the **File** menu.



Reopening a Demos project

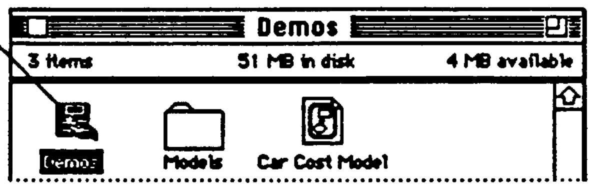
After saving a model and quitting, you may wish to open the model again to look at it or to make changes to it.

1 **Double-click** on the Demos folder on your **hard** drive. If you have **continued** from the previous page, this folder is still opened.



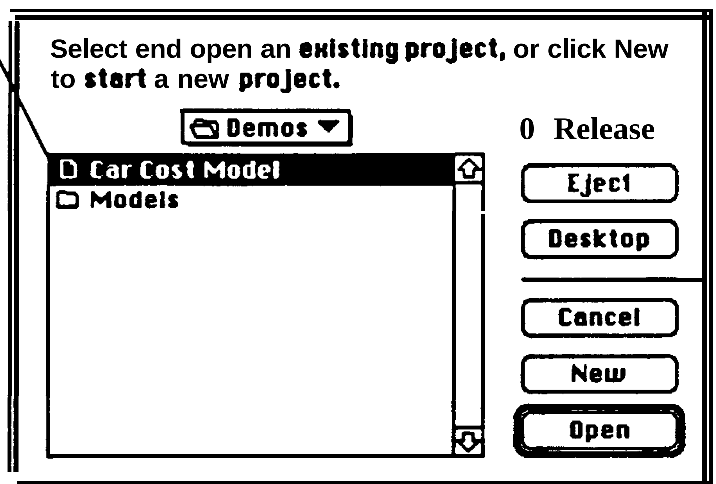
2 **Double-click on** the **Demos icon.**

A Note: You can alternatively double-click on the "Car Cost Model" icon.

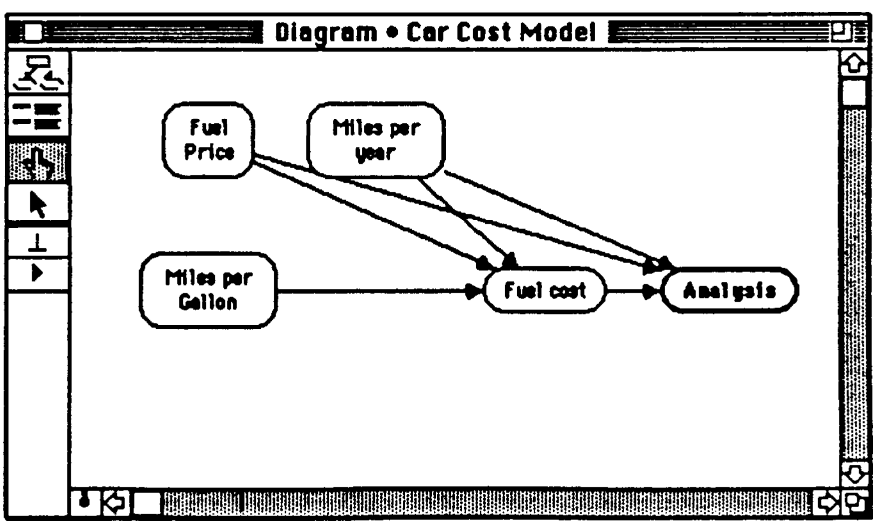


3 Locatethemodelyou **would like to open, in this** case, "**Car** cost Model".

4 **Double-click** on the "Car Cost Model" **model** or single-click and then click **open.**



You should **now** see the "Car **Cost Model**" diagram.



SECTION 4.0

DEMOS QUICK REFERENCE GUIDE

Demos Quick Reference

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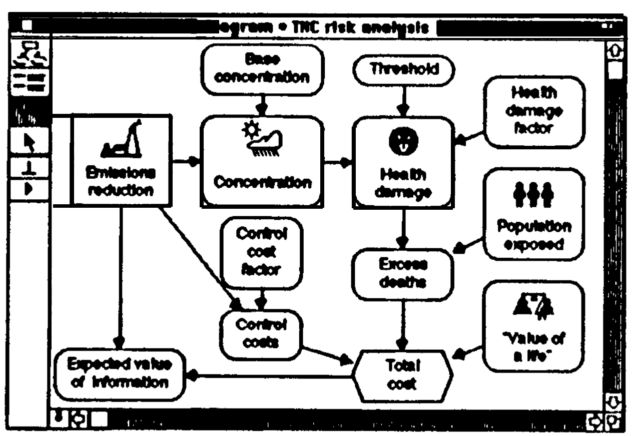

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Table of Contents

Macintosh windows

The window shown here is a Macintosh folder containing the Demos program (also known **as** the Demos application) and some Demos models (also known as documents). The controls described here for moving, scrolling, resizing, and closing this window are the standard Macintosh methods. The Demos windows described in the rest of this manual can be controlled in just the same ways as the folder window shown here. On the other pages we will describe only those buttons, menus, and other features specific to Demos, and we will not repeat the explanations of the standard Macintosh features shown here.

Title bar: you can drag this (or any) window around the screen by pressing the mouse button in this area and moving the mouse.

Close box: click on the box to make the window disappear.

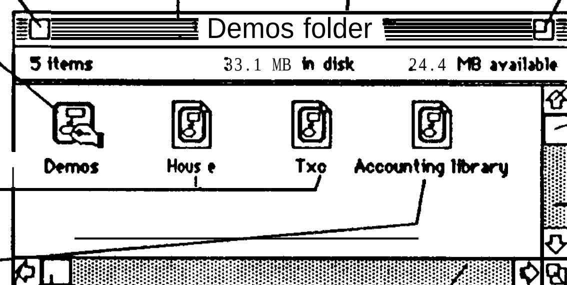
Name of this folder.

Zoom **box: click it to** enlarge the window to the size of your screen. Click it again to revert the window to its oriiinal size.

The Demos Application: to start a new **model,** double **click** on this icon (see pages **2, 3,** and 12).

Demos **model documents: these** are text files containing models. To restart a Demos model, double click on its icon (see **pages 2 and 4).**

A Demos library.



Up arrow: press on the arrow to scroll the view upward.

Thumb box: drag the box to **move** the view up or down.

Down region: click in the area to jump the view down.

Down arrow: press on the arrow to scroll the view downward.

Grow **box:** Drag to change the size or shape of the window.

Vertical scroll **bar**

Thumb box: drag the box to move the view left or right.

Right region: Click in this area to jump **the view right.**

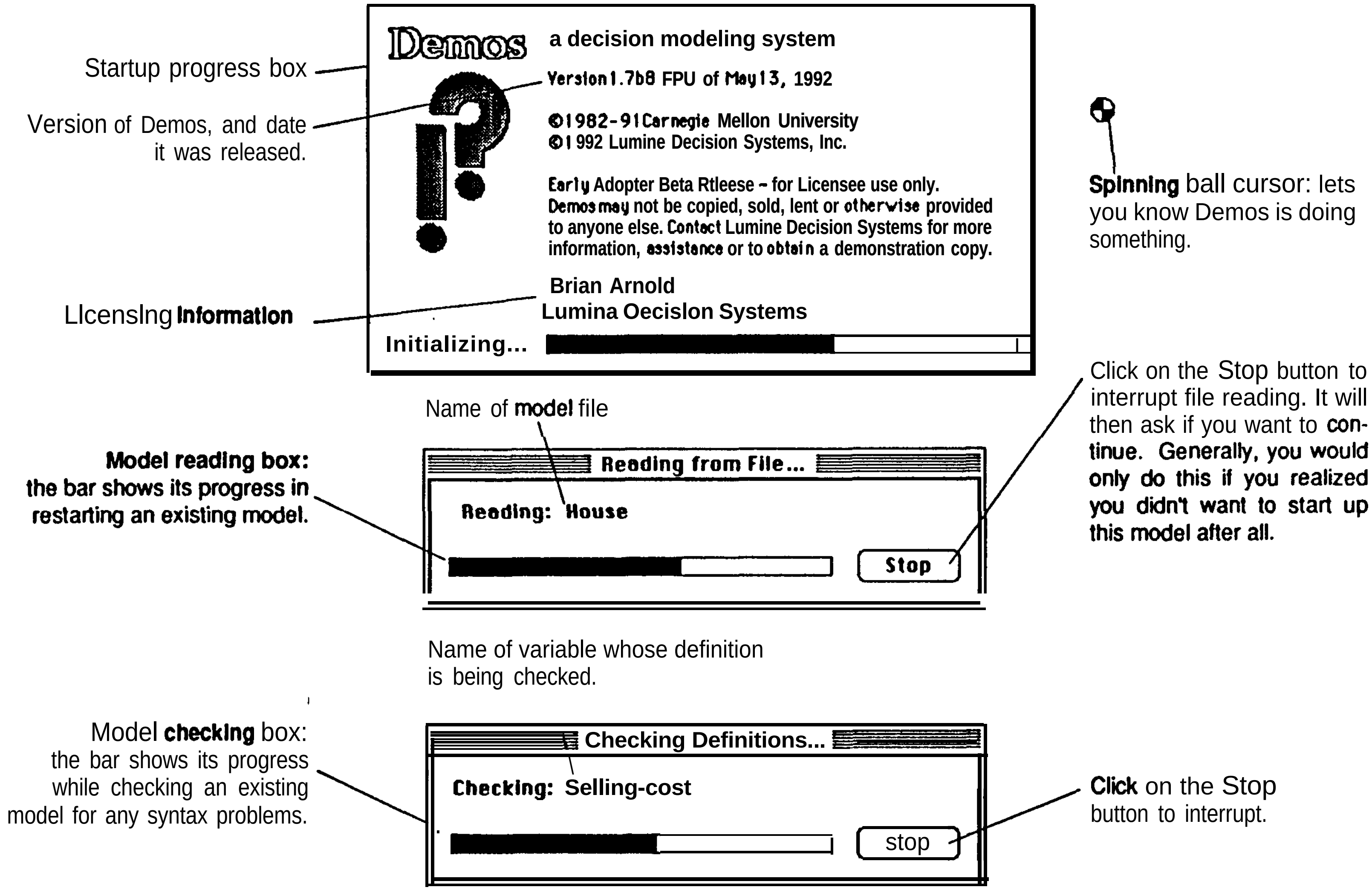
Left arrow: press on the arrow to scroll view left (the document moves right).

Right arrow: press on the arrow to scroll view right (the document moves left).

Horizontal scroll bar

The Demos startup progress box 2

While Demos is starting up, it displays the upper box. This box tells you which version of Demos this is, and provides licensing **information.** The progress bar shows how far Demos has gotten in initializing. If you are **start**-ing up an existing model, Demos will display the two tower boxes next. The middle box shows you its progress in reading in the model file. The bottom one shows you its progress in checking the model to see that the model is well formed. When the model is ready, Demos will display the diagram **win**-dow for the top model (see page 4). If instead, you started Demos directly, e.g., by double clicking on the Demos icon, it. will go to the open model file dialog box next (see page 3).



The open project dialog box

This dialog box lets you open an existing project or start a new one. You will get to this dialog box after seeing the startup box on page 3, if you started Demos by double clicking on the Demos application (see page 1). You can also get this dialog box by selecting **Open Project** from the **File** menu (after selecting Close from the **File** menu to close the current project).

If you want to restart an existing model, use the folder popup menu and contents list to find its file. Once you have found the model you want to start, select it and click the **Open** button. As an alternative, you can simply double click on the file name. You will then see the model reading progress bars shown on page 2. After reading in the model, Demos will display the diagram of the top model (see page 4).

If you want to start a new project, then simply click the New button. It shows you a new project object card (see page 12).

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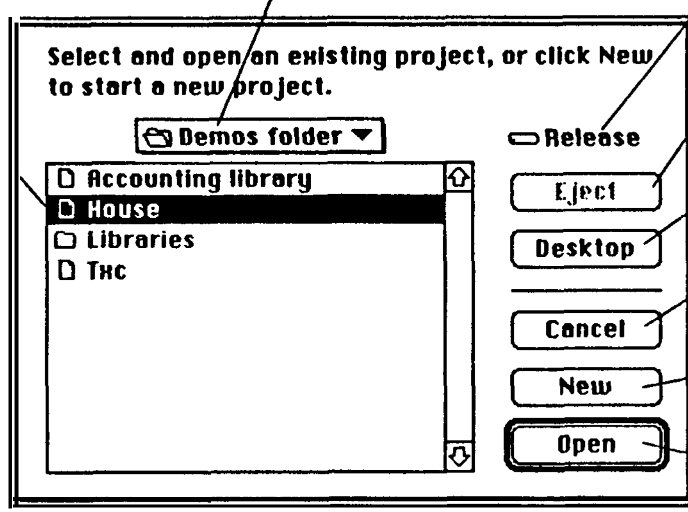
The current folder: press on the folder button for a popup menu of the folders containing it.

The list of Demos models and folders in the current folder.

House Is the selected file.

Click once on any other file to **select it.**

To open a folder and see what is in it, double click on the folder.



The name of the disk containing the current folder.

Click on this button to eject this disk. (Dimmed if it is not a diskette or other removable medium.)

Click on this button to make the desktop the current folder.

Click on this button to close this box without opening anything.

Click on this button to start a new Demos model (see page 12).

Click on this button to open the selected folder or Demos model. Opening the model file will read it in and display the diagram of its top model (see page 4).

The diagram window in browse mode

This window depicts **a** model as an influence diagram. Each node is a **variable** or a submodel. Each arrow depicts an influence, that is, a **direct functional** or probabilistic dependence of one variable on another.

This diagram is in browse mode. In this mode you can inspect the model and evaluate it in order to generate tables and graphs. If you want to change the model structure or add new variables, you must enter the **edit** mode (see page 13).

Click on this icon to go to the parent model diagram. If there is none, this icon is grayed out.

Click on the hand icon to go into **browse mode.** It is grayed out to show you are already in browse mode.

Click on this icon to view the **object window** of the selected node (see page 6).

Title of this model

A selected **node** is indicated by highlighting.

To select a node, single click on it.

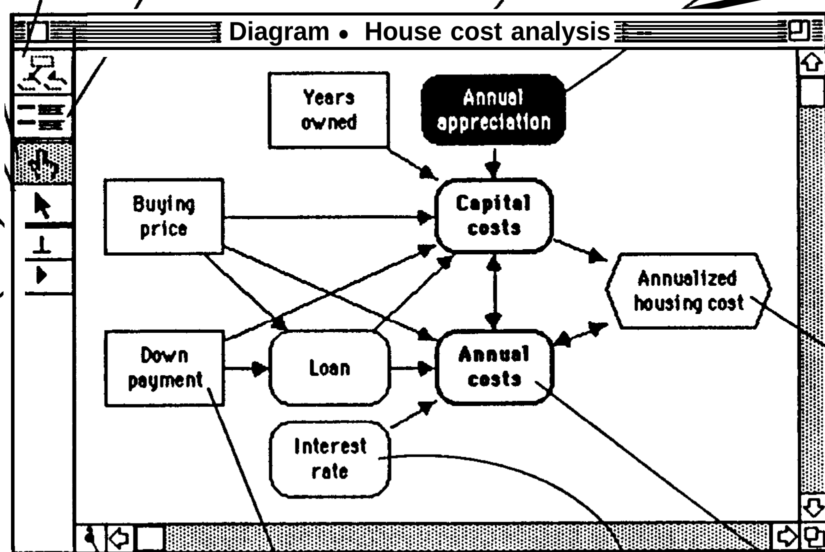
Click on this icon to switch to **edit mode (see page 13).**

Click on this icon to **view** the **value** of the selected variable with the selected uncertainty view option.

Press here to see the **popup** menu of the uncertainty view options:

- ✓ ⊥ Mid **Value**
- m **Mean Value**
- m± **Statistics**
- **Confidence Bands**
- **Probability Density**
- **Cumulative Distribution**
- **Sample**

Choose one **to** display **the** value of the **selected variable node.**



To see details about a node, double click on it. E.g., double clicking on a variable will display its **object** window (see **page 6).**

To **deselect all nodes** click the diagram anywhere outside any nodes.

A hexagonal node depicts the **criterion** or **objective** of the decision model, e.g., net benefit, cost or utility, or whatever you are trying to maximize or minimize. Most models have a single criterion node.

A rectangle depicts a decision variable.

Click on this key **Icon to see the attribute** view below the diagram, showing more information about the selected node (see page 5).

A rounded node depicts a chance (i.e., uncertain) variable.

A **thick** outlined node depicts a **submodel,** containing variables in an influence diagram of its own. Double click on the node to see its diagram.

The attribute view

The attribute view is **a** pane that extends below a diagram window. It lets you view any attribute of any node you **select** in the diagram. Click on the key icon to display the attribute view. **Click** on the node you wish to select. Then press the attribute **popup** menu to see the **list** of attributes available, and select one to inspect. Select another node to see the same attribute of that node. You can edii an attribute in the attribute view, provided the attribute is user-modifiable.

The selected node whose attribute is displayed below. To **select** another node, just **click on it.**

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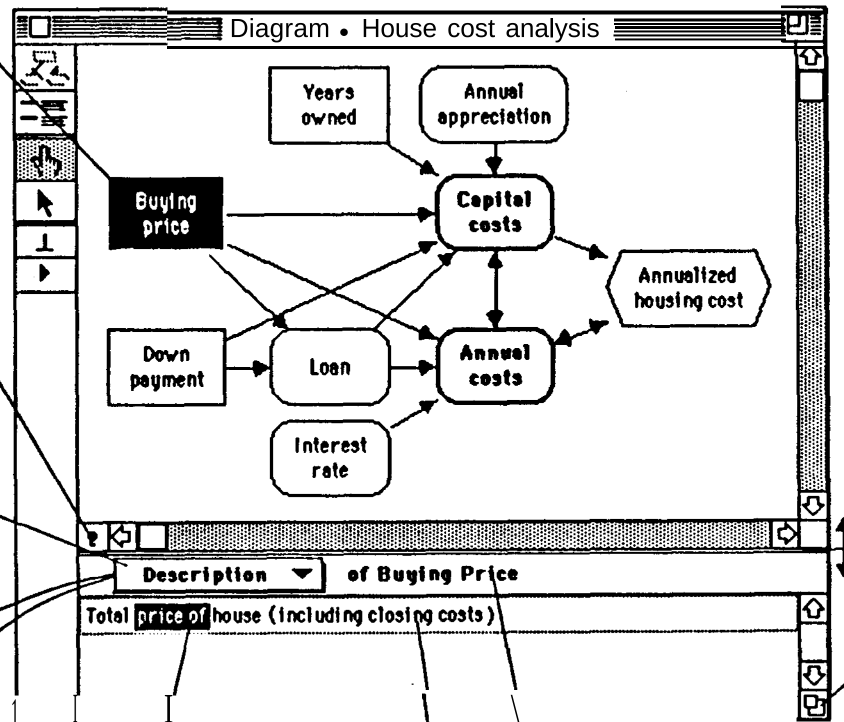
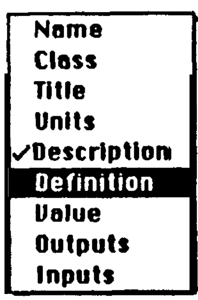
Click on this key **Icon** again to close the attribute pane.

The **current** attrlbute: To select another attribute, press the mouse to see a popup menu of available attributes.



Drag this **partition** up or down to change the heights of the diagram and **its** attribute pane.

Note: dragging the grow box changes the size and shape of the diagram, but the height of the attribute view remains fixed. Drag the partition to change it.



Select the desired anribute from the menu.

The contents of the current attnite of the selected node are shown here. You can edit **it** if the attribute is directly modifiable (rather than computed by Demos). For editing **a** definition, see page 18.

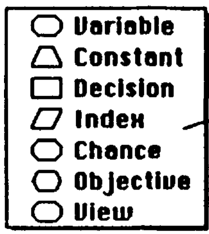
Title of the selected object.

Click in the field, and the gray **outline** will show up if the field is **editable**. When done, press the enter key to store changes.

The object window shows all of the attributes of an object together. You can edit any user-modifiable attribute directly. Inputs and outputs are not user-modifiable, since they are generated by Demos from the influence links or definitions of the variables.

You can see the object window by clicking -- I in a diagram window (see page 4), by double clicking on the object's node in its diagram window (see pages 4 or 13), or by double clicking on the object's name in the browser (see page 10).

Class popup menu



The node shape and the name show the node class of this object. You can change the class with the popup menu that appears when you press here.

This is the **variable's title**, as it appears in the node in the parent diagram. The title can occupy up to 36 characters or 3 lines.

This is the variable's name, as used in mathematical expressions. It must start with a letter, have no more than 20 characters, and contain only letters, numbers, ".", and "_" (used instead of a space).

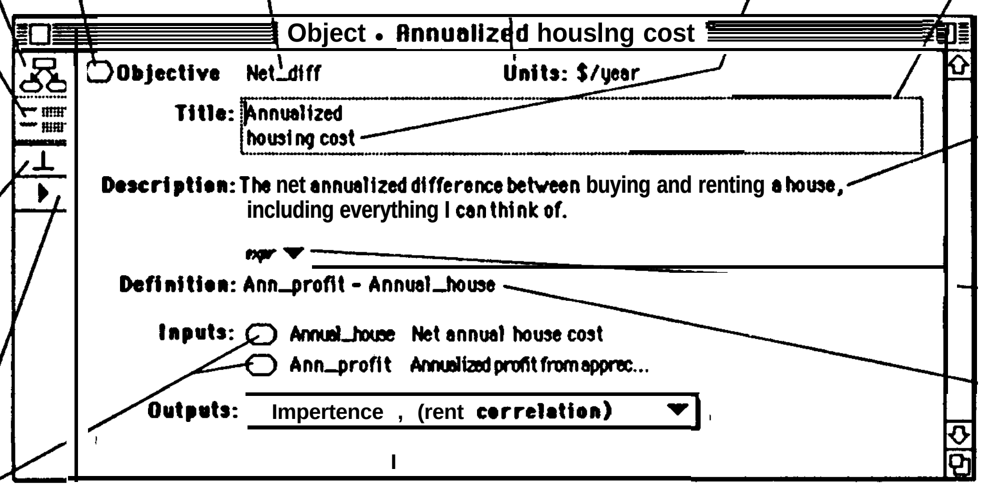
Click on any of these text fields to edit the attribute. The dotted outline shows that the attribute is ready to be edited.

Click on this icon to go to parent model diagram. If there is none, this icon is grayed out.

The **unit** of measurement

Click outside the text field again or press the enter key to accept the modified text.

Click on this icon to view the **object** window of selected node. The icon is grayed out because it is the current window shown.



The description consists of text explaining what this variable represents.

Click on this icon to view the **value** of the selected variable with the selected uncertainty view option.

The **definition type popup menu. See** page 18.

Press here to see a **popup** menu of the uncertainty view options. Choose one to view the value of the selected variable **node (see page** 4).

The definition is a number, probability distribution, or other mathematical expression from **which** to compute the value of **this variable.** See page **18 for** an **explanation of how to specify** or change it.

A list of the variable's Inputs, **i.e.**, the variables and functions appearing in **its** definition.

Double-click on an input to display that input's object window in the place of this one.

Press in the area shown to display a **popup** menu of the variable's outputs, **i.e.**, the variables and functions in whose definition this variable appears.

Select an output from the menu to display the output's object window in the place of this one.

Values in an object window

You can show the **mid** (i.e., deterministic) value of a variable and each of its inputs in that variable's object window. This is often useful for checking if a definition is calculating what you intended, and for finding mistakes in the model. If a value is a table rather than a single number, it will show a **Show Value** button instead of the value. Click on this button to display the value as a table or graph.

To see these values, first click on the object window to make sure it is active. Then select the **Show Values** option from the **Object** menu.

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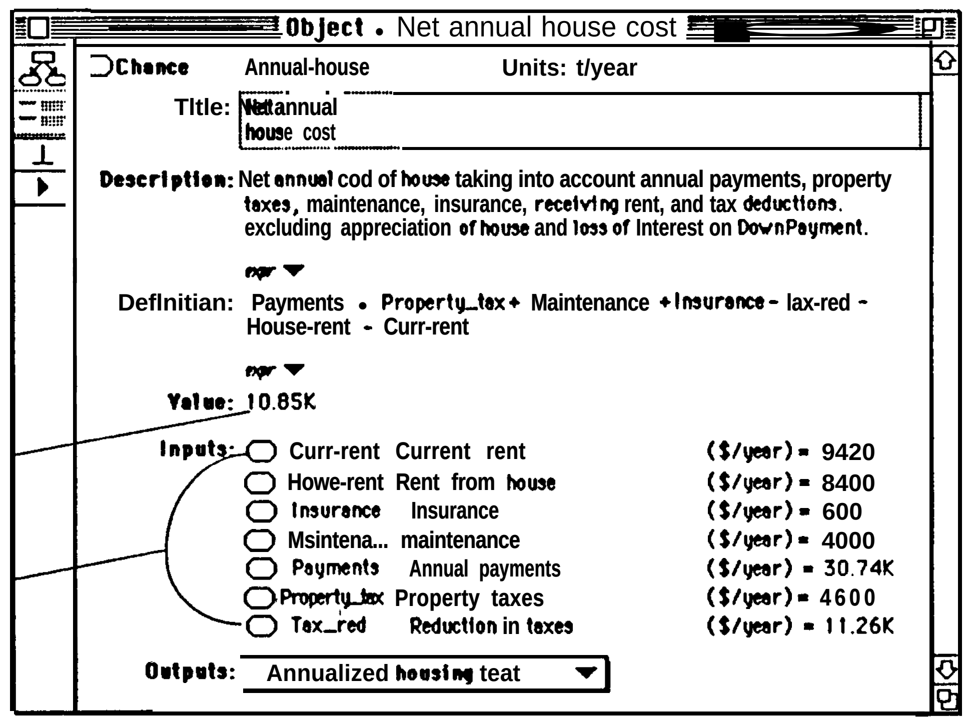


The value of the current variable is shown here.

This **is a list** of **Inputs,** with their units **and values. Double** click on an input to see **its** object window in the place of this one. **It** will also shows the input's values.

The graph window

A graph is a representation of a table value. The vertical (y axis) shows the values. If the graph has one dimension, the values of the dimension are shown horizontally (along the x axis). If it has two dimensions, you can choose which index goes along the x axis, and which is in the key, producing multiple curves. For an array with more than two dimensions, you select a two dimensional slice, using the **popup** menus at the top.

You can display **a** graph by clicking the view button, or by selecting an uncertainty view option in a diagram or object window. If the graph window shows a table, you can (usually) change it to the corresponding graph by clicking the graph button. On **a** color monitor, each curve is displayed in its own color.

Select Graph Setup (see page 25) from the **Graph** menu to change the view (x and y ranges), graph size, and three dimesnional view. Select Graph Styles (see page 26) from the Graph menu to change the frame, grid, and line forms, plotting symbols, and other options. You may also select Graph 3D Effects to control the display of the three dimensional perspective (see page 27). But this is ***not working properly yet.***

Third dimension Index: the **title(s)** of the other index **vari**able(s) if the table has 3 or more dimensions.

Double click anywhere in the graph to get the graph setup dialog box .

The **title** of the variable **whose** value is displayed here.

Click on this **icon** to go to the parent diagram containing this variable.

Click on this **icon** to view the object, window of the selected node.

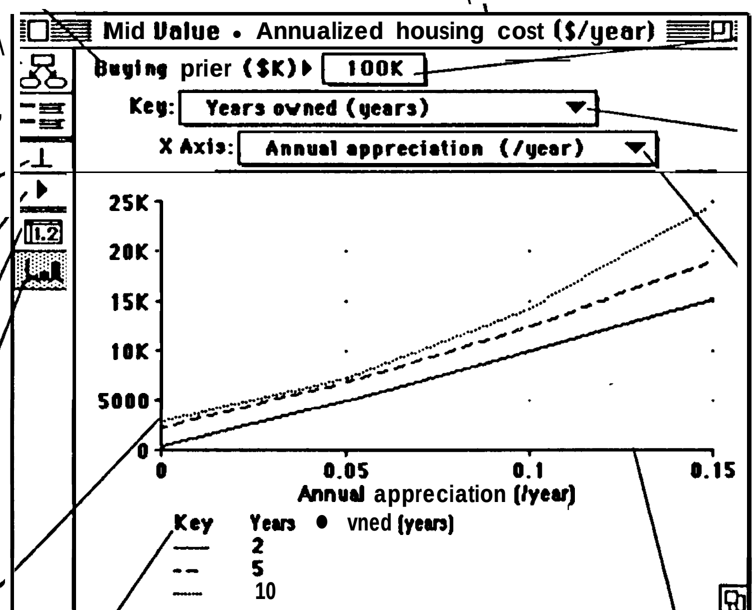
This icon indicates the uncertainty view option displayed in this window.

Click on this icon to change the uncertainty view option and to view the value in this window.

Click on this icon to view the table for this variable.

The graph icon is grayed out because you are viewing a graph of this slice of the table.

y **axis**



This key shows the value of the key index variable that corresponds to each curve, indicated by pattern or color.

This field **shows** the **value** of **this Index variable** for the two dimensional slice currently being graphed. **Press** on **it** to get a scrolling list of all the values you can select from.

Key Index: the title of the index **vari**able for each line in the graph, as specified by the key below. This title nly appears if the value has two or more dimensions. Press this triangle to show a **popup** menu of index **vari**ables to select from for the key.

X Axis Index: the title of the index variable along the horizontal edge (x axis). Press the triangle to show a **popup** menu of index variables to select from.
For example,

Annual appreciation (/year)
Years owned (years)
Buying price ($K)

x axis

Drag the grow box to expand or contract the graph.

The table window

The table window displays the value of a variable **which** has one, two, or more dimensions. You can display a table by clicking the uncertainty view button in a diagram or object window. If it shows a graph, you can change it to a table by **clicking** the table view **icon.** Each dimension is identified by an index variable.

If the value has two dimensions, you can pick, from **popup** menus, which index is displayed horizontally, and which one is displayed vertically. If it has more than two dimensions (this one has three), the table shows a two dimensional "slice". The **popup** menu(s) at the **top allow** you to select which slice to display.

The **title** of the variable whose value is displayed here.

The title (units) of the index variable identifying this two dimensional "slice".

The current value of **this** Index for this "slice". Press in this field to get a **popup** menu of all the values you can **select from.**

Click on this **icon** to go to the parent diagram containing this variable.

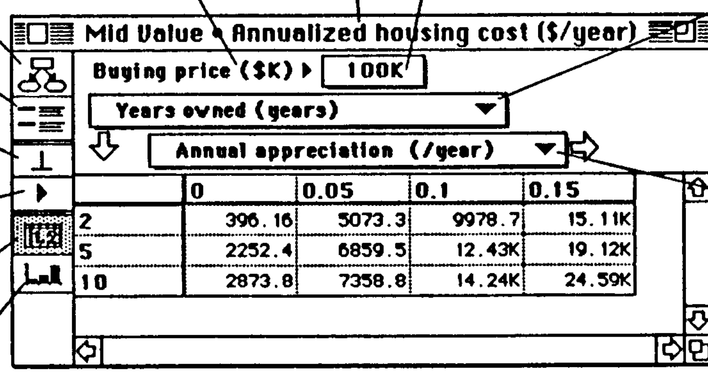
Click on this **icon** to **view** the object window of selected node.

This icon indicates which uncertainty **view option** is displayed in this window.

Press the triangle to see a **popup** menu of the uncertainty view options (see page 4) . Choose one to apply that **option** to the values.

Table vlew button: this icon is grayed out because you are **viewing** the table for this variable.

Graph vlew button: **click** on this icon to **view** this table as a graph.



This field shows the **title** and units of the index variable for the vertical dimension of the table. Press the mouse button to show a **popup** menu of the index variables you can select.

This field shows the **title** and units of the index variable for the horizontal dimension of the table. Press the mouse button to show a **popup** menu of the index variable you can select.

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The browser

This window shows a **scrollable** alphabetical list of all the objects inside a model. Click once on an item **in the list to** select **it. Click twice on** a model to browse it, or click twice on a variable to see its object window. You can also see and edit attributes of any selected object in the attribute view at the bottom of the window.

Select **Browse** from the **Object** menu to see this window.

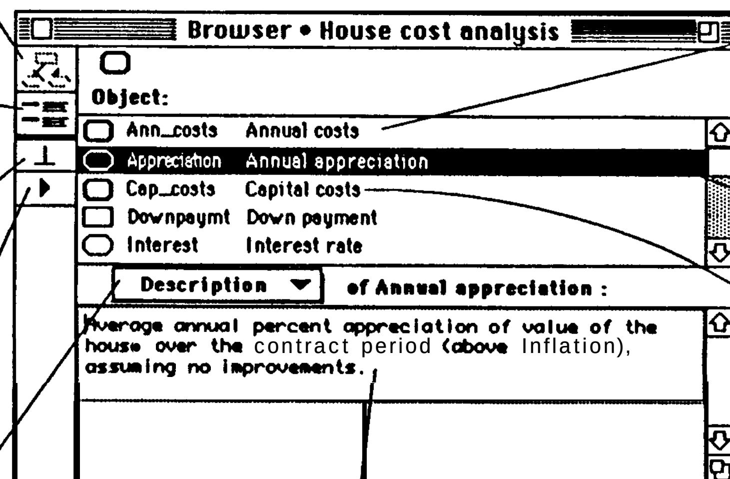
Click on this kon to display the parent diagram. This is grayed out if the current window\ displays the top model.

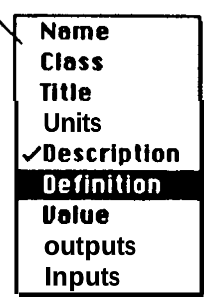
Click on this icon to open the object window for the selected object (see page 6).

Clii on this **icon** to **view** the value of the selected variable node in the selected uncertainty view option.

Click on this icon to change the uncertainty **view** option and to view the value of the selected variable node.

Attribute popup menu: pressing on this box displays **a popup menu** of attributes, from which you can select any attribute to display.





This is a **list** of variables, **sub-**models, functions, and other ob**jects** in the current model. Click on an object to select it.

-The selected object is highlighted.

'Double **click** on a model to see what is in it. Double click on any other object to see its object window (see page 6).

This **field** describes the current contents of this attribute of the selected object. If the attribute is user-soecifiable, YOU can edit it directly, by clicking in this text field.

It's easy to end up with an enormous number of windows cluttering your screen. The best number and arrangement depends on the size of your screen(s), what you want to do, and your personal taste.

If you ask to show a window (object, diagram, graph, or table) that is already on the screen, but perhaps hidden under other windows, Demos moves the one you asked for to the top. You can also select **Bring to front** from the **Window** menu to see the current windows and select which one to display on top.

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Diagram windows

When you open the diagram window for a submodel of your current model, it will create a new window, leaving its parent window on the screen. However, if another submodel of the current diagram is already displayed, it will replace that by this submodel. Thus, Demos encourages you to have not more than one diagram window open for each model level open at any one time.

But if you want to see together two "sibling" diagrams, i.e. models at the same level, press the Command key when you double click on the node (or other button) to open the second diagram. This will create a new diagram without closing any existing one.

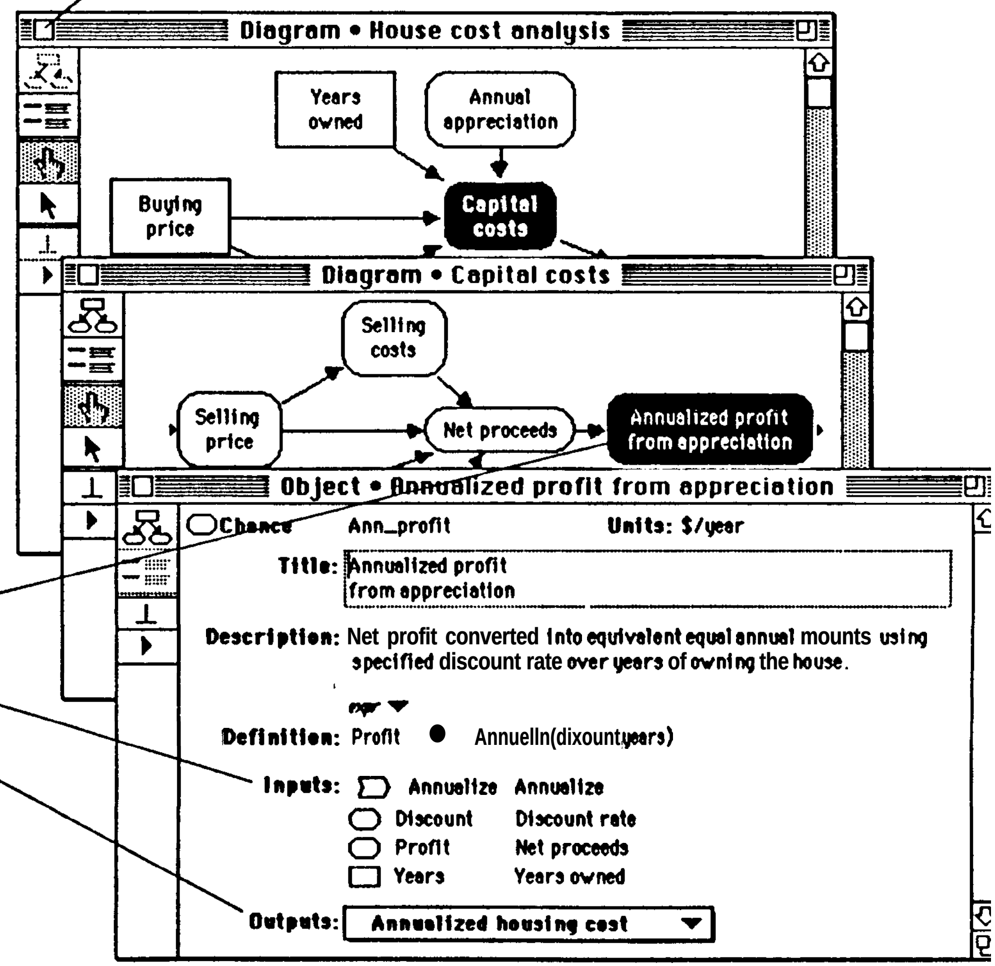
Object windows

You can open an object window:

1. By clicking on its node in its parent diagram, or
2. By clicking on the inputs list, or
3. By selecting from the outputs popup menu of a linked object

If an object window is already displayed, it will display the new object in that window. Otherwise, it will create a new object window. But if you press the Command key while clicking to display the object, it will create another window. Hence you can display two object windows at once.

If you find your screen over crowded, you can always close any window by clicking in its close box.



The project object window

The project object window shows information **about** the project, such as its author(s), creation, and save dates, as well as a description. When you **start** a new Demos project, it will show an object window for the new project, initially untitled. You should start by filling out the name and/or title fields and the description. Enter your name into the author(s) field. The creation and save dates, and the file name are filled in automatically.

You can start a new **project** by **clicking** the **New** button in the file dialog box on page 3, or selecting **New Project** from the **File** menu.

Behind a new project window is a **blank** diagram window. When you have finished entering information into the the projed window, bring the diagram to the front by clicking on the **diagram** button, or anywhere on the diagram window. You can then draw a new diagram for the model (see page 13).

A project may contain several models, modules, or libraries. Each model, module, and library has **its** own diagram, and also its own object window looking much like this project object window.

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Diagram button: Ctii on this **icon** to show the diagram window.

The descrlptbn can **accommodate** one or more lines of text describing what this model **is** for.

This field contains the name(s) of the **author(s)** of this model. Edit it if you don't wish to use your computer's Chooser name.

This **field** displays the date this model was first started.

This **field** displays the date this model was last saved into a file. n. is left blank if you are currently working on **a new** model.

The **file** Info attribute **describes** the file name, folder, **and** disk **containing** the project.

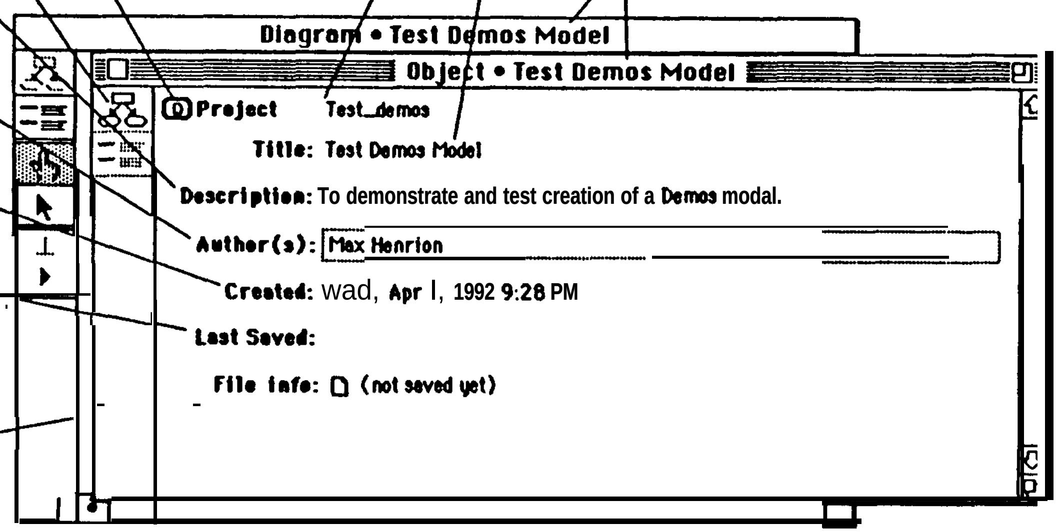
Note: These dates and file info are generated automatically and cannot be edited.

The **class** of this object. **Press** to see a **popup menu of** model classes.

The **title** of this model. It can **be up to 36 characters on up to 3 lines.**

The name of this model. It **can be up to 20 characters with no spaces.**

The title (or name if no title) becomes **the name** of these windows.



Click on the diagram window behind the object window to bring it to the front so you can create **a** diagram.

A diagram in edit mode

This diagram window is in edit mode, so you can create new nodes, and move or modify existing ones. When a diagram window first opens it will be in browse mode (see page **4**), so you can examine, but not change, the diagram. You can switch to edit mode by clicking on the edit tool. See page 14 for an explanation of how to copy and paste nodes. See page 15 on how to draw arrows. See page 14 and 32 on how to reformat and tidy up diagrams.

Click on this icon to see the parent diagram

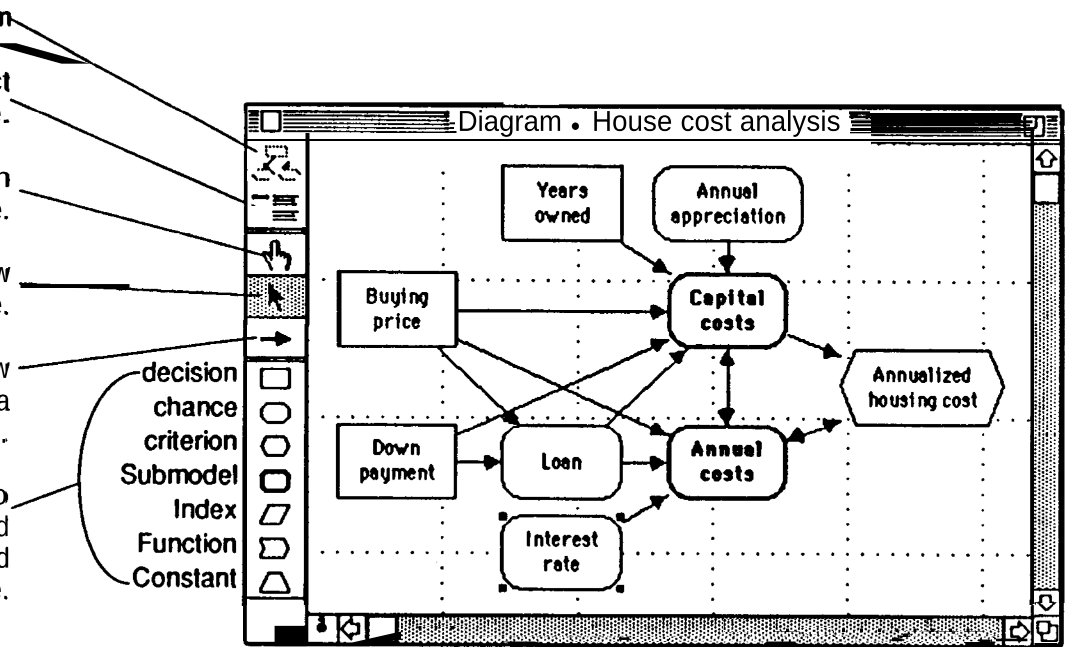
Click on this kon to view the object window of selected node.

Click on the hand icon to switch back to browse mode.

The edit tool is grayed out to show you are in edit mode.

Click on the arrow icon to enter link arrow mode. The cursor changes to a **right** arrow (see page 15).

Node menu: **click** on one of the **icons** to create a new node of the selected type. Then use the keyboard to enter the node's title.



Working wtth Nodes

To move a node: simply drag it **by** any part other than a handle.

Toselect **a node:** single click on it.

Handles indicate that **a node has** been selected.

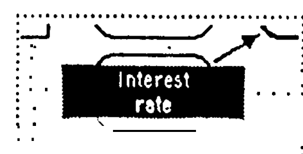
To **change the size and shape** of a node: drag a handle until the node is the size and shape you desire.

To open up the object wtndow of **a** node: double click on the node. See page 6 for details on the object window.

To deselect all nodes: Click anywhere except on a node.

To delete the selected node(s), choose **Delete** from the **Edit menu, or press the delete** key. Demos will ask for confirmation to make sure you really mean it.

To edlt the **tltle** of a node, first select it, then click on its text. It will look like the illustration to the right. When finished, the node will be automatically resized to fit.



Hint: Leave a little pause between the click to select the node and the click to select the text to avoid having Demos intepret it as a double click, which will open up its object window.

More advanced editing of diagrams

Additional commands available for the diagram window in edit mode are selecting mutliple nodes and copying and pasting nodes.

Other editing options including diagram and node style preferences are found in the **Diagram** menu. See page 32 for details.

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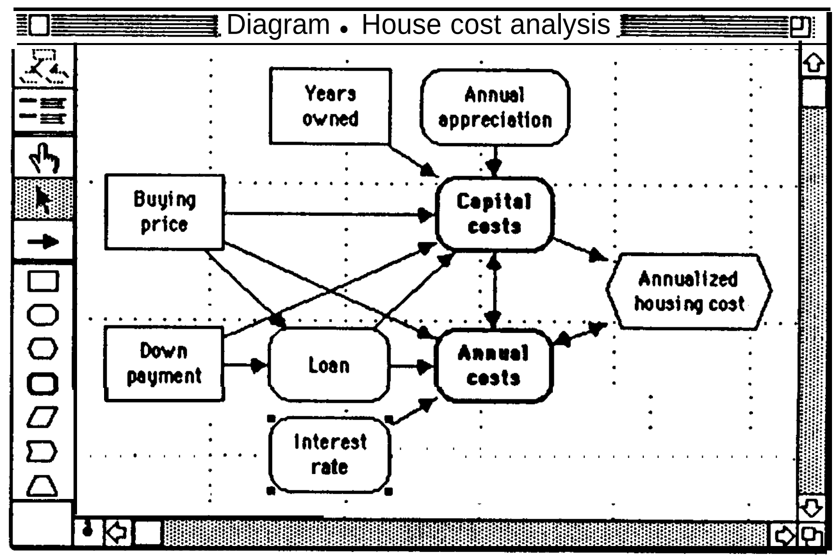
To select multiple **nodes:** either single click on a node while pressing the shift key to add the node to the set of selected nodes (or to remove it if it is already selected). Alternately, drag **a** rectangle, using the cursor, **around** the nodes you wish to select in order to select all the **nodes** inside it. You can drag all of the selected nodes as a group.



Copylng **and pastlng nodes:**

If you want to make nodes with a lot of information in common, you can use the traditional Macintosh copy and paste options. Initially the copies will be identical except for their names which may have numbers appended to make them unique.

To copy **a** selected node into the clipboard, select **Copy** from the **Edit menu or type ⌘-C.**

To **paste a selected node** from the clipboard into this diagram window, select **Paste** from the **Edit** menu or type **⌘-Y.**

You can also paste nodes (the entire graphic representation including arrows) into MacDraw, and similar graphics **applica-**tions.

To cut **a** node (and its object window) into the clipboard, select **Cut** from the **Edit** menu **or type ⌘-X.**

When a diagram window is in arrow mode, you can draw or remove arrows (influences) between nodes. You get into the arrow mode from the edit mode by clicking on the arrow kon ➔ in a diagram window (see page 13). If the diagram is in browse mode, you must first click on the edit button ↖ to go into edit mode (see page 4).

When you draw **an arrow from a variable** node A to a variable B, Demos will create the definition of B **as "FunctionOf(A)".** This means that B is some, as yet unspecified, function of A. If B already has a specified function, it will first ask if you want to change ft. Drawing arrows from other variables into B will add them to its definition. You can then edit the definition of B to specify the **form** of the function. If you type in the names of additional variables into the definition of B, **or remove variables** from **it,** arrows will be automatically drawn or removed to refled these dependencies (see page 18).

If you try to draw an **arrow from a** variable into **a submodel** (or from a model **into a variable),** Demos will ask **if** you want to create an alias of the variable **inside** the submodel. See page 17 for details. You can also link variables in different models by temporarily moving the variable into the same model. See page 16 for more **information.**

A cyclic dependency occurs when a variable depends on itself directly or indirectly, so that the arrows form a directed circular path. Demos will not allow cyclic dependencies except in dynamic models; **it** will **warn** you **if** you try to create one.

In a dynamic model **it** is possible to have cyclic dependencies provided variables depend on their values in an earlier time period. Influence arrows are not displayed for dependencies on an earlier time period, and so even then, no cycles will be visible. See Chapter 18, "Dynamic Simulation", of the Demos User's Manual for details.

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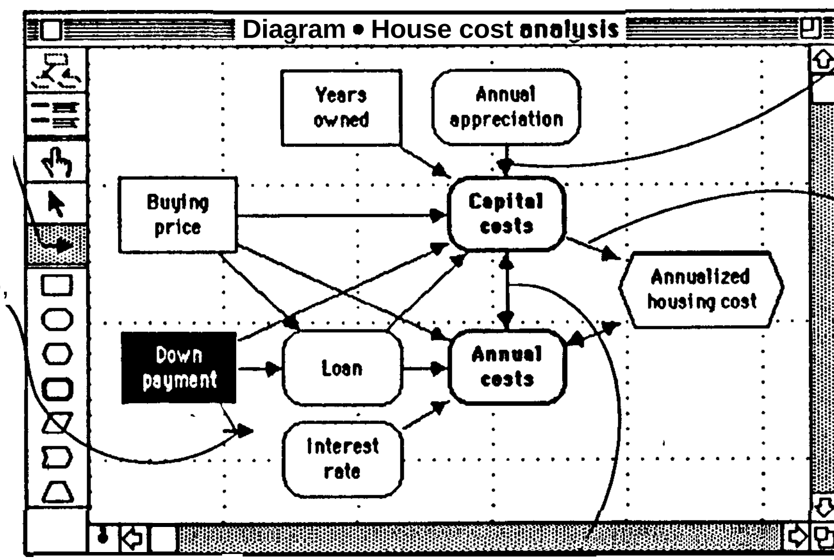
This kon is grayed out to show that you are in **arrow mode.**

To draw an arrow: Move the cursor to the origin node and press the mouse button. The node will be highlighted. Holding the button down, drag the line to the destination node, which will also, become highlighted. Release the button and the **arrow** will be drawn.

To remove **an arrow: Simply do** the same thing as **if** you were trying to draw a second arrow over the first from the origin to the destination.



Arrows and Model nodes: An arrow from a node into a **submodel** indicates that there is at least one variable in the **submodel** depending **on the origin node**

Similarly, an arrow from a submodel to a node indicates that the node depends on at least one variable in the submodel.

If you select **multiple** origin nodes (click on a node holding the shift key to add **it** to the selection), then arrows will be drawn simultaneously from each origin node to the destination node.

A double headed **arrow between two** nodes means that each model contains both inputs and outputs of the other model.

When you create a dependency between two variables in different models, an arrow will automatically appear between the models that contain them or between one variable and the model that contains the other. But you cannot draw arrows directly between models, or between variables in different models. If you want to link variables in different models, it is often easiest to move the variables temporarily into the same model , so you can then draw the desired links directly. When finished, you move the variables back to their proper parent models, and the links between the relevant models will be drawn automatically. This method is illustrated below.

Another method is simply to edit the definitions of the variables, typing in the names of the inputs directly. You may wish to choose **View** by **Name** from the Ob**ject** menu (or type ✖ -I) to remind you of the **variable** names. The relevant arrows will appear automatically when the definition is accepted. A third method is to use an alias (see page 17).

Example : Suppose we want to draw an arrow from the variable *Years* owned to the variable ***Selling price*** in another model.

Step **1:** Moving the variables into the same model.

There are two ways to accomplish the move: One way is to drag one variable (in this example, *Years* owned) into the **submodel** (in this case, *Capital **costs***) which contains the other variable. This is what is done in this example. Alternately, you can move the second variable, ***(Selling price,*** in this case) up into its parent's parent mode, by selecting it, and choosing the **Move Into Parent** command in the Object menu. Either way both variables end up in the same model.

Step 2: Draw an arrow between the variables. Select the arrow tool and **click** on the first variable (Years owned). Drag the arrow over the second variable until it **is** highlighted and release the mouse. An arrow is drawn from the first variable to the second.

Step 3: Move the variables back ihto their original models.

You first need to reverse Step 1. Select the first variable node *(Years owned)* **and choose Moue into Parent** from the **Object** menu. An arrow will appear **from** the first variable to the submodel.

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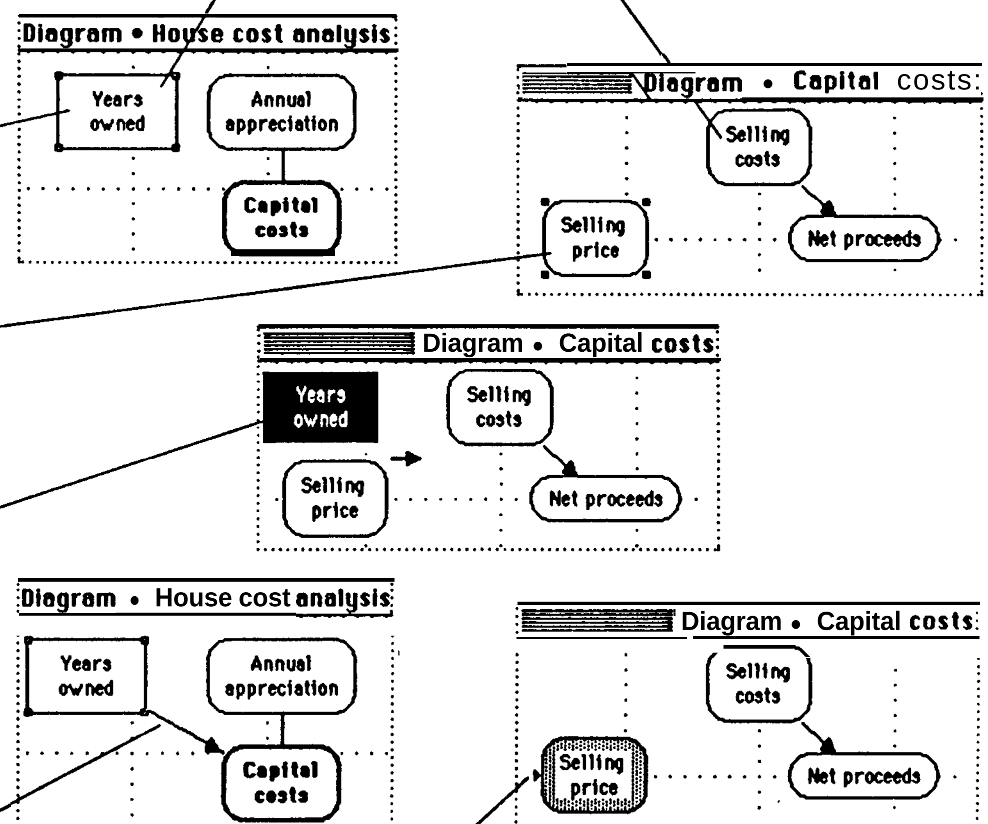

This small arrowhead indicates **that this** node has an input from another model.

Using aliases

When you draw an arrow using the arrow tool from a variable to a submodel, Demos assumes that you want that variable to influence another variable in the submodel, so it asks you if you want to create an alias of the variable in the submodel. An alias is a reference to the original variable. It appears the same as the original, except its title is in italics. If you double-click on the alias, you will get the object window of the original object.

You can also create an alias by selecting a node and choosing the **Make Alias** command in the **Object** menu. You can then use **Moue Into Parent** from the **Object** menu to move the alias into the parent model, and into other submodels. If you locate an alias in a submodel of the original variable, an arrow will appear going into the submodel even though the variable doesn't yet influence any variables in the submodel. Presently, you cannot use aliases to represent influences coming out of models. If you attempt to draw an arrow from a submodel to a variable, or from one submodel to another submodel, Demos won't do anything.

If you draw an arrow from an alias to second variable, a dependency is created from the original variable of the alias to the second variable. II you draw an arrow from a second variable to the alias, a dependency is created from the second variable to the original variable of the alias.

√

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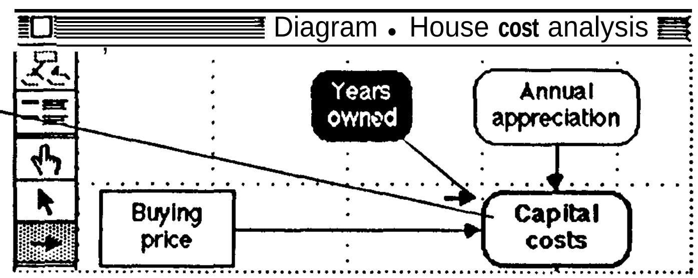
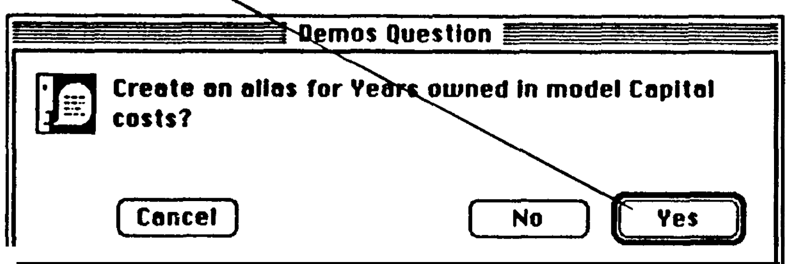
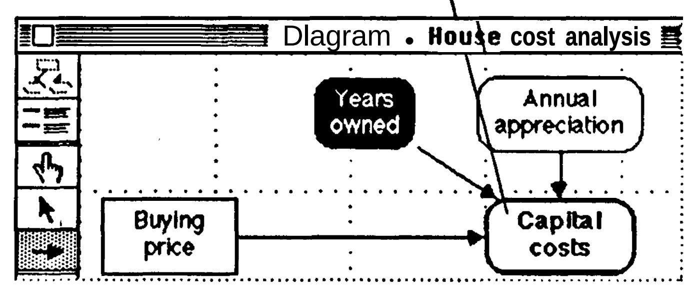
If you draw an arrow from a variable to a submodel as shown here, you will be asked if you want to create an alias in the submodel.

Click Yes to create the alias of the variable in the submodel.



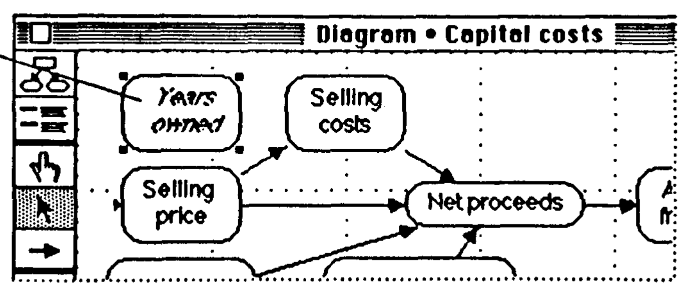


If you open the submodel, the alias will appear in the top-left comer of the window.



Although the dependency is ambiguous (and in fact no dependencies have been specified yet with variables in the submodel) Demos draws an arrow going in the submodel.

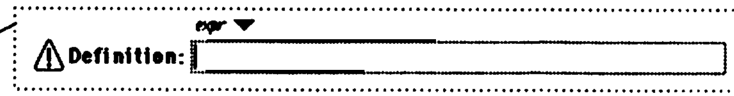
This is the alias for Years owned, with its text in italics. If you doubleclii on this node, you will get the object window for the original variable.



The definition of a variable may be a simple number, a text string, a **probability** distribution, or a more complicated expression. It can also be a list or table of numbers, text strings, distributions, or expressions. The **popup** menu above the definition field shows the class of the current definition, **initially** defined as an expression. You can inspect and edit the definition of a variable either in its object window, as shown below, or by selecting **Definition** in the attribute view of the diagram (see page 5).

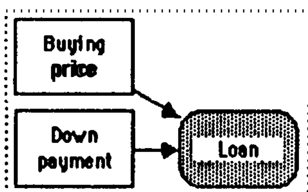
If you want to enter a definition that is a simple number, text string, probability distribution, or other expression, you can just click on the definition field to select it, and type in the expression you want to change it to. See page 38 for the syntax for numbers and simple expressions. After you have selected the definition field by clicking in it, look at the functions menu for lists of the various kinds of functions and operators that you can use in an expression. If you select an option from the functions menu, it will be copied into the definition field at the cursor position. See page 39-45 for **descriptions** of functions and operators in Demos.

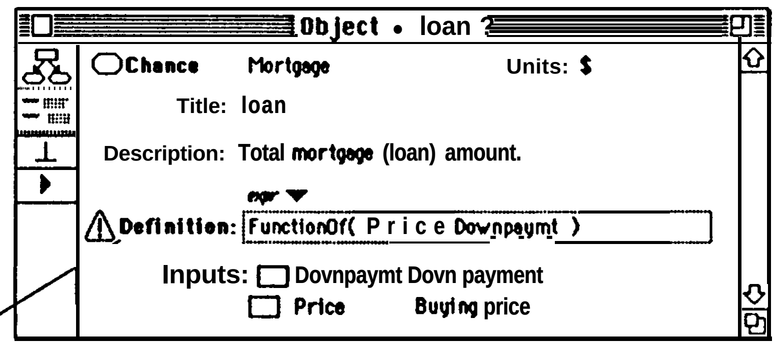
First, display the current definition of the variable. You can show this in its object window (see page 6) or **attribute** view (see page 5).



If the variable has no inputs, **its** definition may be blank.'

If the inputs to a variable have been specified by drawing arrows on the **diagram,e.g.,**

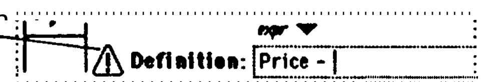


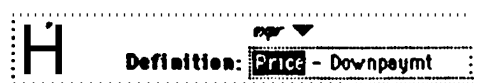


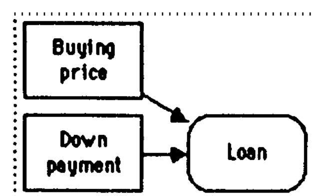
then the definition will **look** like this. This definition shows what the variable depends on, but not the form of the dependence.

Click on the definition, and edit it using the standard Macintosh text edit operators, select, copy **(⌘-C)**, cut **(⌘-X)**, and paste **(⌘-V)**. If the inputs are shown in a **FunctionOf()** form, you can edit them to specify the expression without having to retype the variable names. **If** you want to be reminded of the names and parameters of standard Demos operators and functions, select them from the **Library** menu. **If** you select an option from the **Library** menu, that function or variable will be copied into the definition at the cursor position.

The definition warning sign shows if the definition is not yet syntactically correct. Click on the icon if you want to see a message about what may be wrong. As soon as a variable has a syntactically correct definition. its node in the influence diagram will go from gray to clear.







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A list is an ordered set of values, numbers or text strings. The value of an index variable must be a list. It is also possible to specify a list as the definition of a decision variable or chance variable, specifying the discrete set of alternative values it can take. If you specify that the definition of variable A is a list, then any variable B that depends on A will be automatically evaluated for every value of A. So the value of B will be an array, indexed by A. The array can be looked at as a table or graph. It will show how B varies according to the value of A. This is termed a parametric analysis, and is often very useful. It is possible to specify lists as definitions of two, three, or more variables together to perform a multiway parametric analysis.

To specify a deinition of a variable as a list, first show its definition, either in the variables object window (see page 6), or in the diagram attribute view (see page 5).

Then presson the Expression type and select L is t from the popup menu.

If the variable already has a deinition, it ill confirm that you want to replace it. Click on the Yes button it you do want to replace it.

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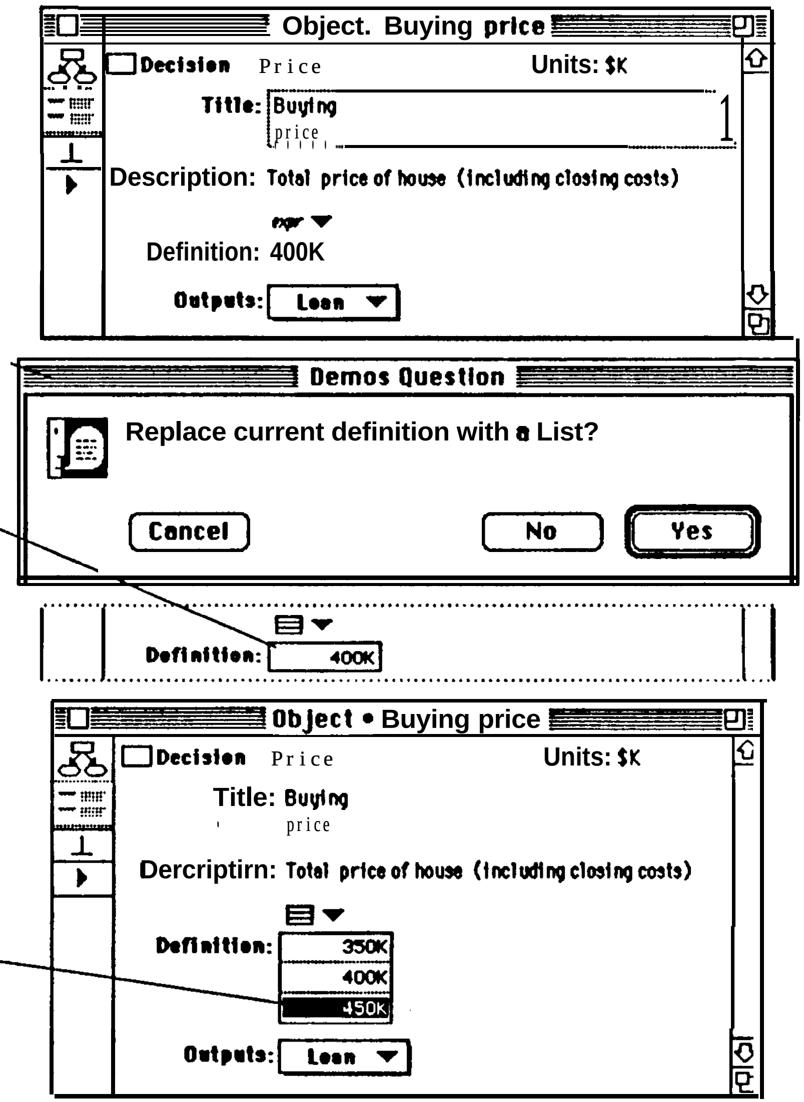
The definition is replaced with a one-element list.

Select the first cell and enter the first value. Each time you press the *return* key at the bottom of the list, an additional cell is added to the list.

If a list element is a text string or label, remember to enclose it in single quotes. You can enter any kind of number, function, or expression as an element of a list.

Up arrow and Down arrow keys will move the cursor up and down the list. Press the option and *return* keys simultaneously to insert a cell after the current cell. Press the delete key once to delete the contents of a cell; press it twice to remove the cell.

If you try to add or delete an element of a list that is an index of an edit table, Demos will ask for confirmation that you want to change the table. If you click on the Yes button, Demos will add or remove the corresponding cell, row, column, or slice of any tables that this list indexes.

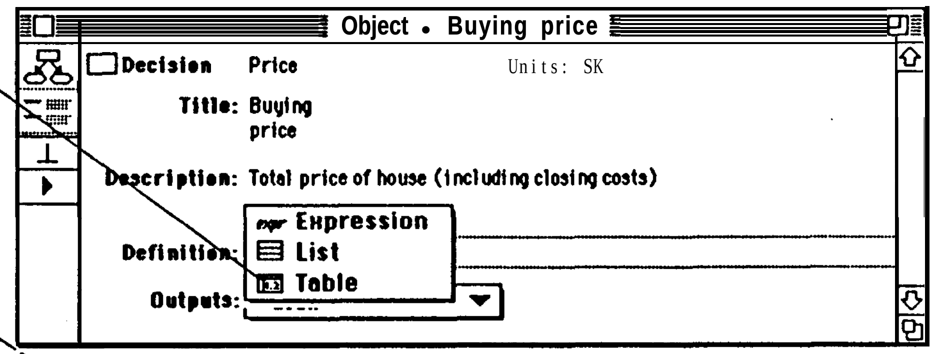


Creating a table

The edit table window shows a table and lets you enter and edit numbers or expressions into each cell of the table. If you want to specify that the **defini-**tion of a variable is to be **a table,** you select Table from the expression **popup** menu, just above the definition field. This will work both in an object window and attribute view. Demos will then ask you to choose which index variables you want to specify for the table's dimensions.

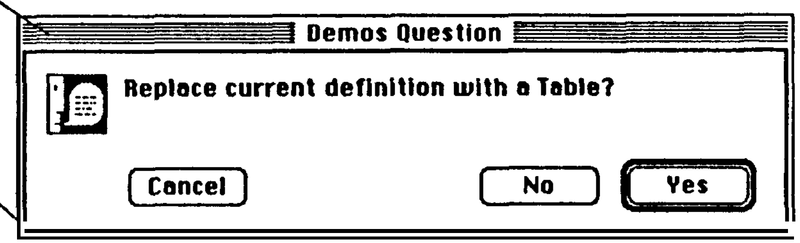
If the definitiin of a variable is already a table, an **Edit Table** button will appear in the definition. Click on it to see the edit table window (see page 21).

If the definition is not yet a table, first select Table from the expression type **popup** menu above the def**inition** field.



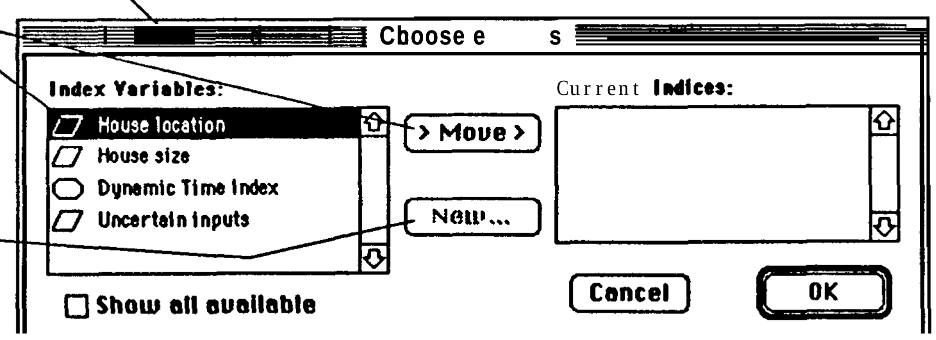
If the variable already has **a** definition, Demos will ask you if you want to replace the current definition with a table. Clii on the Yes button (unless you change your mind).

C-278



Demos will **now show the Choose Indices** window, to allow you to specify the dimensions of the table. **The** number of indices you choose will determine the number of dimensions.

Click on an index to select ft. Then **click** on the Move button to make it a current index.



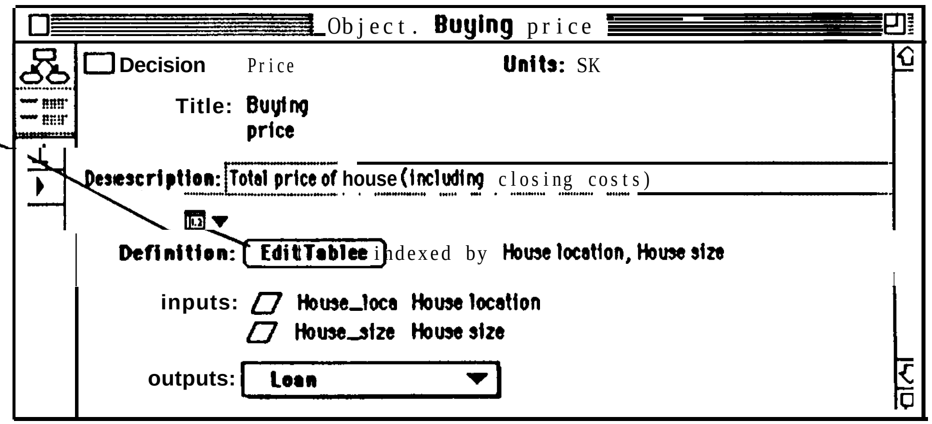
The New button is not currently **available. You** should make sure you create any needed indices before you create **a table.** Each index should be defined as a list of values

After selecting the indices, the edit table window will **appear** (see page 21).

Editing a table

The edit table window **looks very** much like the table window (see page **9),** but you can add indices and edit the cells directly in the edit table window. Although they look similar, it is important to be aware of the difference, since you cannot edit the standard table window.

If you close an edit table and haven't yet **clicked** on the Accept or **Revert** buttons, Demos asks you if you want to accept changes before closing the window. Clicking on the **Cancel** button won't close the window.



You open the edit table window by **clicking** the on the **Edit** Table button in the object window (see page 6) or in the attribute view (see page 5).

Pressing on this button will display **a popup** menu from which to select the index that specifies the rows, instead of the columns, if the table **has** more than one dimension.

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Click on a cell to select it.

Drag the mouse from one cell to another to select **a** rectangular region.

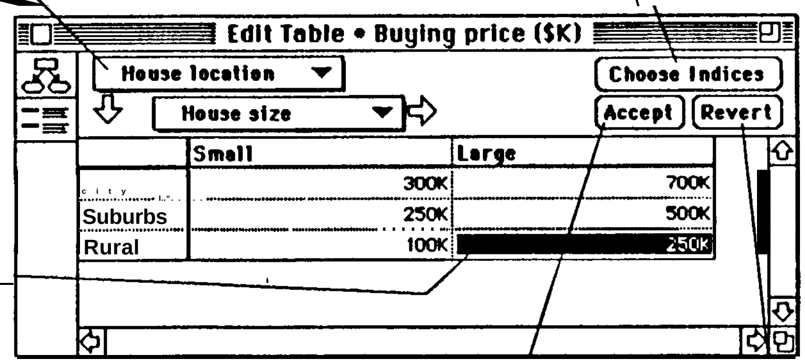
Press the ***return*** key to accept this cell and to select the next cell.

Note: To add or delete **cells,** rows or **columns** in a table, you need to edit (add or delete) the definition of the corresponding indices. The affected table cells will then automatically be added or removed.

Remember to put single quotes (e.g., **'Low') around text** values.

You can copy **a** cell or **a range** (w two dimensional rectangular region) of cells from **a** table. Select the cell **or region. Then choose Copy from the Edit menu (⌘-** C). You can paste these into another **cell** or region.

Click on the **Choose Indices** button to add more indices or to increase the number of dimensions. Any new index of size ***n*** will cause the current table to be copied with its current values ***n*** times, along the new dimension.

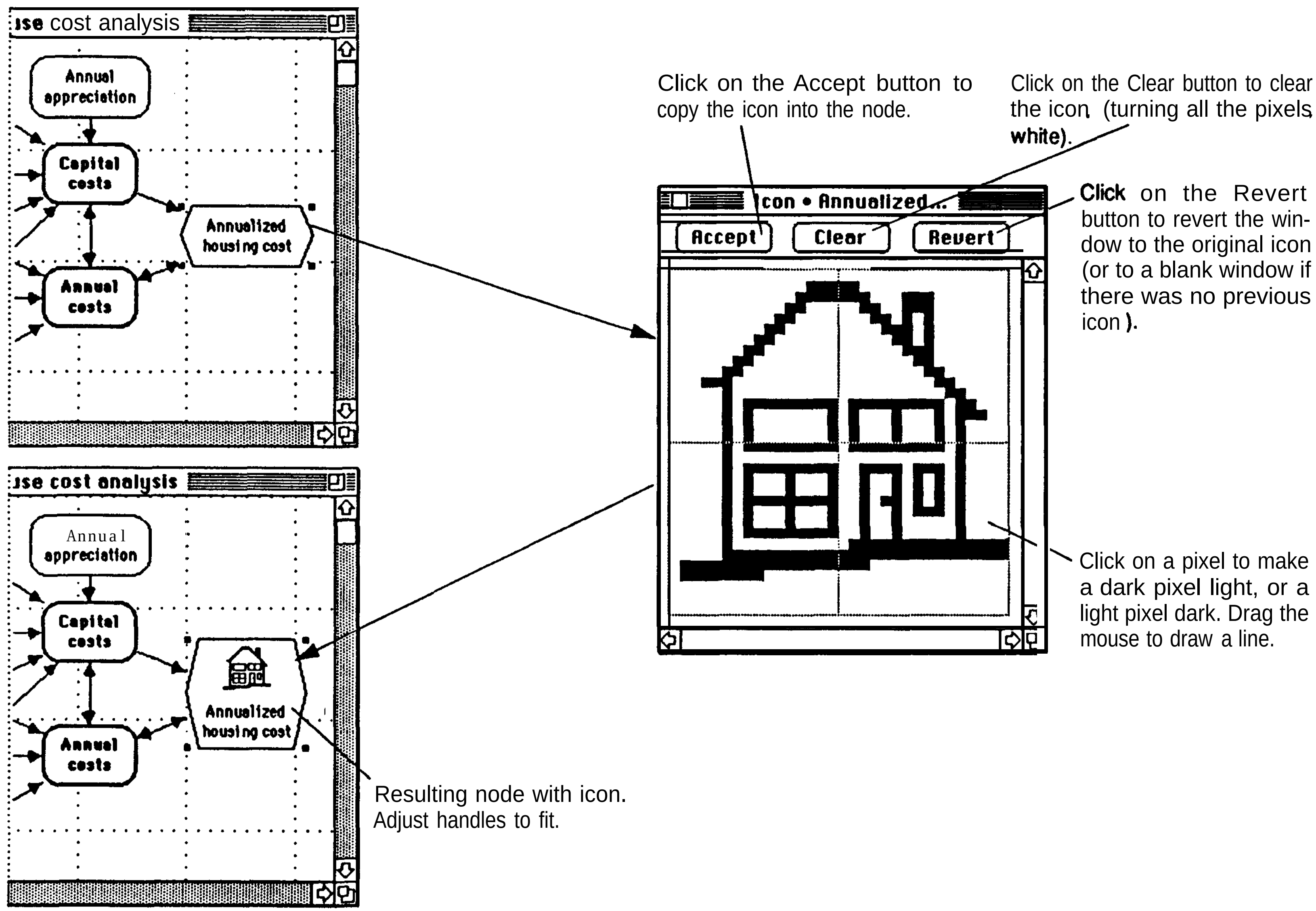


Click on the **Accept** button to store changes you have made.

Click on the **Revert** button to discard changes since opening the window, or since the last time you cliied on the Accept button.

Adding icons to diagram nodes

You can add an icon for any node in a diagram. First, make sure that the diagram is in edit mode, and select the node you wish to illustrate (click on the node). Then select **Edit icon** from the **Edit** menu to get the icon **window**. This shows a much enlarged space for drawing or editing an icon. You can draw or edit the icon one pixel at a time by mouse clicks, or you can draw lines if you hold the mouse button down.

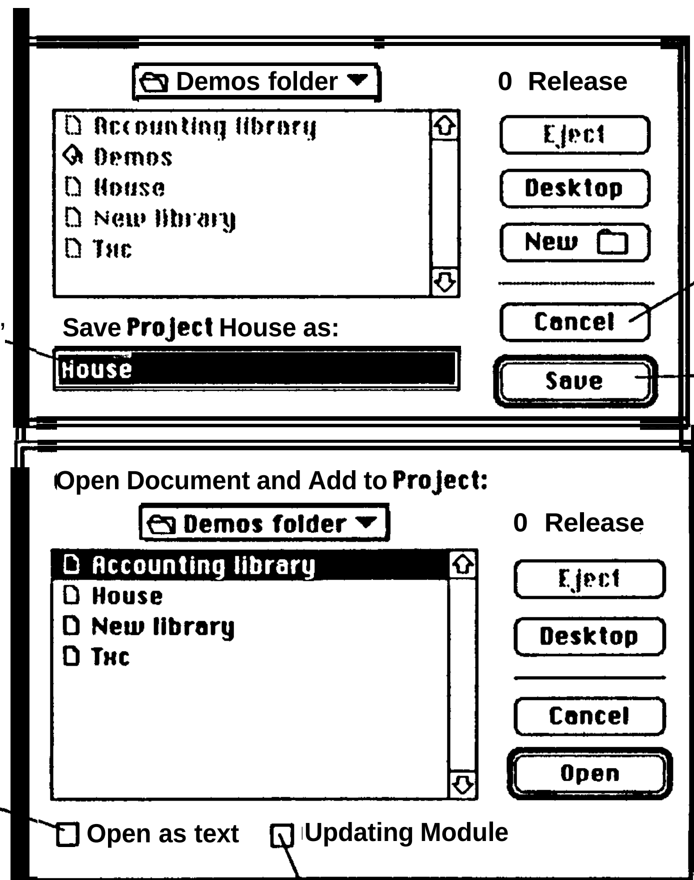


The top dialog box displayed on this page lets you save the project as **a** file on disk. You will see this dialog box the first time you try to save a model by selecting **Saue** from the **File** menu **(⌘-S)**, and whenever you select Saue **as** from the **File** menu.

The bottom dialog box displayed on this page lets you open a file to read it in as the project, or to add it to the currently open project. If the file contains any objects with the same names as objects in the current project, and you want to **overwrite** the existing objects with the attributes of the objects from the file without any warnings, then click on the **Updating Module** check box. This option is useful if the file contains updates or modifications to create a different version of the project.

If you **click** on the Open as text check box, Demos will instead show you the file as text, and will not add the file to the project. This will let you inspect or edit the project as a text file. See page 29 for more information. We do not recommend this procedure for users other than Demos experts.

This is the name of the file in, which the model is to be saved. **Click** In this field to edit the file name.



Don't save the model by clicking on the **Cancel** button.

Click on the **Save** button to save the model using current options.

Click in the Open as text check box to open the **document** in **a** text editing window rather **than** adding the document to the project.

Clii in the **Updatlng Module** check box to allow the document to redeclare existing objects **and** redefine existing attributes.

The preferences dialog box allows you to inspect and set a variety of **preferences** for the operation of Demos. It controls how Demos **does** probabilistic evaluation, the sample size it uses, whether it defaults to a table or graphs, and so on.

Select **Preferences** **(⌘-B)** from the **Edit** menu to see this dialog box. Any changed values will be saved along with your model when you save it .

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Sample Size: enter the number of runs for the model to **perform** to estimate probability distributions. Larger samples will take more time and memory to compute, **but produce smoother distributions** and more precise statistics.

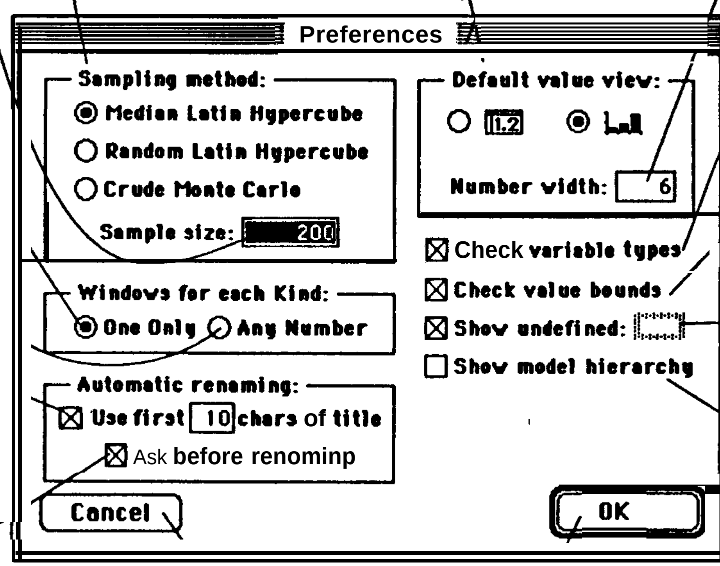
Windows for each Kind: when you create **a** new object window Demos will close an existing object window (if any) if One only is chosen, unless you press the Command key as you create the new window. **If Any Number is** selected, it will not reuse or **close a** window unless you **close** it explicitly by clicking in its close box.

Automatic Renaming: click in the Use first check box it you want Demos to automatically rename a variable when you change its title. Demos will use up to the specified characters (10 by default, from 2 to **20),** replacing spaces and returns with _ (underscore).'

Click in the **Ask before renaming check box if you want Demos to ask you** for **confirmation before it renames the variable.**

Sampling method: the items in this box represent different ways of generating random values from a probability distribution. Demos provides standard Monte **Carlo** simulation and two variants of Latin Hypercube sampling (see Section 9.7 of the Demos **User's** Manual for details).

Default value view determines whether a table or graph appears initially when using the uncertainty view selector options to open **a** value window.



Click on the **Cancel** button to **ignore any changes and** to revert to previous settings.

Cliikon the **OK** button to accept changes.

The Number width field controls the maximum number of characters used in **display**ing a number.

Check variable types: click in this box if you want Demos to report when a **vari**able's value is inconsistent with its class (see Chapter 7 of the Demos **User's** Manual).

Check value bounds: click in this box if you want Demos to compute any check attributes.

Show undefined: click in this box if you want Demos to fill undefined nodes with a gray border

Show model hierarchy: clicking on this box shows a bar at the top of diagram windows to indicate hierarchy depth and other navigation options.

Graph setup dialog box

The graph setup dialog box allows you to override the default view ranges for the x and y axes, change the default size of the graph, and to choose whether or not to select a three **dimensional** perspective view.

You display this **box by** selecting the **Graph Setup from** the **Graph** menu. You can also display it by double clicking **in** a graph window. If you open this box when a graph is the active window, the parameters will apply only to that graph. Otherwise they will be the new defaults for all new graphs.

Click in the **Frame Axis Min/Max Values** check box to control **whethe** the frame ranges on the axes are computed automatically. You must uncheck this box before you can edit the minimum and maximum fields for each axis.

Click in the **3-Dimensional** check box to show the graph in a three **dimensional perspective** view. *This **feature** is not **working** well yet.*

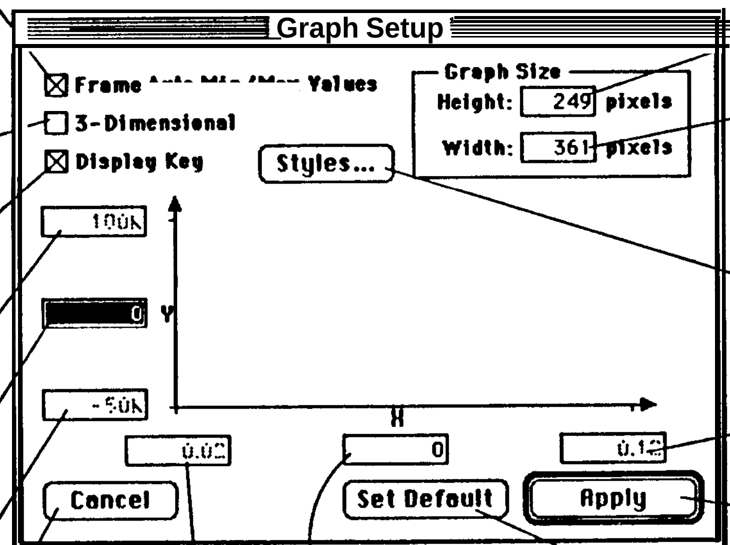
Click in the **Display Key box** to show the Key (for two or more dimensions).

Enter the y axis maximum value in this field.

This field determines the number of intervals between **tick** marks along the y axis.

This **field** determines the y axis **minimum** value.

Click on the **Cancel** button to **close** the box, leaving values as they were before.



Enter the x axis minimum **value** in this field.

This **field** determines the **number** of intervals between **tick** marks **along** the x axis.

You can enter the initial default height and width of the graph view as shown on the screen measured in pixels (72 per inch). You can later resize a graph with its **growbox.**

Note: Small numbers are interpreted as inches for compatibility with earlier versions of Demos.

Click in the **Syles** button to display the graph styles **dialog** box (see page 26).

Enter the x axis maximum value in this field.

Click on the **Apply** button to apply the current setting to the current graph.

Click on the **Set Default** button to accept changed values for the current graphs and all Mure graphs.

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Graph styles dialog box

The graph styles dialog box **allows** you to inspect and change the style parameters for **a** graph, or the defaults for all graphs. You get this box by selecting **Graph Styles** from the **Graph** menu, or from **clicking** on the Styles button in the graph setup **dialog** box.

If you open this window when a graph is the active window, the parameters will apply only to that graph. Otherwise they will be the defaults for all new graphs.

The **Grid** box allows you to control whether the **grid** is comprised of dots or lines.

Line Style: set the line, **sym-bol,** dot and bar chart styles for the graphs.

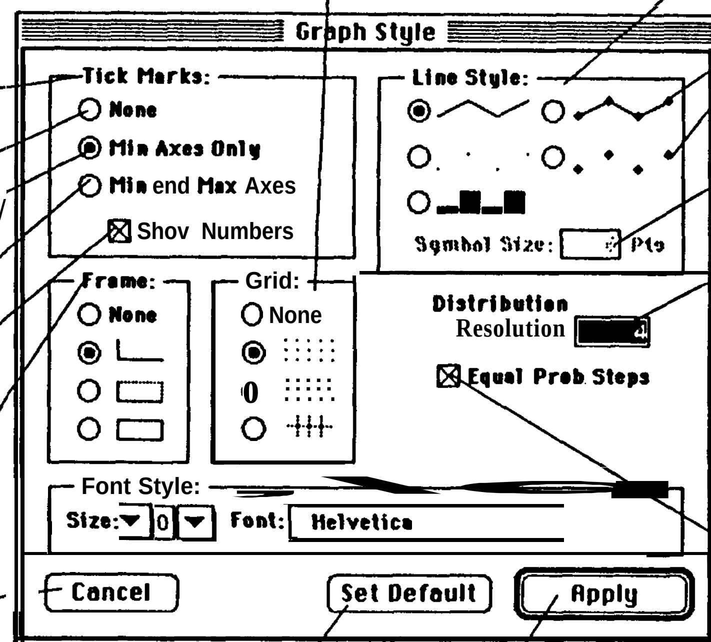
These two styles show a symbol at each plot point. Enter the desired size of the symbols in typographic points in the **Sym-bol Size box.**

The Tick Marks box controls **how** the tick marks appear along the axes:

None: display no tick **marks.**
Min Axes Only: display tick/ marks **along** the bottom and left hand axes.
Min and Max Axes: display tick marks all around the frame.
Show Numbers: click in this box if you would like numbers to be shown along the axes.

Frame: controls whether the graph displays the axes or a frame around it.

Clickon the **Cancel** button to **close** the box and keep the original settings.



Distribution Resolu-tion. when displaying a proba-bility distribution such as a **Pdf** or Cdf, the samples are sorted into *n* intervals. The number of intervals used is calculated from the sample size divided by the distribution resolution. Increase the distribution resolution to **pro-duce** a smoother curve.

When **Equal Prob Steps is** checked, an equal number of values is used for each interval **plot** point in **a** Pdl or Cdf. If it is not checked, Demos uses equal x interval steps in the range of values being **plotted.**

Click on the **Set Default** button to accept changed **val-ues** for the current graphs and all future graphs.

Clii on-the **Apply** button to apply the current setting to the current graph.

Graph 3D effects dialog box

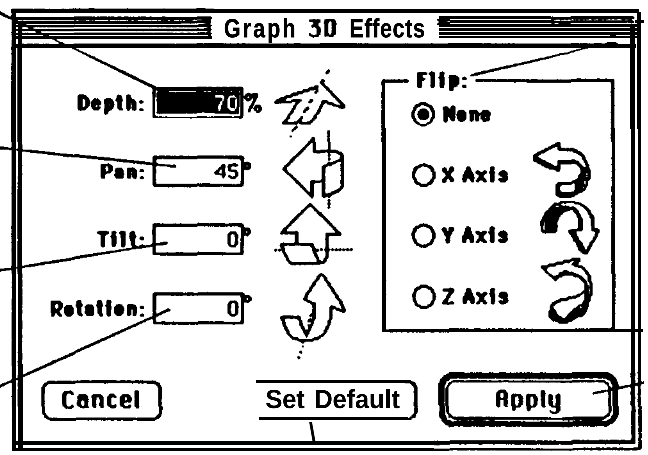
This dialog box controls the point of view for perspective display of three dimensional graphs. Mu can display it by selecting 3D **Effects** in the **Graph** menu, or by clicking on the 3D **Effects** button in the graph setup dialog box (when it is displayed in a three dimensional view). Three ***dimensional graphs are not working properly yet, and we do not recommend using them..***

The Depth field allows you to control the apparenl distance and, hence, the relative size of the front and back planes of the graph.

The **Pan** field allows you to control the rotation of the graph around **a** vertical axis (y-axis).

The Tilt field gives you control over the **rotation** of the graph around **a hori**zontal axis **(x-axis).**

The Rotation field allows you to control the rotation of **the** graph around an axis going into the graph (z-axis).



The Flip box **allows** you **to** determine whether or not to transpose the positive direction of each axis. Clicking in the radii button transposes the positive direction of the axis listed.

Click on the **Apply** button to apply the current setting to the current graph..

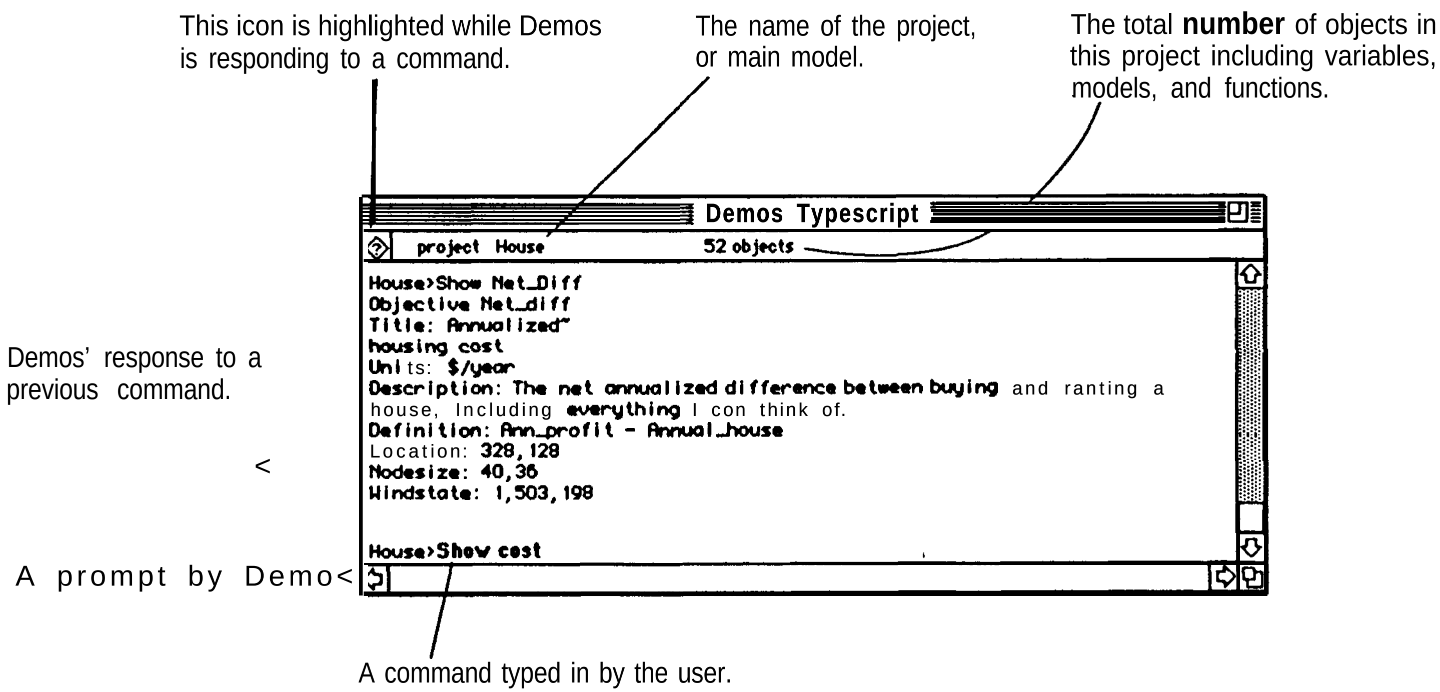
Click on the **Set Default** button to **accept** changed values for the current graphs and all future graphs.

Typescript window

The typescript window provides an old-fashioned teletype-style interface to Demos, familiar to those who have used non-graphical user interfaces. You can type commands on the last line after the prompt. Demos prints its response below. Choose **Show Typescript** from the **Window** menu to see this window.

Most users will not need to use the **typescript** window. Almost all its features are available more conveniently via buttons, text fields, **direct** graphic manipulation, and menu options in other windows. The typescript window contains a record of recent changes, operations, and error messages that are sometimes useful for debugging unexpected behavior. Expert users may occasionally find it useful.

Choose **Hide Typescript** from the **Window menu** to make it go away again.



A Demos model is saved between sessions as one or more model files. A model file is simply a text document. You can examine and edit any model file file, including the file from which the current model was started, or the file into which it was last saved. You do this by clicking the Open **as text** check box in the file open dialog box.

Making changes to this document will have no effect on the current model unless and until it is closed and read in using the **Read** in option from the **File** menu.

You can also create a new text document with the New **Text** option in the **File** menu. This can be useful for making notes on the model.

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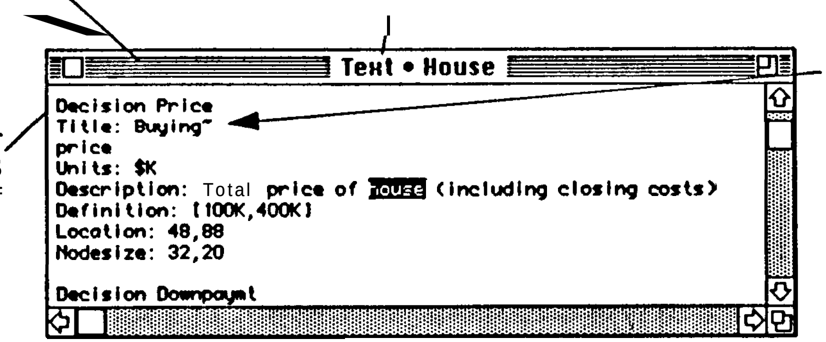
This is **a** standard Macintosh text editing window. Click anywhere to place the editing cursor, or drag the mouse to select text.

The name of the text file

Each Demos object (dedsion, **vari**able, model, function) is specified by its class and name, followed by a list of user-specified attrfbutes.



This high hyphen indicates that the attribute value continues on the next line.

This field shows the location and size, in pixels, of the node in its parent diagram window.

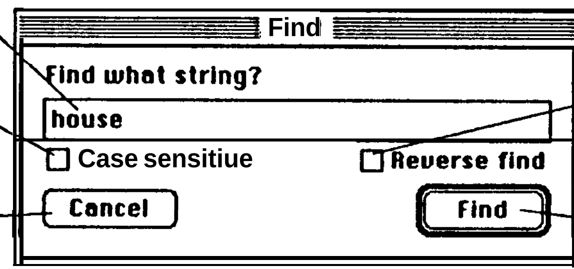
Find dialog boxes

This facility allows you to search **a** text document for a particular text string, e.g., to find a particular variable by name, or to search through the project for a particular **object.** To display this **box, select Find** from the **Edit** menu **(⌘-F).**

Type the string you are **looking** for in this **field.**

Click in the **Case sensitive** check box to have the search match the **string** by case, **as** well.

Clii to the **Cancel** button to cancel the search.



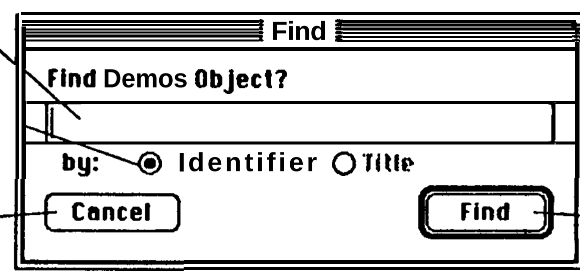
Click in the Reverse Find check box to search the file backwards from the cursor position.

Click ~~on the Find~~ button to initiate a search.

Type the name (identifier) of the Demos object you are looking for in this field.

Presently, you can only search by identifier, but the **ability** to search by title is a feature that will be added.

Click on the **Cancel** button tb close the window without starting **a** search.



Click on the **Find** button to initiate a search.

The memory usage window gives information about how much RAM memory the project is using, and the number of objects and sample size that affect it. This window appears automatically when Demos runs bw on memory. To display it at other times, select **Memory Usage** from the **Window** menu.

If you run bw on memory, and your Macintosh has sufficient RAM available, you can increase the memory assigned to Demos. The RAM Memory initially assigned to Demos is 1500 Kilobytes (1.5 Megabytes) in the regular version (Mac II, Mac SE or other machine with a FPU). If your Macintosh has more RAM available, you can increase the RAM allocated to Demos.

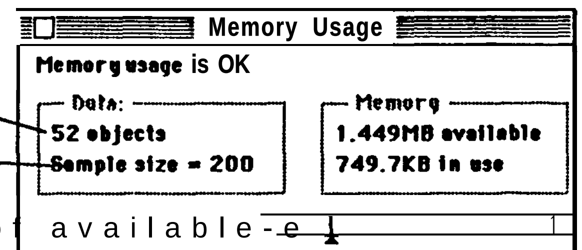
In order to find out how much memory your system requires, select **About thls Macintosh (About the Finder** for system 6 and earlier) from the finder's Apple menu. Then size Demos accordingly.

If your Macintosh is running operating system 7, you can use virtual memory, and assign more memory to Demos than you have RAM available. This will allow you to run larger models but may reduce the speed of Demos noticeably.

The number of user-defined variables and other ojects.

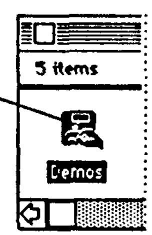
Current sample size (you might want to reduce it if you are having memory problems).

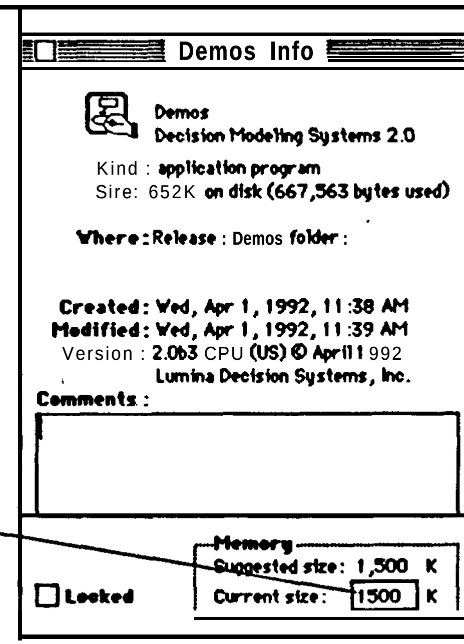
Shows proportion of available memory currently used.



You can change the initial suggested memory size in the standard Macintosh way, as follows:

1. Make sure Demos is not currently running.
2. Select the Demos application by single clicking on it to highlight it. (Not a double click which would start to run Demos.)
3. Select the **Get** Info **(⌘-I)** option from the **File** menu. **This will** display the Info box for Demos.
4. Enter the amount of memory, in kilobytes, to be assigned to Demos. This is the maximum it can use.
5. **Close** the Info window.
6. **Start** up **Demos** in **the usual** way (see page **1**).





The diagram style dialog box lets you control various aspects of how a diagram is displayed. It lets you control the font style and size for the node labels, whether arrows are displayed for specified node types, and whether the background should be gray (on a monitor that can show grayscales or colors). You can display this dialog box by selecting **Diagram style** from the **Diagram** menu. **The Diagram** menu is available only when the diagram is in edit mode.

The node style dialog box lets you control how a node is displayed in a diagram. It lets you specify the font style and size, and whether to display the incoming arrows, outgoing arrows, the node outline, icon, or label. The options for each node will override the defaults specified for the entire diagram. To change the node style, you must first select a node in edit mode.

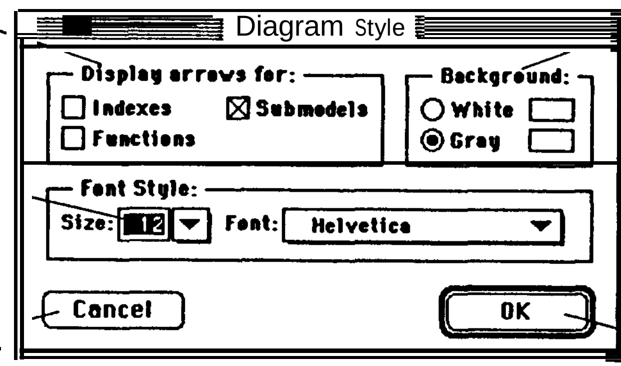
Then select **Node style** from the **Diagram** menu. The other menu options in the **Diagram** menu help you create tidy, clearly arranged diagrams. When the grid is on (the default) each node you create or move will be centered on a grid point. This makes it easier to position nodes so that the arrows are exactly horizontal or vertical when the nodes are side by side, or one above the other. If nodes get inexplicably off center, the Align **to grid** command in the **Diagram** menu may help adjust the selected node(s).

Adjust to text in the **Diagram** menu will change the size of the selected node(s) so that they just enclose the node label.

Turn on **or off** the **display of arrows** into and out of index variables, functions, and submodels.

Set the **font style** for all of the nodes in the diagram.

Click on the **Cancel** button to discard any changes.



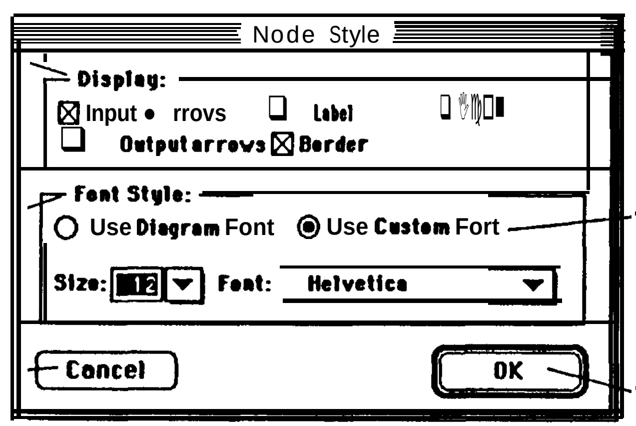
Set background **color** behind nodes to white or **gray**

Click on the **OK** button to accept changes.

Turn on **or off display** of input arrows, output arrows, **label** (title), border, and icon.

Set the font style for the selected node in the diagram.

Click on the **Cancel button to** discard any changes.



Font Style: use the diagram font style, or set a custom font style for this node.

Clii on the OK button to accept changes.

File menu

The **File** menu contains file opening and saving commands.

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Starts a new project.

Opens a previously saved project.

Closes the active window.

Closes the current project.

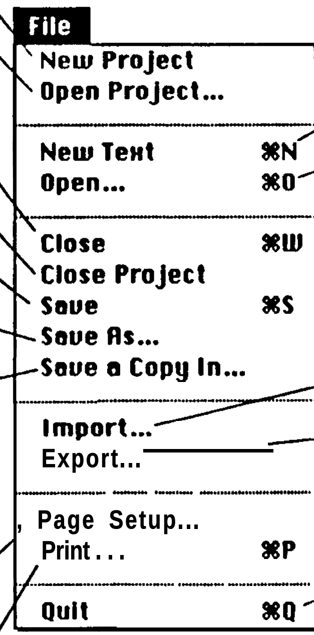
Saves the current **project** to a file, and each module and library to its file.,

Saves the current module as a new file. It will prompt for the file name and **its** folder.

Saves **a** copy of the current **module** into a new file, leaving **its** current file name for future saves. **It** will prompt for the new file name and its folder.
file into the current view.

Displays a **dialog** box in which you can select paper size, **orientation** and other printing options.

Displays a **dialog box** in which you can specify the number of copies you want to print and other **printing** options.



Creates a new text file.

Opens **a** saved library or module and adds it to the current project.

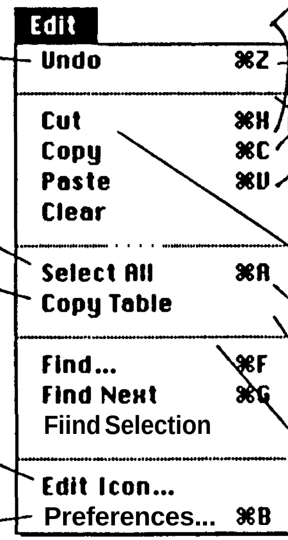
Imports the contents of a text or data

Exports the contents of the current view into a file.

Quits the Demos application program. It will ask if you want to save any changes.

Edit menu

The Edit menu contains commands to manipulate text or graphics, find a Demos object, display the Preferences dialog, and other options.



Undo: Undoes your last action.

Cut: Cuts the selected text, nodes, graph or table cells into clipboard **temporarily for pasting.**

Copy: Copies the selected text, nodes, **graph or table cells into clipboard temporarily.**

Paste: Pastes the contents of the clipboard after the cursor or replaces the **current selection.**

Clear: Deletes selected text or node.

Select All: Selects all text, nodes, or table cells.

Copy Table: Copies the entire multidimensional value as a tab-delimited list of tables.

Find...: Displays a dialog box to find text or a node by its **name ~~(identifier)~~.**

Find Next: Finds the previously found text again.

Find Selection: **Finds a node by its name ~~(identifier)~~ that matches the currently selected text.**

Edit Icon...: Opens a window to edit the icon for the selected node.

Preferences...: Displays ~~a~~ **dialog** box to examine or change the sampling method, number of samples, number format and other preferences.

The Object menu ontains Demos object commands.

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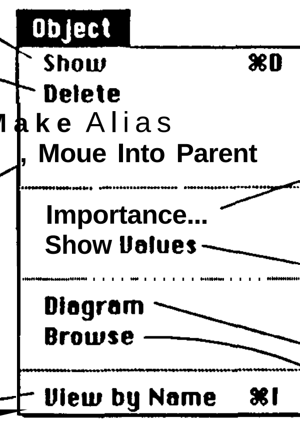


Shows the currently selected object in an object window.

Deletes the selected object.

Creates an alias for the selected object. An alias is a reference to the original object. You can move the alias node into a submodel.

Moves the selected object from the current diagram to its parent diagram.

Each node in this diagram Is labeled by the objects title. Select this item to show by name (identifier).

Creates an Index and Chance variable for the selected variable to compute the uncertainty importance (rank correlation) contributions of its inputs.

Select to show the values of the variable and all its inputs.

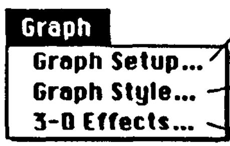
Open the Diagram for the selected model.

Open the Browser window to examine the model hierarchy and the objects in each model.

Graph and Library menus

The **Graph** menu contains commands for changing the setup and style of graphs.

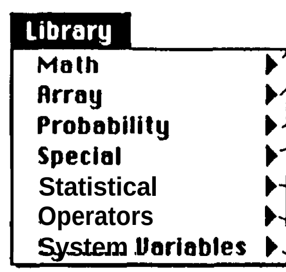
The **Libray** menu lists builf-in system function libraries, as well as any libraries of user-defined functions that are currently open. If you are editing a definition, selecting **a** function pastes the function name and parameter types at the insertion point.



Displays dialog box to specify the default size and frame of view for the graph.

Displays a dialog box to specify the style for drawing graphs.

Displays **a** dialog box to specify 3-D effects for graphs.



Displays **a** list of the standard mathematical functions available.

Displays a list of functions for creating and transforming arrays.

Displays functions for specifying probability distributions.

Displays special functions available in Demos.

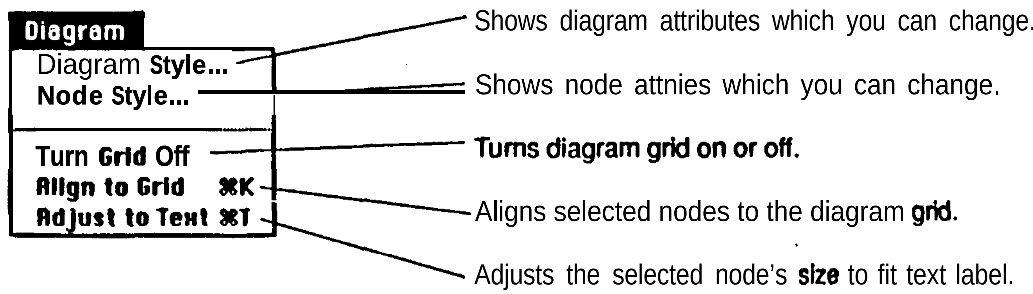
Displays statistical functions available in **Demos.**

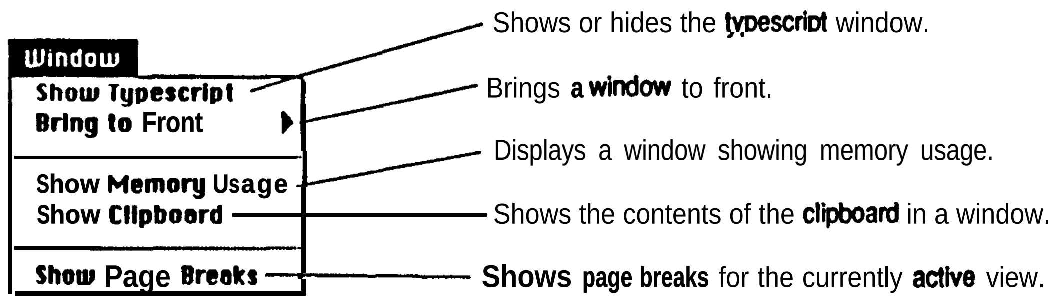
Displays a list of arithmetic, comparison, logical, and conditional operators.

Displays **a list of System variables** which you can use in definitions.

The **Diagram** menu contains commands for changing the display of diagram arrows, fonts, and other diagram editing commands.

The **Window** menu contains commands for bringing windows to front, or opening special windows.





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Numbers and syntax

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The following are all legal formats for entering numbers:

	EXAMPLES
Integers:	**2, 10,** 1234
Decimals:	32.5, **.0002, 0.000012345**
Character exponent:	**250K, 10.5M, 10.5m,** 22%
Exponential form:	**53E11, 1 E20, 4.5632E-25**

The signed integer after the E denotes a power of ten.
The character after the number denotes a power of ten, thus:

Power **of 10**		**Prefix**	Power **of 10**		Prefix
3	K	Kilo	-2	%	percent
6	**M**	**Mega** or Million	-3	m	**milli**
9	**B**	**Billion**	-6	u	micro (mu)
9	**G**	**Giga**	-9	n	nano
12	T	Tera or Trillion	-12	p	**pico**
15	**Q**	Quad	-15	f	femto

Range: Demos can represent numbers from about 10^{30} to 10^{-30}.
Precision: The maximum precision of numbers is up to the 6th decimal place. The actual precision may be less if, for example, the number is computed as a small difference between two almost equal numbers.

Syntax: The arithmetic expression

1/2 * 3 - 3 ^ 2 + 4

is interpreted as

(1 / 2) • 3) - (3 ^ 2) + 4

The expression

If a and b > c or d + e < f ^g then x else y + z

is interpreted as

If ((a and **(b>c))** or ((d+e) **< (f^g)))** then **x** else **(y** + **z)**

Pages39 through 45 describe the operators and system functions available in Demos.

Operators and functions often expect to work on expressions or values of a particular type. These symbols represent what type they expect:

x, y	An expression that gives a number, or an array of numbers.
u, v	An expression that **gives a** number or text string, or an array of numbers or text strings.
b, c	An expression that gives a boolean value true (1) or false (0), or an array of boolean values. Any non-zero number **is** treated as true.
a	**An** expression that yields an array of numbers.
i, j, k	The name of an index variable.
v	The name of **a** variable.
m, s, r	An expression that yields a single number **(a** scalar), not an **array.**
a	The name of an attribute.

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Arithmetic operator9

Operator	**Meaning**	Examples
+	**plus**	**3+2** → 5
-	**minus**	3-2 → **1**
.	times	3'2 → **3 × 2** → 6
/	**divided** by	**3/2** → $\frac{3}{2}$ 3 1.5
^	to the power of	**3^2** → **3²** → 9

Comparison operators

Operator	**Meaning**	Examples
<	**less than**	**2<2** → **0** **'A'<'B'** → **1**
<=	**less than or equal to**	**2<=2** → **1** **'ab'<='ab'** → **1**
=	equal to	**100=101** 3 0 **'AB'='ab'** → 0
>=	greater than or equal to	**100>=1** → 1 **'ab'>='cd'** 3 0
>	greater than	**1>2** → **0** **'a'>'A'** 3 1
<>	not equal to	**1<>2** 3 **1** **'A'<>'B'** 3 1

Logical operators

Operator	**Meaning**	**Examples**
b* AND *c	**true if both *b* and *c* are true**	**1 AND 20<2** → **0**
b* OR *c	**true if *b* or *c* or both are true, otherwise false**	**0 OR 1<2** → **1**
NOT *b*	true if ***b* Is false,** otherwise false	**NOT (2<3)** → 0

IF ***b* THEN** x **ELSE y**

For values of b that are true, x is returned: for values of b that are false, y is returned.

Abs (x)

This returns the absolute value of x.

Arctan (x)

This returns the Arctangent of x in degrees. For example, remembering the venerable trigonometric identity, Tan(x) **= Sin(x)/Cos(x),** we get: **Arctan(Sin(12.34)/Cos(** 12.34)) ➔ 12.34.

Cos (***x*** **)**

This returns the Cosine of ***x*,** in degrees.

Exp (***x*** **)**

This returns the exponential of ***x*,** i.e., e^x.

Factorial (x)

This returns the factorial of ***x*,** whkh must be positive or zero.

Ln (***x*** **)**

This returns the natural iogarithm of x. Hence, Ln(Exp(12.34)) ➔ 12.34.

Logten (x)

This returns the kg to the base 10 of x. Hence, **Logten(10^12.34)** ➔ 12.34.

Round (x)

This returns the round value of x to the nearest integer. For example, Round(l.8) 3 2, and Round(l.499) ➔ 1.

Sin (x)

This returns the Sine of ***x*,** x assumed in degrees.

Sqr (***x*** **)**

This returns the square of x.

Sqrt (***x*** **)**

This returns the square root of ***x*, which** must be positive or zero. For example, **Sqr(Sqrt(** 12.34)) ➔ 12.34.

You can use the **List** and Table options **in** the expression type **popup** to specify simple arrays and tables. Use the **Expression** optbn in the **popup** to use **[ ]** (list brackets), and **Array()** and **Table()** functions, if you need more flexibility and control in specifying arrays.

Most array functions accept an expression a that yields an array of numbers, and an index name *i*. The Index name is optional if the array is one-dimensional. **If** a has more than one dimension, the parameter *i* should be used to specify the dimension over which to perform the function.

Area (***a, i*** **)**

This computes the area under **array *a*** across Index *i*.

Array (***i1 , i2, ... in, y*** **)**

This assigns **a list** of indices, ***i1, i2***, . . . ***in*, as** the Indices **of** the array ***y***, with ***i1*** as the Index **of** the outermost dimension, 12 as the second outermost, etc. y must have **at least *n*** dimensions.

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Average (a, ***i*** **)**

This returns the mean **value** of an array, averaged over Index *i*.

Concat (***a, b, i, j, k*** **)**

This appends array ***b*** to **array *a*.** If they are **multidimensional,** then the Indexes, ***i*** and ***j*** specify the dimensions of a and ***b*** respectively **which** are to be concatenated. If specified, ***k*** is the index of the resulting dimensbn, and **will** consist of the vector created by concatenating ***i*** and ***j***.

Cumulate (***a***, I)

This returns an Array of the same dimensions as ***a*** **with** each element being the sum of all the elements of **a** along dimension ***i*** up to and including the corresponding element of ***a***.

Integrate (***a, i*** **)**

This applies the trapezoidal **rule** of Integration of **array *a*** over Index ***i*** and returns the result.

Max (***x, i*** **)**

This returns the highest valued element of x **(if** an array) along a specified Index ***i***. To get the maximum of two numbers, you must make them into an array: **Max([** a, ***b*** **])**.

MIn (x, ***i*** **)**

This returns the lowest valued element(s) of x (if an array) over a specified Index *i*. To get the minimum of two numbers, you must make them into an array: **MIn([** ***a, b*** **])**.

Normalize (*a, I)*

This normalizes array ***a***, such that the values along Index ***i*** **sum** to **1**.

Product (a, I)

This returns the product of all the elements of ***a***, **along** the dimension indexed by ***i*, The** resulting value has the dimensions of a with ***i*** removed.

Rank (***a, i*** **)**

This returns an array of the rank values of ***a*** (provided that a is an array); the **lowest** value **in *a*** has a rank value of **1,** the next-lowest has a rank value of 2, **and so** on.

Reform (***a***, *[i1 , i2, . . . In])*

This reforms a **multi-dimensional** array ***a*** in **a** sequence so that index ***i1*** is outermost, ***i2*** next outermost and so on. The Indices ***i1, i2***, etc., must he some or all of the Indices of ***a***.

Sequence (***r***, s)

This creates a one-dimensional array of successive integers from ***r*** to s. If rand s are not integers, Demos will round them first. If s is greater than ***r***, the sequence will be increasing. If ris greater than ***s***, the sequence will be in decreasing order.

Size (x)

This returns the number of elements of the outermost dimensions of an array x.

*Slice (a, **i,** x)*

This returns the ***nth*** value of array *a* over the dimension indexed by ***I.*** x must be between 1 and the length of *i.* x may also be an array **of** values, in which case, Demos will return an array of corresponding values from *a.*

Sortlndex *(a, **I**)*

This computes the ranks of *a* (from smallest to largest value) and returns the **items** of Index ***I*** **sorted** according to those ranks.

Subscript (*a, **i, u*** **)**

This gives the element of array *a* for which index I has value ***u. u*** must be one of the values of Index *i.* ***u*** may also be an array of values from index ***I,*** in which case it will produce **a** corresponding array of resulting **values** from *a.* (It Is essentially the same as ***a[i=u],*** but it allows *a* to be a general expression, instead of restricting it **to be** a variable).

Sum(***a, I***)

This sums **array** *a* over the dimension Indexed by Variable *i.*

Table (***I1*** , 12, . . . ***in*** **) (** ***u1 , u2, u3, ... um*** **)**

This creates an n-dimensional array, Indexed by the Indices ***I1,*** 12, . . . In. The number of Indices, *n may* be 1 or more. The Indices must be separated by commas and enclosed In parentheses, as shown. The second set of parameters to Table specify the values that go into the Array. These are also enclosed In parentheses, and the separating commas are optional. Each of these values is specified by an expression ***u1, u2, u3,*** . . . *urn.* The number of values required is the number of elements of the array, *m* which is the product of the sizes of all the dimensions. In this list of elements the last Index *in* is the innermost, varying most rapidly.

Uncumulate (*a, **i*** **)**

This returns an array of the same dimensions as *a.* The first element **(along *i*)** of the result is the same as the first element of a. Each other element of the result is the between the corresponding elements of *a* and the previous one. It does the opposite of Cumulate. it is like a discrete differential operator.

*[**u1 , u2, u3,** . . . urn]*

This list of expressions separated by commas and surrounded by brackets creates a one-dimensional unindexed array, i.e., a list, whose values are ***u1, u2, u3,*** . . . *urn.* When a variable whose definition contains this kind of expression is computed, the computed array becomes indexed by the variable itself. Thus, Index variables are **typically** defined in this way. This expression is also often used in the Array function expression parameter.

v [i = u]

Given ***v,*** a variable, and brackets enclosing an index variable name equal to an item value for that Index, this returns the slice or slices of ***u*** **along** that Index, like the ***Slice*** function. More than one index can be specified at a time.

Probabllfty functlons

Chancedlst (*u,* a, *i*)

This creates a discrete probability distribution with a vector of values given in *u* and their corresponding probabilities given in **a** vector of probabilities a.

Cumdlst (a, I)

This converts an array a representing cumulating probability values **along** Index *i* into a continuous probability distribution.

Fractlles ([*s0* , *s1*, *s2*. . . . *sn*])

This Is used to specify an **arbltrary** continuous distribution by a vector of *n+1* elements *si* **for** *i* from 0 to *n*, where *si* **specifies** the *i/n* **fractile** (quantile) of the distribution. The probability density is assumed uniform between the specified **fractiles** in the distribution.

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Lognormal (*m,* s)

This creates a lognormal **distributlon** with median *m* and geometric standard deviation *s.*

Normal (*m,* s)

This creates **a normal** probability**distributlon** where *m* is the mean and *s* is the standard deviation.

Probdlst (*a, i*)

This converts an array *a* representing probability **density** values **along** Index *i* **into a contlnuous** probability distributbn.

Unlform (*r, s*)

This creates a uniform distribution between values rand *s*

Statlstlcs functlons

Confbands (x)

This returns probability or **"confidence"** bands over *x*, assumed to be uncertain, for probabilities **specified** in System variable Confidences, which by default is **5%,** 25%. **50%,** 75% and 95% probability.

Correlatlon (*x,* y)

This returns the correlation from -1 to 1 between the given distributions x and y, i.e., the degree to which the two distributions are similar, where -1 means negatively correlated, 0 means no correlation, and 1 means positively correlated.

Getfract (x, y)

This returns the ***yth* fractile** of x, **i.e.,** the value which has a probability yof being greater than x. Demos evaluates x probabilistically.

Mean(x)

This returns the mean of x if H's a probabilistk value. Otherwise it simply returns x.

Mid (*x*)

This **returns** the **mid** value of an expression ***x*, i.e.** the value where all probabilistic inputs are replaced by their median values. MM forces deterministic evaluation in contexts where it would otherwise be evaluated **probabilistically.**

Rankcorrel (x, y)

This computes the rank-order **correlation** of x to *y*, which is the relative strength of the distribution(s) in x contributing to the uncertainty distribution(s) in y.

Sample (x)

This evaluates x probabillstkaily **and** returns a sample of values **from** the **distribution** of x in an array Indexed by System Variable Run.

Sdevlatlon (x)

This estimates the standard deviation of x from its sample if it is **probabilistic.** If x is not probabilistic, It returns 0.

Vvarlance (x)

This returns the variance of x **if it** is probabilistic. **If** it **isn't** it returns 0. it is spelled with two Vs so that it has a different abbreviation from variable".

Argmax (x, *i*)

This returns the corresponding value In Index *i* for which x is maximum.

a Of v

This returns the attribute a of variable **v**. This is useful for adding units, titles etc. to table and graph results. Note: Demos does not automatically recompute variables that use this expression when the attribute changes.

CublcInterp (***i*, *y*,** x)

This returns the natural cubic spline interpolated values of y along Index ***i*,** Interpolating for values of x. Index *i* must be in increasing order, and must be an Index of y. For each value of x, this function finds the nearest two values from *i* and uses a natural cubic spline between the corresponding values of y and computes the interpolated value. If x Is below the minimum value for ***i*,** then the y value corresponding to the **minimum** I value is returned; **if** x is above the maximum value for ***i*,** then the y value corresponding to the maximum *i* value is returned.

Dydx (*x*, *y*)

This returns the **derivative** of expression ywith respect to ***x*,** evaluated at current Midvalues. This shows how a small change In x affects y. The "small change" is 1 OE-6 if x-0, otherwise **x/1** 0000.

Dynamic (***x1*,** x2, . . . xn, y)

This performs dynamic simulation, used in the definition of Variables whose values change over time, and may depend on their own values at a previous time. Suppose the variable ***A*** is assigned the expression. The first ***n*** parameters are expressbns giving the values of ***A*** for the first ***n* Time periods.** The last parameter y is an expression giving the value for each subsequent **Time** period, and which may refer to the Variable in earlier **Time** periods, e.g. **it might** be ***A[Time-1]+Dx*.**

Elasticity (*y*, *x*)

This computes the percent change in y caused by a 1% change in a Variable x. It is related to Dydx thus: **Elasticity(** y, x) = Dydx(***y*,** x)****x* / *y***.

LlnearInterp (***i*, *y*,** x)

This returns linearly interpolated values **of *x*,** given y representing an arbitrary piecewise linear function. ***i*** is an Index of input values in increasing order. y is an **arrayof** the corresponding output values for the function (not necessarily increasing, and may be more than one dimension). ***i*** must be an index of y. x may be probabilistic **and/or** an Array. For each value of x, this function finds the nearest two values from ***i*** and interpolates linearly between the corresponding values from y. If x is less than the first (and smallest) value in ***i*** it returns the first value In y. If x is greater than the last (and largest) value in ***i*** it returns the last value in y.

SubIndex (x, ***y*,** I)

This returns the index value of ***i*** corresponding to value y In Array ***x*.** For example, Argmax uses SubIndex(***x*, Max(*x*, *i*), *i*)** to return the index value corresponding to the maximum value in x. If y is an array of values, an array of index values is returned.

Using ***I* :=** x Do y

This assigns a temporary variable named ***I*** the value of x and then evaluates ***y*,** assumed to be an expression **referring** to the temporary variable ***I*. *I*** is essentially the same as a user-defined function parameter. You can optionally specify a parameter type qualifier to I by adding a colon after the temporary name I, followed by the qualifier name (see page xx), as, "**: *p*.**" Demos evaluates evaluates x according to the parameter type ***p*,** You can also optionally specify an Index ***i*** to iterate over slices of x using the **keyword** In after x, followed by the Index name, as, 'In ***i*.**" Each slice will be evaluated in ***y*,** and the results will be indexed by ***i*.** You can use this special syntax for simplifying complex expressions, reducing the computational effort of your model, and to be able to pass array parameters to functions that require scalar values.

WhatIf (***y*,** x, z)

This temporarily replaces the expression z in the definition of variable x and evaluates the expression y (assumed to be a function of or dependant on the value of x), returning the result. The original definition of x is restored following **this** substitution.

A user-defined function node can be created in the diagram window in edit mode. Use the information on page 13 to create a user-defined function node, **edit** its title, and open its **object** window.

A function has one or more parameters and its definition can be an arbitrary expression containing these parameters. Parameters must be enclosed in parentheses and their names separated by commas.

By default, the expressbns you pass into your function will be evaluated according to their context, i.e., **deterministically** or probabilistically.

Controlling the evaluation of functions

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The default qualifier type **Is Context,** or **Expr** (the two keywords are equivalent In Demos). To apply a different parameter type qualifier to a parameter or parameters:

- separate qualifiers from parameters by colons, e.g., (x : **Prob)**
- apply a qualifier to all parameters by using commas to separate the parameters and placing the qualifier after all the parameters, e.g., (x,y: **Prob)**
- apply **a** qualifier to only one parameter by **separating** the list using semicolons, e.g., in the parameter (*x;* y : **Prob),** the qualifier **Prob** only applies to y
- separate multiple parameter-qualifier pairs by semi-colons, e.g., (x **: IndexT; y : Prob).**

Function parameter type qualifiers

ArrayType

Specifies that the parameter should be an Array of one or more Dimensions.

Ascending

Specifies that the parameter should be. a one-dimensional list of increasing values.

Context, Expr

Default qualifier for user-defined functbns. Demos **evalutes Function** parameters according to their surrounding **context unless you apply specific qualifiers to them.**

Determ

Used if the parameter should always be evaluated **deterministically.**

IndexType

Used if the parameter should always be an index, **i.e,** a list.

Numeric

Used if **a** parameter should be a number, or an array of numbers.

Positive

Used if a parameter should be a single **positive** value.

Prob

Used to evaluate the parameter probabilistically (if possible).

Samp

Used to evaluate the parameter probabalistically and checks that it is one-dimensional (i.e., one array of sample values indexed by Run).

Scalar

Used if a parameter should be **a single** number (scalar).

Unevaluated

Used if a parameter should not be evaluated, e.g., if it Is an Array of text strings.

Vector

Used **if** a **parameter** should be a single dimension, i.e., a set **of** scalar **numbers.**

An array is a collect&n of numbers (or text strings) that can be treated as a single unit. Arrays are part of what makes Demos such a powerful modeling language. Operations and functions that work on single numbers generalize almost effortlessly to work on arrays. In most cases, the definition of a variable requires no change if you change the dimensions of the variables on which **it** depends. This makes it **suprisingly** easy to build models with multldimensbnal array values.

An array can have one or more dimensions (up to 15). A simple number (scalar) has zero dimensions. Each dimension Is **identified** by an index, a one-dimensional array specifying its **size** or range of values.

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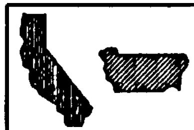
You may often want to calculate **a** model using alternative **decisions,** categories (or tables) of information, **a** specified range of values, or alternative values for parametric **analysis.A** category or collection of alternative values is **a** dimension or Index, and Is **a** simple array. Each value In the dimension Is called an item or slice. Page 19 of the Quick Reference shows you how to create **a** List.

	1990 1991 **1992**	0% **5%** **10%**	limit CO2 **limit** Methane
category: states	***sequence:*** *years*	***parame ter:*** ***rate***	***decision:*** ***policy***

Examples of dimensions or indices

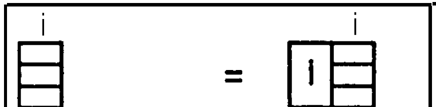
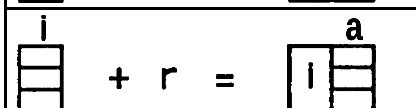
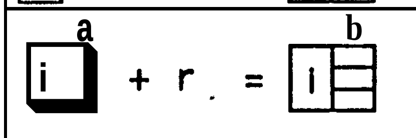
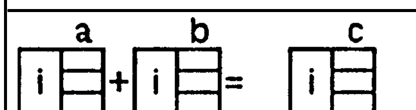
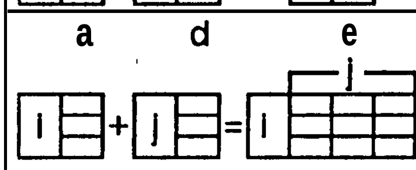
A collection of values that correspond to **items** in **a** dimension or dimensions Is table, and is the general form of an array. Page 20 of the **Quick** Reference shows you how to create **a** Table.

California 30M Pennsylvanla 1 OM	**limit** CO2 co2_Costs **limit** Methane me_Costs
Population by state	***Cost function by policy***

Examples of one-dimensional tables

What happens when computing with lists and tables

These pictures Illustrate how various kinds of arrays can be combined during evaluation of variables.

	Identity: an Index ***i*** is equivalent to a Table ***i*** indexed **by Itself.**
	Operating on a **List *i* and** a scalar ***r*** produces a table *a* indexed **by *i*.**
	Operating on a table ***a*** indexed by ***i*** and a scalar ***r*** produces a table ***b*** Indexed by ***i*.**
	Operating on tables *a*, ***b*** both indexed by ***i*** produces a table c Indexed by ***i*.**
	Operating on **a** table *a* Indexed by ***i*** with a table ***d*** indexed by ***j*** produces a twodimensbnal result ***e*** for cross-product of ***i* and *j*.**