AUTOMATED VEHICLE DECISION SUPPORT SYSTEM (AVDSS) FOR INCLEMENT WEATHER

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INTRODUCTION

- Current issues
- Current methods
- Decision Support System (DSS) developed
- DSS results
- Applications of DSS in Connected Vehicle Technology (CVT)
- Future refinement
- Conclusions & Questions

LEARNING OUTCOMES

- Identify current issues with weather and freight
- Learn how decisions are currently made
- Show development of DSS using BBN and data
- Learn how results of AVDSS in terms of knowledge based decisions add benefit to freight during weather

KEY POINT

AVDSS enhances safety and mobility of freight during weather through knowledge based system using connected vehicle technology

CURRENT ISSUES

- Weather related delay costs the freight industry almost $9 billion annually (FHWA, 2012)
- Trucks move 64 % of the weight of freight (about 11.3 billion tons) in 2011, increasing to 18.8 billion tons by 2040. (FHWA FFF, 2012)
- In 2012, 80,302 fatal and injury crashes
- 75 % of the fatalities and injuries occurring in occupants of other vehicles (NHTSA, 2012)
- Many of the decisions are left up to the individual truck driver, these decisions are called naturalistic decisions

NATURALISTIC DECISION MAKING

- Entire field of research dedicated to Naturalistic Decision Making (NDM) that evolved in the 1980's
- Research has found that the naturalistic decision is based on prior experience rather than a ranking of options
- This led to using information enhancing technologies such as decision support systems to improve decision making

(Klein, 2008)

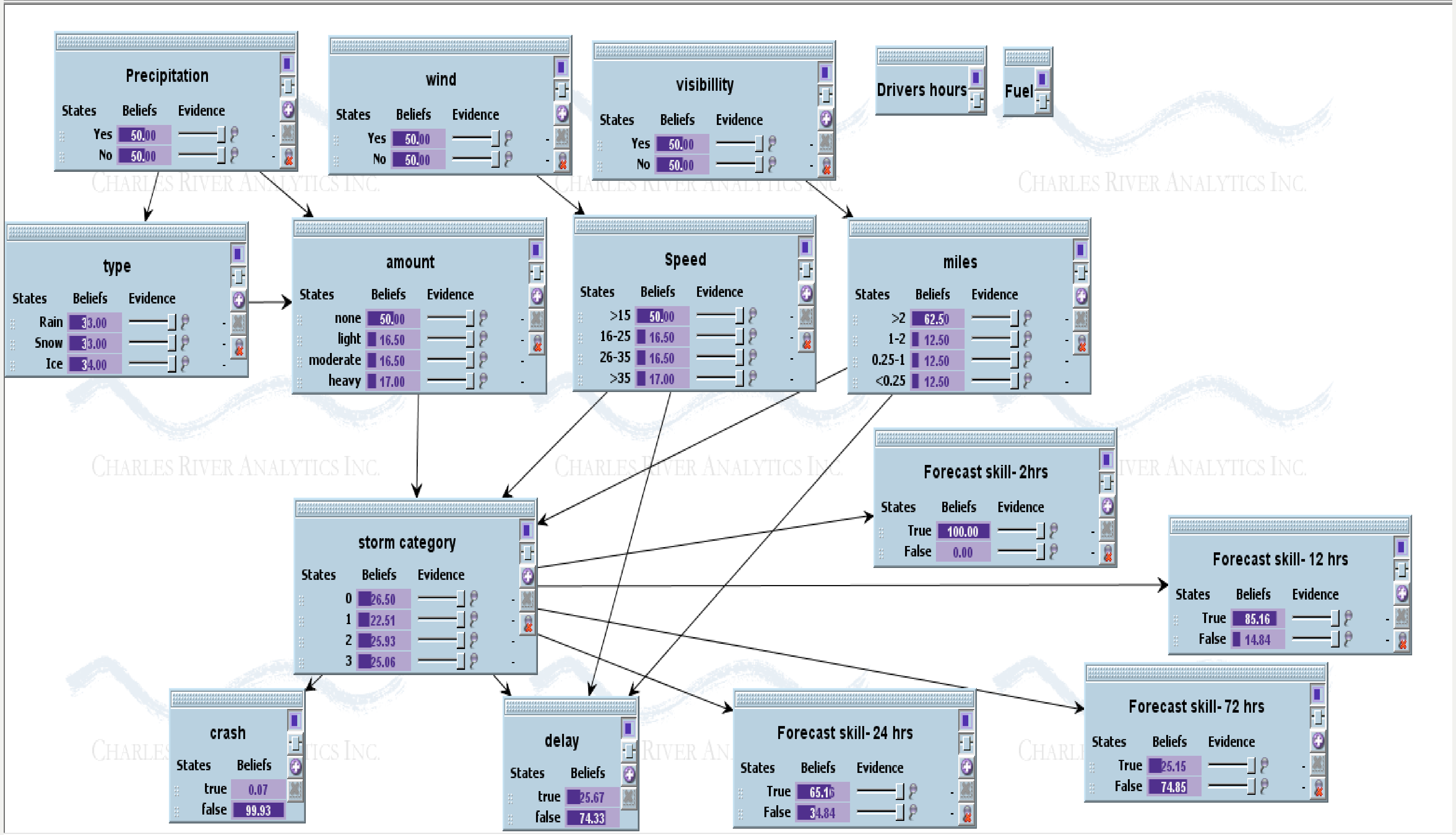
Decision Support Systems

- Decision support systems (DSS) are a growing field to assist the transportation manager
- Many different types of DSS including Artificial Intelligence and neural networks
- Successful example MDSS
- Bayesian Belief Network (BBN) chosen

Description of BBN

- Graphical models using the knowledge domain similar to modeling the expert in rule based systems
- A probabilistic model that can deal with uncertainties in data
- Uses a system of nodes and links and establishes a probability for each node
- The probabilities are assigned based on both evidence, educated hypotheses and priori knowledge (Cao et al, 2009)

Inputs of BBN



Inputs 2

- 5 storm parameters; rain, snow, ice, wind and visibility
- 6 storms modeled
- Levels of 4 discrete storm categories
- Probabilities of delay and crash determined from existing data

Storm categories

STORM CATEGORY	Wind (mph)	Rain	Snow	Ice	Visibility(mi)
0	<15	NONE	NONE	NONE	>2
1	≤25	Light	Light	Moderate Snow	1-2
2	≤35	Moderate	Moderate	Heavy Snow	0.25-1
3	>35	Heavy	Heavy	Heavy snow	0.25

Final delay probabilities per storm category

PERCENTAGE PROBABILITY OF DELAY(%)	Wind	Rain	Snow	Ice	Visibility
0	0	0	0	0	0
1	0.02	0.05	0.05	0.22	0.18
2	0.02	0.22	0.22	0.79	0.22
3	0.04	0.36	0.79	0.79	0.22

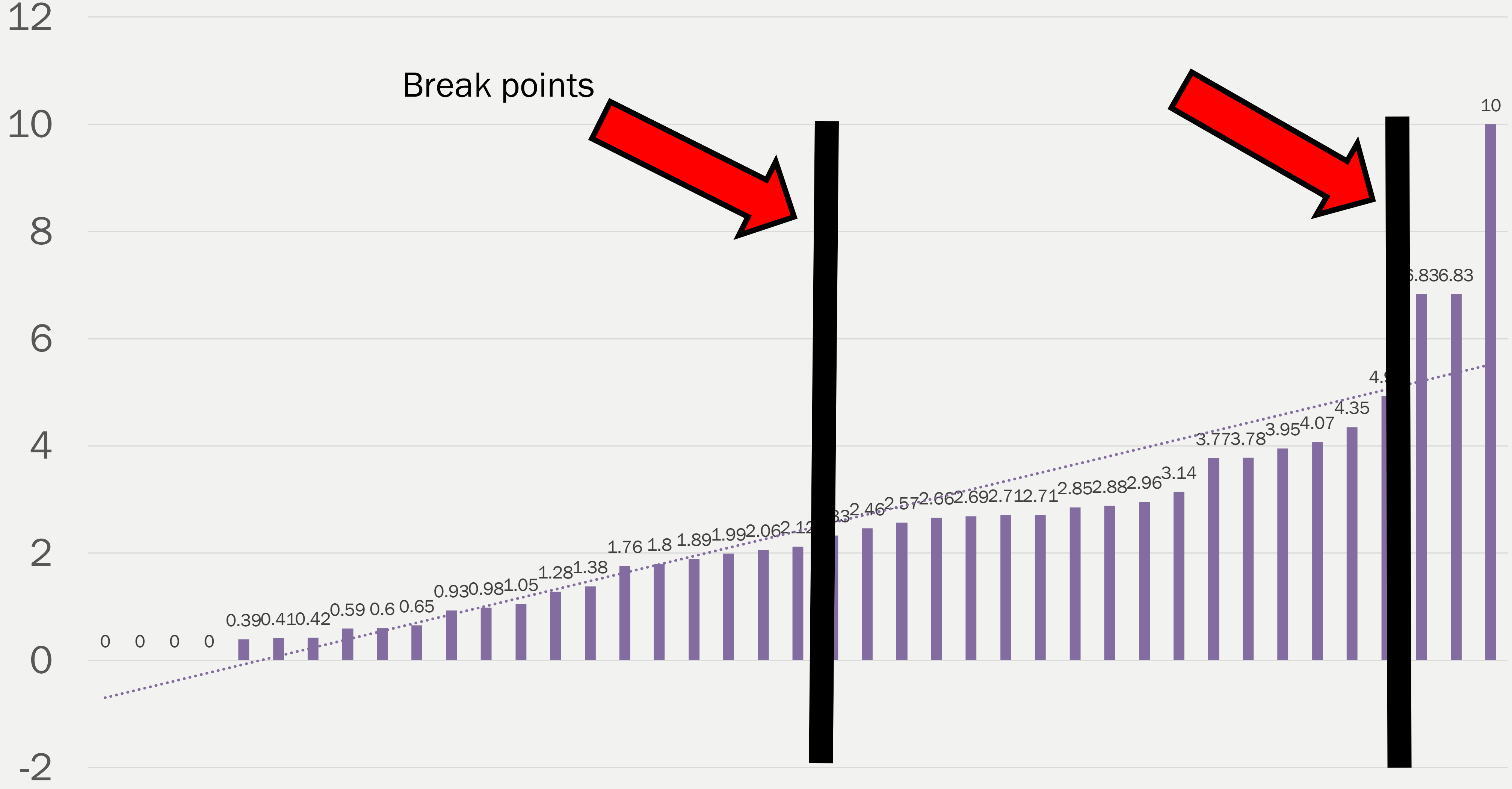
Results

	STORM 2	Storm Category	Probability Delay %	Probability Crash %	Normal Driving Crash %
Scenario 1	Denver	0	0	0.2746	0.0265
	Des Moines	1-2	18.9		
	Davenport	3	100		
Scenario 2	Kansas City	0-1	2.5	0.1205	0.0116
	Des Moines	2-3	35.5		
Scenario 3	Chicago	1-2	15.5	0.1281	0.0124
	Des Moines	3	100		
Scenario 4	Springfield IL	1-2	24	0.1629	0.0157
	Springfield MO	1-2	40.9		
Scenario 5	Kansas City	1-2	18.9	0.0958	0.0092
	to Des Moines	1-2	15.5		

Development of Indexes of collective risk

- Use of Geometric mean to put in terms of useful output for decision
- $G.M. = \sqrt(N_C * N_{D)}$
- $Index = 10 * G.M$
- Final indexes between 0-10

FINAL INDEXES



Results 2

RANGE OF INDEXES	DECISION
8.5-10	STOP NOW
6-8.5	STOP SOON
2-6	POSSIBLE STOP*
0-2	DRIVE THROUGH

* More research needed to develop better decisions in this range

SURVEY PROVIDES VALUABLE INFORMATION

- Three items to compare to assumptions in AVDSS: storm category, decisions during certain storms and at what probability would you stop.
- RESULTS:
  - *Drivers think storm is less severe than our model*
  - *Most drivers would never stop in severe storms*
  - *Most claim they would stop if they knew risk was 3x normal or less*

KNOWLEDGE BASED DSS FOR AUTOMATED VEHICLES

- Growing use of telematics equipment is part of the USDOT Connected Vehicle initiative (formerly known as IntelliDrive and Vehicle Infrastructure Integration [VII]
- New technologies: rain intensity sensing wipers, adaptive cruise control, stability control, and driver assist systems
- Advancement of connected vehicle technology, the importance of decision making increases

CONVOY EXAMPLE

- If convoyed with 5-10 trucks, decision of one affects all
- Example of connected vehicle technology: Lane delineation
- Decisions become much more important

Discussion of Results

- More robust than NDM based
- Decision is data driven
- Quantifying risk that hasn’t been done
- Survey shows that drivers NDM conflicts data of existing crash and delay
- With Automated Vehicles, becomes a critical tool in Truck Decision Making of Automated Fright vehicles.

Future refinements, some not all…

- Significant gaps in data
- Time dependent weather forecast accuracy
- Expand crash probability research for trucks in different storm conditions
- Extensive survey to relate AVDSS output and storm category for freight

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CONCLUSION & QUESTIONS?

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