

# **THE NETWORK RELIABILITY OF TRANSPORT**

**PROCEEDINGS OF THE 1<sup>ST</sup> INTERNATIONAL SYMPOSIUM ON TRANSPORTATION  
NETWORK RELIABILITY (INSTR)**

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INVESTOR IN PEOPLE

## Preface

The reliability of transportation networks has become an increasingly important issue as sustained economic growth and improvements to the quality of life around the world lead to increases in the value of time. Consequently, schedules and routes need to be able to accommodate the unexpected, like accidents, disasters or traffic flow fluctuations, with as little loss in operational efficiency as possible. Sources of unreliability include variation of demand and supply. People in the 21st century will desire a more stable transportation system with less travel time uncertainty. It is widely expected that network reliability analysis will play a more important role in the planning, design and management of transportation facilities and networks in the future.

The First International Symposium on Transport Network Reliability (INSTR) was held at Kyoto International Community House, Kyoto, Japan on 31st, July and 1st, August in 2001. The aim of the symposium was to bring together researchers and professionals interested in transportation network reliability to discuss both recent research topics and future directions in this expanding research field. Fifty-five persons participated and thirty-eight papers were presented from all over the world.

This book, *The Network Reliability of Transport*, is an outcome of the symposium, consisting of twenty-four selected papers. It covers various aspects of transport network reliability, such as definitions and methodological developments for reliability indices, behavioural analysis under uncertainty, evaluation methods for the disaster resistance of transport networks, and simulation / observation of travel time reliability. We believe that this book successfully encapsulates current understanding of transport network reliability and will become a useful reference for future research activities.

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# 1

## **ASSESSING TRANSPORT RELIABILITY: MALEVOLENCE AND USER KNOWLEDGE**

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### **ABSTRACT**

The objective of this paper is to give an overview of various reliability concepts that have been developed in the last decades. The paper first summarises various indicators that have been developed in order to measure the reliability of a network and then looks at techniques to calculate these indicators. The usefulness and limitations of the different indicators is discussed. The paper suggests that there is no single perfect indicator but that the choice of indicator and technique depends on several factors, including the viewpoint of the analyst and the type and range of interventions being considered. In order to assess the impact of incidents the authors propose to distinguish between three types of intervention, namely “benevolent”, “neutral” or random, and “malevolent”. Also discussed is why the provision of up-to-date information to the traveller has a central role to play when trying to minimise the impact of an incident.

### **INTRODUCTION**

Transport reliability has been of interest for many years. For instance, Garrison (1960) used graph theory concepts to assess the connectivity of the USA Interstate Highway system and the

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accessibility of major urban areas to the system. He also compared the accessibility of cities in the south-east of the USA to the Interstate Highway System, with their accessibility to the railroad system. There is a variety of measures of reliability, Chapman (1976) identifying sixteen possible measures of bus reliability.

In basic terms, a facility is 'reliable' if the expectations of users are almost always met, and the reliability increases as the frequency and/or consequence of failing to meet user expectations decrease. Expectations can vary considerably between users, from 'unrealistically high' to 'quite modest'. They can also vary within users (i.e. can vary with time), with the spread of the 'just-in-time' philosophy indicating an increase in the expectations of users of the transport system.

Transport networks are subject to two types of phenomena that may affect reliability:

- (1) variations in the demand for transport services; and
- (2) variations in the supply of transport services.

The latter has been primary focus of the research to date, with most studies investigating the effect of service disruptions (e.g. roads being closed or public transport services being cancelled) on the performance of the network.

In recent years there has been an increasing interest in the health, financial and environmental risks facing society, and this has led to the development of techniques and procedures for risk evaluation and management. A transport system user faces a number of risks, including the risk that his expectations will not be met (i.e. they may not complete their trip safely and/or in good time). Risk evaluation and management techniques involve considering both the probability and consequence of adverse events. For transport systems, there are numerous models for helping to identify the consequence of system degradation (e.g. increased travel times, distances and costs), but there is little experience in the identification of the probability of disruption.

One approach is to consider the worst-case scenario, where a network is under attack from a malevolent agency, which is seeking to cause the greatest possible adverse impact. Alternatively, one might consider an event where the intention is to minimise the adverse effect (e.g. the temporary partial closure of a traffic lane at a building site to facilitate construction). In this case there is no malevolence involved; indeed, the effort to minimise the adverse effect suggests the opposite of malevolence, namely benevolence. The actual situation might involve random degradations and thus lie somewhere between these two extreme cases. The case of random degradations can be termed 'neutral', in that neither malevolence nor benevolence are involved.

The failure probability for the component whose failure will have the greatest adverse impact will lie somewhere between zero and unity (the probabilities of a 'benevolent' and malevolent attack on that component, respectively). The difficulty is to estimate where in this range the probability lies. Similarly, it is difficult to estimate the probability of degradation for the other components.

Malevolence can affect both the probability and consequence of disruption. The more malevolent the persons involved in an attack, the more determined they are to succeed in causing disruption (i.e. the greater the probability of degradation) and the more determined they are to maximise the consequence of the degradation. An intervention can be fully characterised in terms of its location (i.e. which link), the level of degradation (i.e. whether the link is completely or partly closed, whether the public transport service has stopped or headways are more variable), and the duration of the degradation (i.e. whether long or short). As the level of malevolence increases, the greater will be the effort to degrade 'critical' components, and to maximise the level and duration of the degradation (i.e. to maximise the severity of the degradation).

The importance of a link for network reliability depends upon both its ability to withstand degradation (e.g. a bridge may be strengthened to enable it to survive the largest reasonably foreseeable earthquake) and the consequences of degradation (e.g. the extra user costs if a bridge fails, plus the costs of any repairs). The level of degradation would be characterised by the physical damage to the link (i.e. the effect on the link characteristics), but the effect of the degradation (i.e. travel disruption) is much broader, and includes the extra user costs.

The effect may well be mitigated (i.e. the consequence of degradation will be alleviated) through users adapting to the disruption. The response can take various forms, including:

- (1) cancelling their trip (i.e. a change in trip generation);
- (2) postponing their trip (i.e. a change in the temporal distribution of trips);
- (3) choosing another destination (i.e. a change in the spatial distribution of trips);
- (4) travelling by another mode (i.e. a change mode split);
- (5) choosing a different route (i.e. a change in the traffic assignment).

When estimating the expected costs of disruption, allowing for no user response and all possible responses gives the worst-case and best-case scenarios respectively, given that an event has occurred.

Users need to have some information about the nature of any degradation in order to respond. If the user has a high level of information (i.e. information is provided well in advance, and route guidance is available once the trip has commenced), the range of available options is greater and the consequence of the degradation is reduced. If there is a low level of information