



# Measure of Passenger Service Dependability in Communication-Based Transit System: Statistical Approach

**Proven innovations for railways**



# The Need For Dependability: Insight

## Insight

- n Level of service dependability achieved by a transit system is instrumental to its success;
- n Transit system supplier/owner/operator must make its own determination as to why and how much dependability is necessary in its product/service;
- n Factors to consider:
  - ÿ Characteristics of marketplace:
    - Market competition;
    - Diverse market needs
  - ÿ Cost of implementing (or not implementing) a reliability program;
  - ÿ Customers' perceptions.

# Customer Expectations

How to design, manufacture and operate transit system to best meet the expectations:

## n The cost of meeting/exceeding all/several expectations:

Y For transit system supplier:

- Customer: system owner;
- Expectations: Technical Spec, project schedule.

Y For transit system Owner/ Operator:

- Customer: Passenger;
- Expectations: Transportation from A to B within T time, with quality Q.

## n The cost of non-meeting customer expectations:

Y Non-performance penalties;

Y Decreased market share.

# Transit System Characteristics

## Design-Related:

- n Passenger Capacity
- n Travel Time
- n Headway
- n Passenger Amenities
- n Ride Comfort Level

## Quality-Related:

- n Schedule Adherence
- n Service Delivery
- n Number of delays greater than the delay threshold
- n Reliability
- n Availability/Dependability

# Availability

**Availability** is the chance of the product/service to work as expected when the customer wants to use it.

In a transit system:

- n **Operator-centered Availability:** Ability to perform a set of equipment functions requested by the Operator;
- n **Passenger-centered Dependability:** Ability to carry a passenger from point “A” to point “B” within a specified time period and with an acceptable quality of ride.

# IEC Definitions

## Area: Dependability and quality of service

EN availability (performance)

IEV number: 191-02-05

The ability of an item to be in a state to perform a required function under given conditions at a given instant of time or over a given time interval, assuming that the required external resources are provided

# IEC Definitions

## Area: Dependability and quality of service

**EN** dependability

**IEV number: 191-02-03**

The collective term used to describe the availability performance and its influencing factors : reliability performance, maintainability performance and maintenance support performance

*Note* — Dependability is used only for general descriptions in non-quantitative terms.

# EN 50126 Definitions

## 7. Availability

The System Availability  $A$  may be specified in parts attributed to:

- planned Non-Availability (Maintenance):  $1 - A_M$
- unplanned Non-Availability (Repair):  $1 - A_R$
- $A = 1 - [(1 - A_M) + (1 - A_R)]$
- $A = MUT / (MUT + MDT)$ ;  $0 \leq A \leq 1$
- where,
- $MUT$  = Mean Up Time; substitute as appropriate MTBF, MTBSF, etc.
- $MDT$  = Mean Down Time; substitute as appropriate MTTM, MTTR, etc.

# MIL-STD-721C Definitions

**AVAILABILITY:** A measure of the degree to which an item is in an operable and comitable state at the start of a mission when the mission is called for at an unknown (random) time. (Item state at start of a mission includes the combined effects of the readiness-related system R & M parameters, but excludes mission time; see DEPENDABILITY.

# MIL-STD-721C Definitions

## DEPENDABILITY:

A measure of the degree to which an item is operable and capable of performing its required function at any (random) time during a specified mission profile, given item availability at the start of the mission. (Item state during a mission includes the combined effects of the mission-related system R & M parameters but excludes non-mission time; see AVAILABILITY) see Figure 1.

# MIL-STD-721C Definitions

Figure 1

EXAMPLES OF  
SYSTEM R&M PARAMETERS

PARAMETERS RELATED TO:

\* READINESS (OR AVAILABILITY)

RELIABILITY

MEAN TIME BETWEEN DOWNING EVENTS (MTBDE)

MAINTAINABILITY

MEAN TIME TO RESTORE SYSTEM (MTTRS)

\* MISSION SUCCESS (OR DEPENDABILITY)

RELIABILITY

MISSION TIME BETWEEN CRITICAL FAILURES (MTBCF)

MAINTAINABILITY

MISSION TIME TO RESTORE FUNCTIONS (MTTRF)

# Example 1: Single Item

$$\text{Availability} = \text{Uptime} / (\text{Uptime} + \text{Downtime})$$

Operating time during a day: 20 hrs

Downtime: 6 minutes (0.1 hrs)

Uptime = 20 hrs – 0.1 hrs = 19.9 hrs

Availability =  $19.9/20 = 0.995 = 99.5\%$

## Example 2: Fleet

Availability = Uptime/(Uptime + Downtime)

(all parameters are cumulative across the fleet)

Operating time during a day: 20 hrs

Number of trains: 10

Cumulative operating time:  $20 * 10 = 200$  train/hrs

Downtime: Train1=1 hrs, Train2= 0.2 hrs, Train3=0.3 hrs

Cumulative downtime:  $1 + 0.2 + 0.3 = 1.5$  train/hrs

Uptime =  $200 - 1.5$  hrs = 198.5 hrs

Availability =  $198.5 / 200 = 0.9925 = 99.25\%$

(Not  $(20 - 1)/20 = 0.95$ )

# Example 3: Large System

## Automatic Train Control Equipment:

- n - 20 on-board controllers on trains;
- n - 10 communication devices Train – Control Center;
- n - 28 wayside units to control the platforms;
- n - 12 wayside units to control the track switches;
- n - etc., etc., etc.



# Large System: Solution 1

Measuring the Availability for multiple equipment groups:

- n On-Board Equipment;
- n Central Equipment;
- n Trackside Equipment;
- n Platform-based equipment;
- n Other equipment.

Drawbacks:

- n Impossible to compare different sites;
- n Complexity;
- n Low correlation with Customer's satisfaction.

# Large System: Solution 2

## Solution 1, plus:

### n Adding the measurements for passenger transportation quality, like:

- ÿ Number of actual vs. planned train-trips during the day;
- ÿ Number of delays during the day;
- ÿ Etc., etc.

## Drawbacks:

- n Still impossible to compare different sites;
- n Even more Complexity;
- n Still insufficient correlation with Customer's satisfaction.

# Large System: Solution 3

## Measuring the passenger-based Availability/Dependability:

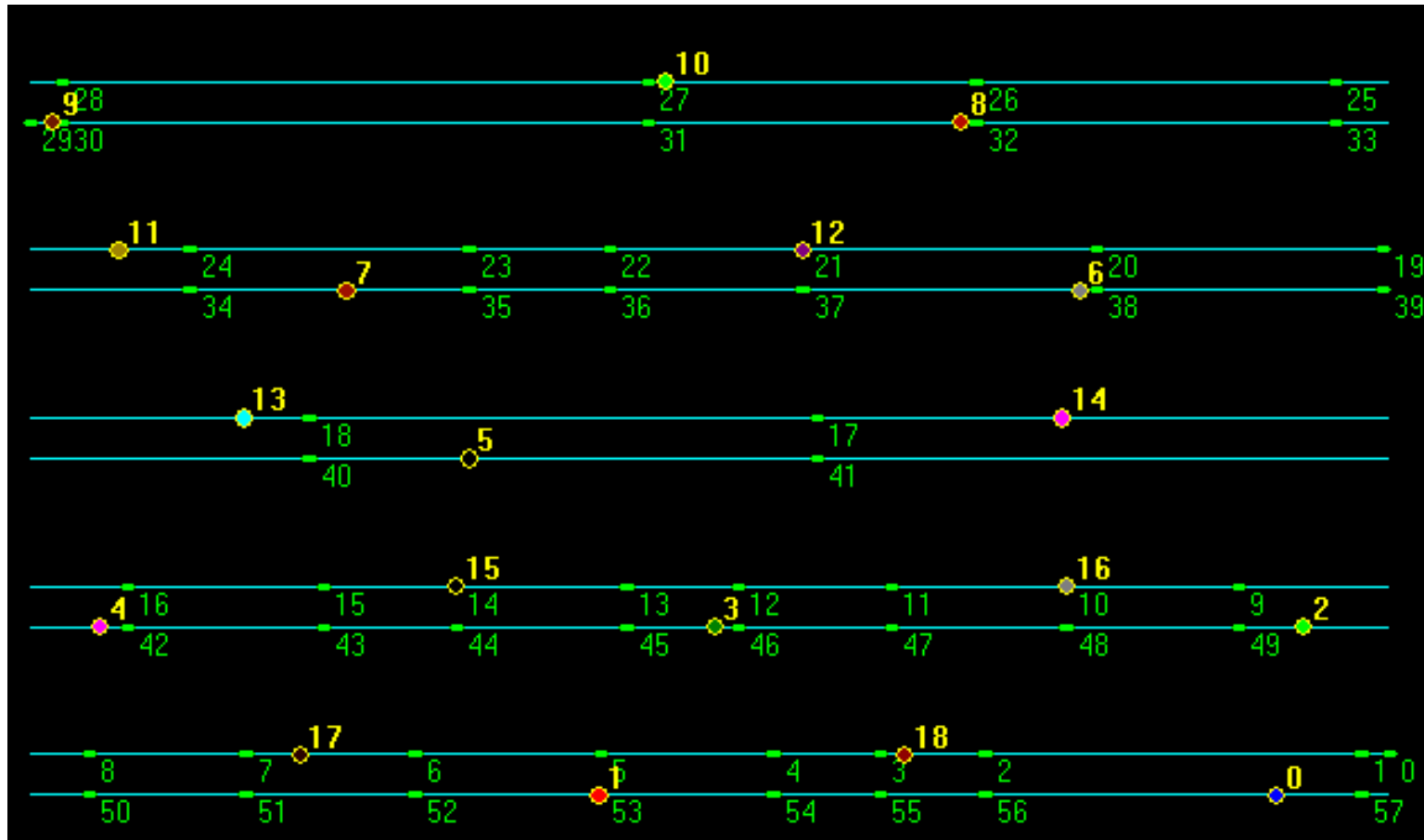
**n Availability = Number of Service Requests Fulfilled/  
Number of Service Requests Total**

**Y Service Request: Getting from Platform A to Platform B  
in not greater than  $T_{AB}$  minutes and with the ride quality  
Q**

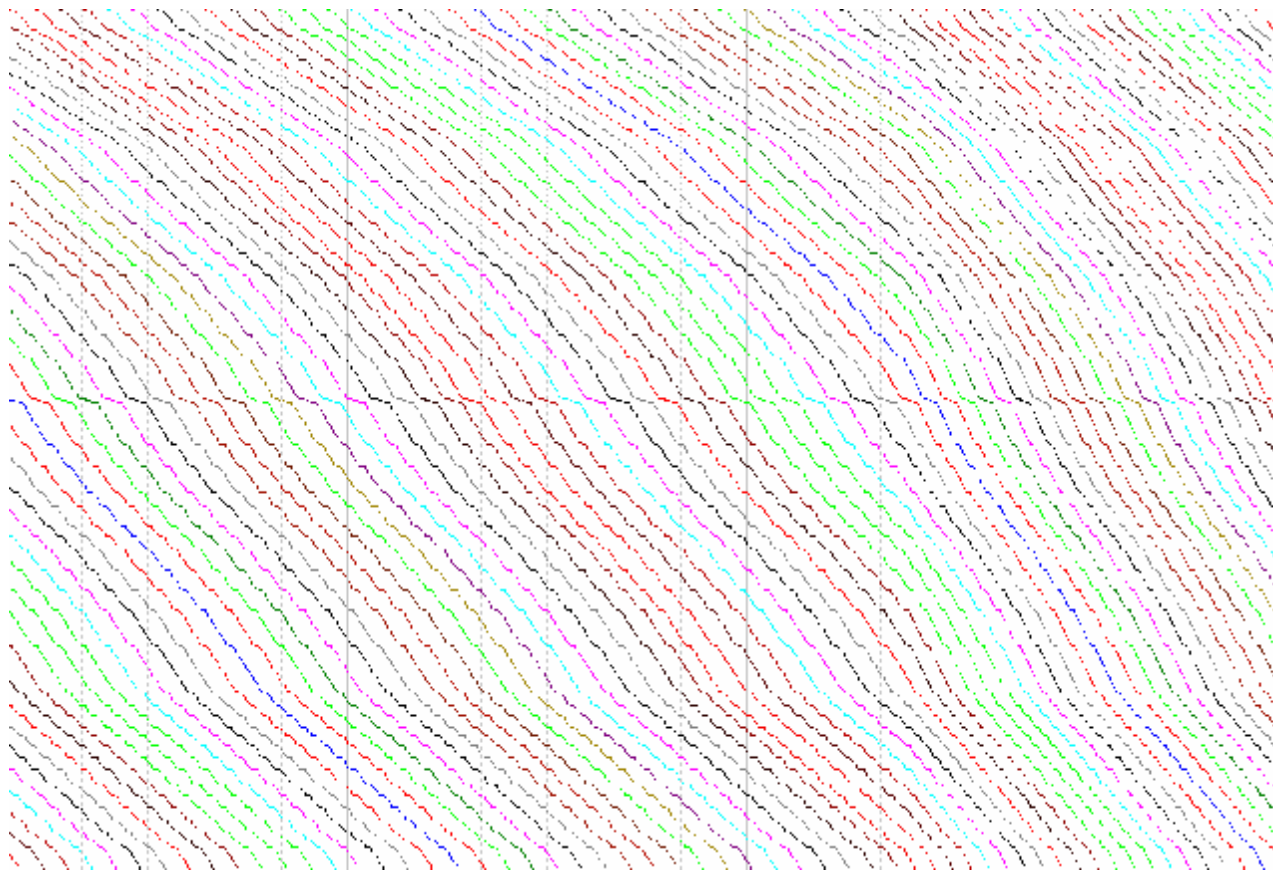
## Features:

- n Easy to compare different sites;**
- n Can be easily automated in CBTC;**
- n Direct measure of Customers' satisfaction.**

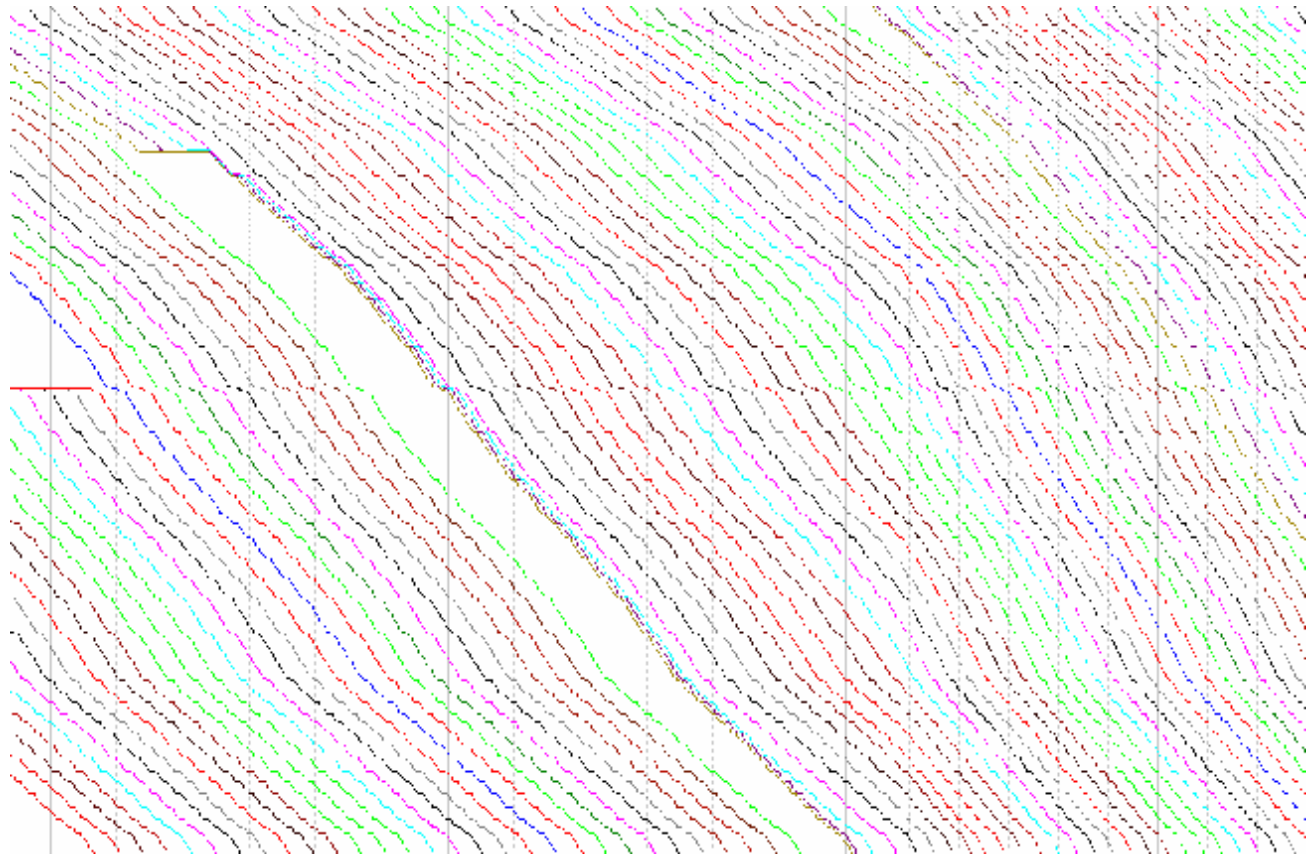
# Mimic



# String Chart: Normal Operation



# String Chart: Downtime Event



# O-D Matrix of Daily Train Trips

Origin	Destination0	Destination1	Destination2	Destination3	Destination4	Destination5	Destination6	Destination7	Destination8	Destination9	Destination10
0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	57	57	57	57	57	57	57	57	57
2	0	0	0	57	57	57	57	57	57	57	57
3	0	0	0	0	57	57	57	57	57	57	57
4	0	0	0	0	0	57	57	57	57	57	57
5	0	0	0	0	0	0	57	57	57	57	57
6	0	0	0	0	0	0	0	57	57	57	57
7	0	0	0	0	0	0	0	0	57	57	57
8	0	0	0	0	0	0	0	0	0	57	57
9	0	0	0	0	0	0	0	0	0	0	57

# Calculation

System Availability = (Operating Time - Downtime) / (Operating Time) = (8 hrs - 0.167 hrs) / 8 = 0.9791 = 97.91%

Train Fleet Availability = (Operating Time - Downtime) / (Operating Time) = (8 hrs \* 38 trains - 0.167 hrs) / (8 \* 38) = 0.9995 = 99.95%



The screenshot shows a 'Stats' window with a menu bar (File, Table, Options) and an 'Action' field. Under 'Delay Threshold', the value is 180. Under 'Train Trips', 'End-to-end' is selected. The statistics are:

Actual	114
On Time	112
Scheduled Service	114
Delivery	100.00%
Punctuality	98.25%

The 'Done' button is highlighted at the bottom.



The screenshot shows a 'Stats' window with a menu bar (File, Table, Options) and an 'Action' field. Under 'Delay Threshold', the value is 180. Under 'Train Trips', 'All Orgrn/Dest' is selected. The statistics are:

Actual	43092
On Time	42696
Scheduled Service	43092
Delivery	100.00%
Punctuality	99.08%

The 'Done' button is highlighted at the bottom.

# References

## References

- n IEC 60050(191): International Electrotechnical Vocabulary – Chapter 191: Dependability and Quality of Service
- n MIL-STD-721 Definitions of effectiveness Terms for Reliability, Maintainability, Human Factors and Safety
- n EN 50126: 1999 Railway Applications: The Specification and Demonstration of Dependability, Reliability, Availability, Maintainability and Safety (RAMS)
- n RAC Reliability Toolkit: Commercial Practices Edition
- n E. Cascetta: Transportation Systems Engineering Theory and Methods

# References

- n L. David Shen et al. : Automated People Mover Applications: A Worldwide Review
- n IEEE Rail Transit Vehicle Interface Standards Committee, Working Group 2. Communications Based Trains Control Performance / Functional Requirements. Minutes Of Meeting. July 15, 1998, MUNI, San Francisco
- n M.A. Sulkin : "Dependability as a Measure of On-Time Performance of PRT Systems" (*Journal of Advanced Transportation*, 26:3, pp. 201-212.)

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Measure of Passenger Service Dependability

Oct 19, 2006



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