



ATIS-0100037.2013 (R2018)

IMPACT WEIGHTED MTBF –  
A METRIC FOR ASSESSING RELIABILITY OF HIERARCHICAL SYSTEMS

AMERICAN NATIONAL STANDARD FOR TELECOMMUNICATIONS



As a leading technology and solutions development organization, ATIS brings together the top global ICT companies to advance the industry's most-pressing business priorities. Through ATIS committees and forums, nearly 200 companies address cloud services, device solutions, emergency services, M2M communications, cyber security, ehealth, network evolution, quality of service, billing support, operations, and more. These priorities follow a fast-track development lifecycle — from design and innovation through solutions that include standards, specifications, requirements, business use cases, software toolkits, and interoperability testing.

ATIS is accredited by the American National Standards Institute (ANSI). ATIS is the North American Organizational Partner for the 3rd Generation Partnership Project (3GPP), a founding Partner of oneM2M, a member and major U.S. contributor to the International Telecommunication Union (ITU) Radio and Telecommunications sectors, and a member of the Inter-American Telecommunication Commission (CITEL). For more information, visit < [www.atis.org](http://www.atis.org) >.

## AMERICAN NATIONAL STANDARD

Approval of an American National Standard requires review by ANSI that the requirements for due process, consensus, and other criteria for approval have been met by the standards developer.

Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made towards their resolution.

The use of American National Standards is completely voluntary; their existence does not in any respect preclude anyone, whether he has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

The American National Standards Institute does not develop standards and will in no circumstances give an interpretation of any American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute. Requests for interpretations should be addressed to the secretariat or sponsor whose name appears on the title page of this standard.

**CAUTION NOTICE:** This American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken periodically to reaffirm, revise, or withdraw this standard. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

## Notice of Disclaimer & Limitation of Liability

The information provided in this document is directed solely to professionals who have the appropriate degree of experience to understand and interpret its contents in accordance with generally accepted engineering or other professional standards and applicable regulations. No recommendation as to products or vendors is made or should be implied.

NO REPRESENTATION OR WARRANTY IS MADE THAT THE INFORMATION IS TECHNICALLY ACCURATE OR SUFFICIENT OR CONFORMS TO ANY STATUTE, GOVERNMENTAL RULE OR REGULATION, AND, FURTHER, NO REPRESENTATION OR WARRANTY IS MADE OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE OR AGAINST INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. ATIS SHALL NOT BE LIABLE, BEYOND THE AMOUNT OF ANY SUM RECEIVED IN PAYMENT BY ATIS FOR THIS DOCUMENT, AND IN NO EVENT SHALL ATIS BE LIABLE FOR LOST PROFITS OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES. ATIS EXPRESSLY ADVISES THAT ANY AND ALL USE OF OR RELIANCE UPON THE INFORMATION PROVIDED IN THIS DOCUMENT IS AT THE RISK OF THE USER.

NOTE - The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights. By publication of this standard, no position is taken with respect to whether use of an invention covered by patent rights will be required, and if any such use is required no position is taken regarding the validity of this claim or any patent rights in connection therewith. Please refer to [<http://www.atis.org/legal/patentinfo.asp>] to determine if any statement has been filed by a patent holder indicating a willingness to grant a license either without compensation or on reasonable and non-discriminatory terms and conditions to applicants desiring to obtain a license.

## ATIS-0100037.2013(R2018), *Impact Weighted MTBF – A Metric for Assessing Reliability of Hierarchical Systems*

Is an American National Standard developed by the **ATIS Network Performance, Reliability, and Quality of Service Committee (PPQC)**.

Published by  
**Alliance for Telecommunications Industry Solutions**  
1200 G Street, N.W., Suite 500  
Washington, DC 20005

Copyright © 2013 by Alliance for Telecommunications Industry Solutions  
All rights reserved.

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher. For information contact ATIS at 202.628.6380. ATIS is online at < <http://www.atis.org> >.

Printed in the United States of America.

American National Standard for Telecommunications

## Impact Weighted MTBF – A Metric for Assessing Reliability of Hierarchical Systems

Alliance for Telecommunications Industry Solutions

Approved: July 11, 2013

American National Standards Institute, Inc.

### Abstract

The impact of failures in modern systems for voice and data transmission (e.g., IP routers or a Radio Network Controller) as well as mobility and wire-line communication networks with hierarchical design increases progressively with the hierarchical level. The Impact Weighted Mean Time Between Failure (IW-MTBF) – a combination of MTBF values for all hierarchical levels of a given network element or network segment weighted for each level by its respective impact on failures – is proposed as a method for evaluating overall reliability of the hierarchical system during the design phase.

## Foreword

---

The information contained in this Foreword is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, this Foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the Standard.

The Alliance for Telecommunication Industry Solutions (ATIS) serves the public through improved understanding between providers, customers, and manufacturers. The Network Performance, Reliability, and Quality of Service Committee (PRQC) develops and recommends standards, requirements, and technical reports related to the performance, reliability, and associated security aspects of communications networks, as well as the processing of voice, audio, data, image, and video signals, and their multimedia integration. PRQC also develops and recommends positions on, and foster consistency with, standards and related subjects under consideration in other North American and international standards bodies.

ANSI guidelines specify two categories of requirements: mandatory and recommendation. The mandatory requirements are designated by the word *shall* and recommendations by the word *should*. Where both a mandatory requirement and a recommendation are specified for the same criterion, the recommendation represents a goal currently identified as having distinct compatibility or performance advantages.

Suggestions for improvement of this document are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, PRQC, 1200 G Street NW, Suite 500, Washington, DC 20005.

At the time of consensus on this document, PRQC, which was responsible for its development, had the following leadership:

P. Tarapore, PRQC Chair  
J. Colombo, PRQC Vice-Chair  
Y. Kogan, Technical Editor  
P. Tarapore, Technical Editor  
C. Underkoffler, ATIS Chief Editor

### Active Participants:

K. Biholar	M. Linnell
J. Colombo	C. Makris
C. Dvorak	A. Nguyen
Y. Kogan	P. Tarapore
O. Lima	A. Webster
	X. Zhang

**Table of Contents**

<b>1</b>	<b>SCOPE &amp; PURPOSE</b> .....	<b>1</b>
<b>2</b>	<b>NORMATIVE REFERENCES</b> .....	<b>2</b>
<b>3</b>	<b>DEFINITION</b> .....	<b>2</b>
<b>4</b>	<b>ACRONYMS &amp; ABBREVIATIONS</b> .....	<b>2</b>
<b>5</b>	<b>RELIABILITY IMPACTS ON COMPLEX HIERARCHICAL SYSTEMS – AN INTRODUCTION</b> .....	<b>3</b>
<b>6</b>	<b>COMPLEX HIERARCHICAL SYSTEMS</b> .....	<b>4</b>
6.1	SINGLE CHASSIS IP ROUTER .....	4
6.2	MULTI-CHASSIS IP ROUTER.....	6
6.3	RADIO NETWORK CONTROLLER .....	6
6.4	SEGMENT OF 4G LTE NETWORK.....	7
<b>7</b>	<b>DEFINITION OF IMPACT WEIGHTED MTBF</b> .....	<b>8</b>
<b>8</b>	<b>IMPACT WEIGHTED MTBF – PRACTICAL EXAMPLES</b> .....	<b>9</b>
8.1	SINGLE CHASSIS ROUTER.....	9
8.2	MULTI-CHASSIS ROUTER.....	10
8.3	RADIO NETWORK CONTROLLER .....	10
8.4	ACCESS SEGMENT OF LTE NETWORK.....	11
<b>9</b>	<b>CONCLUDING REMARKS</b> .....	<b>11</b>

**Table of Figures**

FIGURE 1 - SINGLE CHASSIS ROUTER .....	5
FIGURE 2 - MULTI-CHASSIS ROUTER.....	6
FIGURE 3 - RNC ARCHITECTURE .....	7
FIGURE 4 - 4G LTE SEGMENT ARCHITECTURE .....	8

**Table of Tables**

TABLE 1 - IW-MTBF REDUCTION IN COMPARISON WITH LC-MTBF .....	9
TABLE 2 - UPTIME FOR RP, SF, AND L2.....	9
TABLE 3 - G-UPTIME REDUCTION IN COMPARISON WITH LC-MTBF .....	10
TABLE 4 - IW-MTBF REDUCTION IN COMPARISON WITH CP-UPTIME .....	10
TABLE 5 - UPTIME FOR MP, IP, SF, AND L2-UPTIME .....	11
TABLE 6 - G-UPTIME REDUCTION IN COMPARISON WITH ENB-UPTIME .....	11

ATIS Standard on –

# Impact Weighted MTBF – A Metric for Assessing Reliability of Hierarchical Systems

## 1 Scope & Purpose

Modern day Service Provider (SP) network architectures are continuously evolving to provide a growing and complex range of telecommunications services to their customers. From a reliability perspective, the evolving nature of telecommunications networks with their inherently complex elements can pose a difficult challenge. Reliability metrics need to address network design and operations, service delivery, element functions, and provide guidance on development of Service Level Agreements (SLA).

Two traditional reliability measures – Mean Time Between Failures (MTBF) and Availability – can be applied only to elements with two states: Up State (Element is Functioning) and Down State (Element is Failed). Availability is a steady state metric defined as:

$$A = \text{MTBF} / (\text{MTBF} + \text{MTTR})$$

where MTTR is the Mean Time to Repair, and Unavailability:

$$U = 1 - A = \text{MTTR} / (\text{MTTR} + \text{MTBF})$$

For systems with partial failures, the telecommunication industry developed two reliability measures: Defects per Million (DPM) and Mean Time Between Outages (MTBO), which incorporate the impact of failures. DPM is a generalization of Unavailability where downtime of each failure is weighted by the number of customers impacted. DPM is calculated for a given period of time T as a fraction of the total weighted downtime during that period multiplied by 1,000,000 [ATIS-0100008].

MTBO is an extension of MTBF – it is a field metric that removes the main limitation of practical application of the field MTBF where only failures leading to Field Replacement Unit (FRU) are counted. MTBO counts all customer impacting failures, including software reboots that do not result in element replacement.

The impact of failures in modern systems for voice and data transmission (e.g., IP routers or a Radio Network Controller) as well as mobility and wire-line communication networks with hierarchical design increases progressively with the hierarchical level. For example, a silent failure of just one component in a router switch fabric (top hierarchical level) results in unacceptable packet loss across all router line cards (bottom hierarchical level) until the failure is detected and the router is taken out of service. As described in clause 5, DPM and MTBO have limitations that prohibit reliability assessments in the design phase of such systems. The intent of this document is to define a new metric that could be applied to reliability assessment of such systems at the design stage.

The proposed metric is an extension of the MTBF metric – *Impact Weighted MTBF (IW-MTBF)* – that combines MTBF values for all hierarchical levels of a given network element or network segment by weighting MTBF for each level by its respective impact on failures. The scope of this document is restricted to the definition of this new metric and the derivation of illustrative examples to demonstrate its power and usage. These illustrations provide guidance on estimating the reliability of complex systems in the design phase via IW-MTBF and then comparing this value with the actual field reliability via MTBO. The development of the necessary measurement capabilities needed to collect data for metric estimation is for further study.