Calculating Uptime of a Multi-Technology System

HK Systems 1-18-04

INTRODUCTION

System Uptime or Availability for complex systems is subjective and dependent on many variables including:

- the relative importance or contribution of each subsystem to the mission of the overall system
- The relationship between duration of a subsystem failure and it's impact on the total system.
- The interdependencies of each subsystem and the cascading effect of downtime between them.

The best way to fairly evaluate "Total System Uptime" is to first break the system down into major functional areas or subsystems that each have a mission of their own. Then objectively determine how at any given time, that subsystem effects the mission of the total system.

PROCESS

To determine uptime percentages, we will use downtime (in minutes) as the common unit of measure.

Total System Downtime shall be defined as the sum of the downtimes of each functional sub-system in as much as that sub-system contributes to the mission of the Total System.

It could be argued that if any piece is unavailable long enough, the total system cannot perform it's mission. Assume that the mean time (MTTR) to repair an average failure is 15 minutes. Evaluate each independent sub-system in terms of its impact on the overall mission of the Total System if it were unavailable for 15 minutes.

The System Downtime calculation is as follows:

$$(C_1 D_1) + (C_2 D_2) + (C_3 D_3) \ldots\ldots = D_T$$

And thus, uptime or availability is calculated as:

$$U_T = (T - D_T) / T$$

Where:

C_n = The amount (%) that the sub-system contributes to the mission of the Total System. Ask yourself, “how would the mission of the entire system suffer if this subsystem were down for 15 minutes”?

D_n = The *net* dowmtime (minutes) of that sub-system (n). It may be the average of the downtime of multiple parallel pieces of equipment $(U_{2a} + U_{2b} + U_{2c} + U_{2d} + U_{2e})/5$

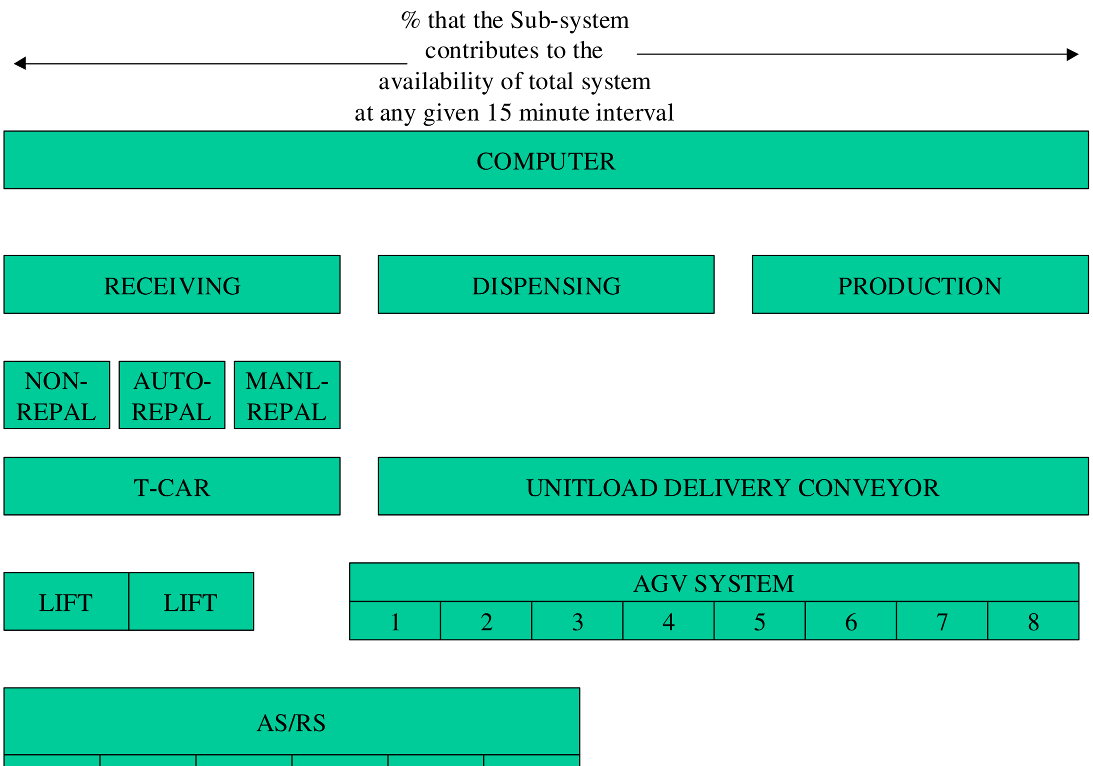
U_T = The uptime of the total system (minutes)

T = The timeframe over which we are measuring availability (minutes)

<u>EXAMPLE</u>

In the illustration below,

- The Computer System has 100% impact on the availability of the Total System. If it goes down, the whole system is stopped.
- The ASRS however, in any given 15 minute time frame, contributes about 50% of the mission of the Total System at any given time. The ASRS is made up of 6 parallel functioning machines (SRMs)
- The receiving transfer car contributes about 30% to the mission of the total system.



So the down time of this fictional system is calculated as:

$$D_T = (D_{Computer} \times 1.0) + (D_{ASRS} \times 0.5) + (D_{TCar} \times 0.3).....$$

Further considering the parallel pieces of equipment that make up a sub-system:

$$D_T = (D_{Computer} \times 1.0) + \left(\frac{(D_{SRM\,1} + D_{SRM\,2} + D_{SRM\,3}.........)}{6} \times 0.5 \right) + (D_{TCar} \times 0.3).....$$

<u>SAMPLE SCENARIOS</u>

1. For a 40 hour (2400 min) period, if the computer system is unavailable for 8 minutes and all of the other systems have 100% uptime for the entire 40 hours, the system uptime is

$$D_T = (8 \times 1.0) + \left(\frac{(0+0+0.........)}{6} \times 0.5 \right) + (0 \times 0.3)..... = 8 \min$$

$$U_T = \frac{(2400-8)}{2400} = 99.6\%$$

2. For a 40 hour period, if SRM #2 is unavailable for 25 minutes and the Transfer car is unavailable for 20 minutes and all of the other systems have 100% uptime for the entire 40 hours, the system uptime is, the system uptime is

$$D_T = (0 \times 1.0) + \left(\frac{(0+25+0.........)}{6} \times 0.5 \right) + (20 \times 0.3)..... = 16.17 \min$$

$$U_T = \frac{(2400-16.17)}{2400} = 99.3\%$$

DEFINING DOWNTIME

The goal of measuring reliability is to determine the quality and usefulness of a system and it's components. Thus, we define downtime as the time that a system is not available for use, not due to human or uncontrollable variables. These variables are, for example:

- Operator or system user errors (pressing an e-stop by mistake)
- Product or material related occurrences (an open box triggering a photoeye)
- Maintenance travel time (the time it takes a person to travel to a piece of failed equipment. To consider this would lead to overstaffing of maintenance and/or encouraging unsafe behavior.)
- Preventative Maintenance time (performing regular scheduled maintenance in the interest of long term system health)

The industry standard for the uptime of complex automated systems is 98-98.5%

DEFINING ACTUAL AVAILABILITY

Actual Availability is net of these variables and varies wildly based on the content of the system, integrity of the material handled, quality of maintenance and more. A typical examples follows.

Let's assume:

- A given sub-system operates (2) 8 hour shifts, 5 days per week.
- Each major subsystem requires 4 hours of Preventative Maintenance per quarter.
- The average MTTR is 15 minutes.
- The average system uptime is 98.5%
- The travel time for a maintenance person from notification to arrival at the problem is 5 minutes.

Total Time = 2 shifts x 8 hrs x 5 days x 50 weeks x 60 min	3,840,000	100%
PM Time = 4 quarters x 4 hours x 60 min/hr	- 960	0.03%
Operator Errors = assume 5/week @ 15 min to recover	- 3,750	0.09%
Product Errors = assume 5/week @ 15 min to recover	- 3,750 .	0.09%
Subtotal (runtime)	3,831,540	99.8%
Downtime at 98.5% uptime	- 57,473	1.49%
number of failures = 3,831		
Maintenance Travel Time = 3,831 x 5min	-19,155 .	0.49%
Total Availability	3,754,912	97.7%