Calculate availability and reliability

This handout is designed to help you evaluate the availability and reliability of robotic systems. Furthermore, we present typical sources of error and show how they are included in the evaluation.

FEM Norm & VDI 3580

A standardized norm that can be used to calculate availability is **FEM 9.222**. Among other things, it defines what is meant by availability, reliability, and malfunction. It also presents calculation options.

The **VDI 3580** ("Basics for recording faults in warehouses") can also provide you with fault logs with which you can determine availability and other key figures. However, this is not required for a simpler evaluation of a robot system.

Calculation of Availability

When calculating availability, the **actual availability** (measured value) and the **target availability** (target value) play an important role. The difference between the two values can be used to evaluate the overall system.

The FEM 9.222 defines availability as η. It is calculated as follows:

$$\eta = (t_E - t_A) / t_E$$

Where t_E represents the total time the system has been working, and t_A represents the time where the system had an error.

The following formula offers an intuitive way of calculating:

$$\eta = 1 - (t_{Error} / t_{Total})$$

If the robot is in an error state for 30 minutes within 10 hours of operation and is not available, this results in:

$$\eta = 1 - (30min / (10h * 60min))$$

This results in an **actual availability** of the system of

$$\eta = 95\%$$

If several robots are to be included in the calculation, it must be ensured that the exact duration of use is weighted in the calculation.

Calculation of Reliability

Reliability indicates how many operations the robot has reliably performed. The reliability can be used in many different ways. Potential reliability calculations can be:

- Reliability of driving/orientation (localization)
- Reliability of missions (picks, transport tasks, etc.)
- Reliability in sub-operations (distance, docking at a charging station, etc.)

The FEM 9.222 defines the reliability as ϕ. It is calculated as follows:

$$\phi = n_r / (n_r + n_f)$$

Here n_r indicates the number of correct operations. The erroneous operations are indicated with n_f.

If 90 operations are executed without errors and 10 operations are incorrect, the following calculation results:

$$\phi = 90 / (90 + 10)$$

This results in **system reliability** of:

$$\phi = 90\%.$$

To get a better assessment of the reliability of the system, you can also weigh different operations differently. In this way, more precise insights into reliability can be achieved, particularly in the case of complex systems.

Error handling

Various types of errors can occur during the operation of the robot. Some of these errors are valid to judge the availability and reliability of the robot. Other forms of

errors are not the fault of the robot system and should not be included in the calculation. The table below provides information about typical error types and how to assess them.

Typische Fehler	Relevant
Fleet manager error (manufacturer)	Yes
Technical/mechanical errors of the robots	Yes
Software error/robot controller error	Yes
Missions with objects (cardboard boxes, boxes, pallets, etc.) that do not fit (outside the agreed tolerances)	No
Customer operating errors (e.g. pressing emergency stop, imprecise operation)	No
Lack of missions for the robot	No
Errors caused by software tools that are independent of the manufacturer	No
Malfunction of the robot caused by employees (e.g. blocking the route)	No