# Design for Reliability

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## Abstract

Design for Reliability (D*f*R) concepts is formed by a set of tools and techniques used in Product Design/Development Life Cycle (PDLC).
D*f*R has begun to receive a great deal of attention because of customer assurance, lowering life cycle costs.
Due to heterogeneity of constituent D*f*R tools and techniques, this research reports a resource based model for measuring the achievement level of D*f*R implementation in PDLC.
The model utilizes D*f*R and reliability metric to calculate the achievement level of D*f*R. The results depict how the resources should be distribute among D*f*R activities and to be tracked in order to meet reliability requirements.

## Introduction

Today's engineering systems are complicated. For example, a space shuttle is made up of hundreds of thousands of components. These components functioning together form a system. The reliable performance of the system depends on the reliable performance of its constituent components. In recent years, statistical and probability models have been developed for evaluating system reliability based on the components' reliability, the system design, and the assembly of the components.

The development of the current system reliability models is based on the following assumption and conditions:

1) Stochastic independence (e.g., in analyses by reliability-block diagrams, fault trees, etc.),
2) 'lack of memory' in the stochastic processes of component state transition (e.g., Markovian systems),
3) No dependent and cascading failures in system reliability, availability and safety analyses,
4) No 'weak interactions', and
5) Overlooking emerging behavior, within reliability, availability and safety analyses.

As a result, the models are heterogeneous. In another word, D*f*R is made up of heterogeneous tools and techniques that its achievement level needs to measured by common parameter such resources (e.g., man-hours, budget, time).

## Methods and Materials

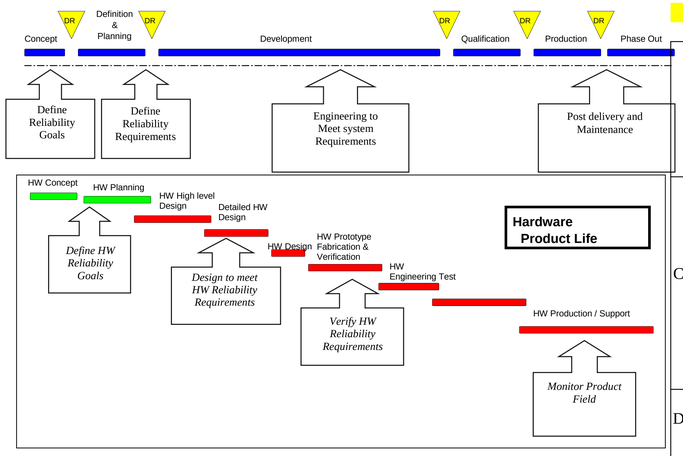



**Figure 1.** D*f*R in PDLC

Notation and formula:

- Total importance = $M_k = \sum M_{ik}$
- D*f*R matrix denoted by $M_{ik}$

Where

- $M_{ik} = W_{ij} \times W_{jk}$
- $W_{ij}$ *:DfR/DR Resource Allocation Matrix*
- $W_{jk}$ :Task Apportionment Matrix

**Table 1. D*f*R/DR Resource Allocation Matrix**

| DfR Activities ( $d_i$ ) | | Resources ( $r_i$ ) | Design Release ( $f_j$ ) | | | | |
|---|---|---|---|---|---|---|---|
| | | | DR0-Concept | DR1-Defining & Planning | DR2-Development | DR3-Qualification | DR4-Production & Release |
| Conceptual Design | Reliability Goals | 8 | 5 | 3 | 0 | 0 | 0 |
| | Reliability Apportionment | 10 | 5 | 3 | 2 | 0 | 0 |
| | Design Review & FMEA | 15 | 0 | 2 | 8 | 5 | 0 |
| | Qualitative Reliability Assessment | 12 | 0 | 2 | 5 | 5 | 0 |
| Development | Prototype Testing | 15 | 0 | 0 | 10 | 5 | 0 |
| | Reliability Growth | 15 | 0 | 0 | 5 | 5 | 5 |
| Production | Production Testing | 15 | 0 | 0 | 0 | 7 | 8 |
| | Field Data Analysis | 10 | 0 | 0 | 0 | 0 | 10 |
| Resources of DRs | | 100 | 10 | 10 | 30 | 27 | 23 |

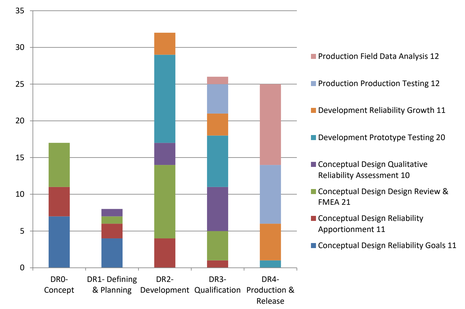
**Table 2. Task Apportionment Matrix**

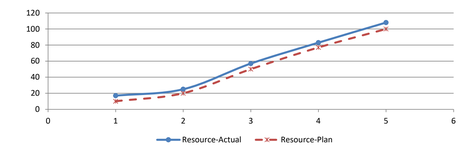
| Reliability Req. ( $C_k$ ) | Design Release ( fj ) | | | | |
|---|---|---|---|---|---|
| | DR0-Concept | DR1-Defining & Planning | DR2-Development | DR3-Qualification | DR4-Production & Release |
| Req 1 | 0.5 | 0 | 0.1 | 0.3 | 0.5 |
| Req 2 | 0 | 0.2 | 0.9 | 0.4 | 0 |
| | | | | | |
| Req n | 0.5 | 0.8 | 0 | 0.3 | 0.5 |
| Total | | | | | |

## Results

**Table 3. D*f*R Matrix**

| | DfR matrix | | | | | | | | Total Resources Mk | Relative Resources ( Ik ) |
|---|---|---|---|---|---|---|---|---|---|---|
| | *d1* | *d2* | *d3* | *d4* | *d5* | *d6* | *d7* | *d8* | | |
| Reliability Req 1 | 2.5 | 2.7 | 2.3 | 2 | 2.5 | 4.5 | 6.1 | 5 | 27.6 | 27.60% |
| Reliability Req 2 | 0.6 | 2.4 | 9.6 | 6.9 | 11 | 6.5 | 2.8 | 0 | 39.8 | 39.80% |
| | | | | | | | | | | |
| Reliability Req n | 4.9 | 4.9 | 3.1 | 3.1 | 1.5 | 4 | 6.1 | 5 | 32.6 | 32.60% |
| Product (P) | | | | | | | | | 100 | 100% |




## Discussion

The Design Release Matrix depicts the distribution of resources among reliability activities known D*f*R during Product Design Life Cycle (Table 1).

The Apportionment Matrix explains the distribution of resources among design requirements in each Design Release phase (Table 2).

The D*f*R Matrix presents the resource distribution among reliability activities and design requirements (Table 3).

Comparing the original D*f*R Matrix with updated D*f*R Matrix would help in analyzing deviation from original resource plan to fulfill reliability requirements within PDLC.

## Conclusions

Literature pertaining to D*f*R is rich. However, no method apparently exits that measure s the level of achievement in D*f*R. D*f*R is made of up a set of tools and techniques which are heterogeneous.
As a result, the proposed model is developed based on common parameters in all tools and techniques.
Using D*f*R Matrix developed by multiplication of Resource Allocation and Apportionment Metric , we can find the optimum way to distribute the resources among design requirements and D*f*R activities.
By tracking the phase-to-phase D*f*R Matrix during Design Release (Dr0, Dr1, …, DRn), we can control the resources and progress of achievement in meeting reliability requirements.
Lack of information and experience in D*f*R tools and their resource requirements is the implication of this method.
This method has some limitations such as expressing expert's opinion over required resources for each D*f*R activity.

## Future Directions

Due uncertain situations, those metric would be redesigned with fuzzy linguistic variables.

## Contact Information

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