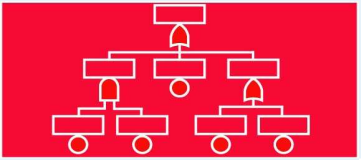
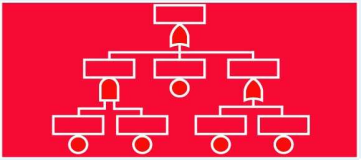
Chapter 1
Introduction

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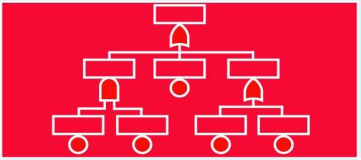
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Brief History

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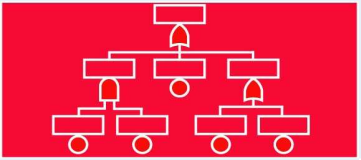
1930's:	Statistical methods for quality control of industrial products (Shewhart, Dodge and Romig)
	Determination of air crash probability
1940's	Analysis of German V1 missiles (Robert Lusser)
1950's	Failure modes and effects analysis (FMEA)
	Reliability growth (AGREE)
1960's	Analysis of intercontinental ballistic missiles
	Space research programs
	Fault tree analysis (Minuteman missile)
	New textbooks in reliability (e.g., Barlow and Proschan)
1970's	Reactor Safety Study (WASH-1400)
	Offshore activities (e.g., in Norway and the U.K.)
	Reliability centered maintenance (e.g., Nowlan and Heap)
1990's	Integration of RAMS into product and process design



Different Approaches

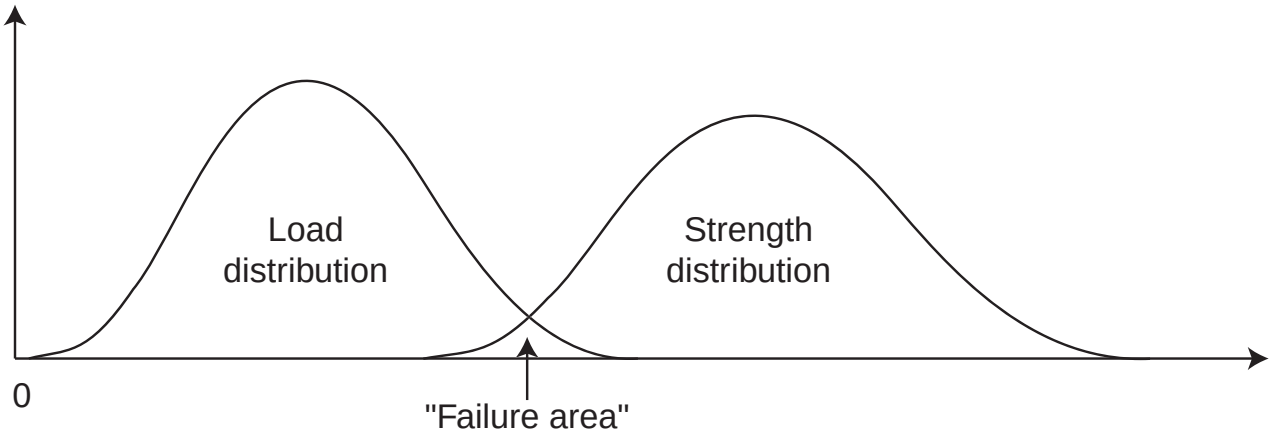
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- Hardware reliability
  - Physical approach
  - Actuarial approach $\Leftarrow$ [Main focus in this book!]
- Software reliability
- Human reliability



Physical Approach

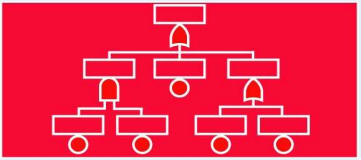
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$S =$ Strength of item
$L =$ Load on item

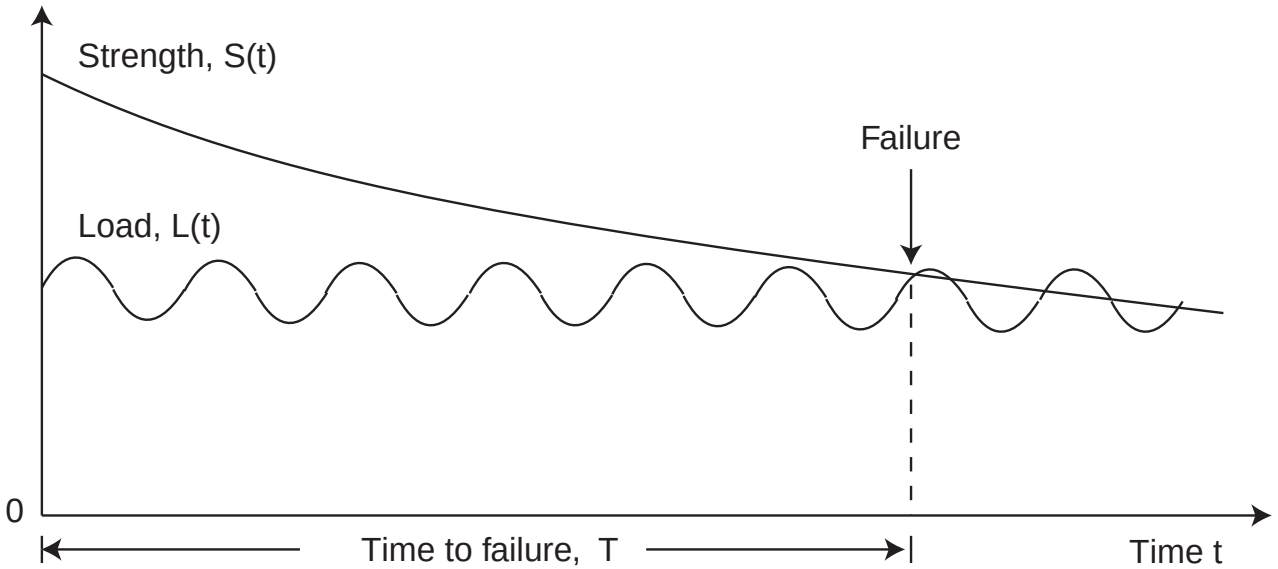
The reliability of the item is defined as:

$$R = \Pr(S > L)$$



Time Dependent

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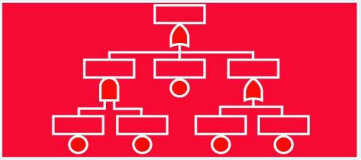


The time to failure T is

$$T = \min\{t; S(t) < L(t)\}$$

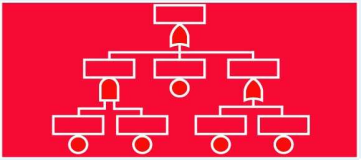
and the reliability $R(t)$ is defined as

$$R(t) = \Pr(T > t)$$



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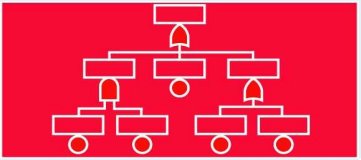
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Reliability

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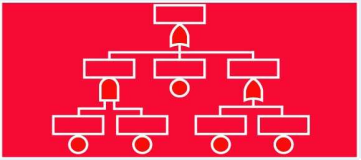
The ability of an item to perform a required function, under given environmental and operational conditions and for a stated period of time [ISO 8402]



Quality

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The totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs
[ISO 8402]

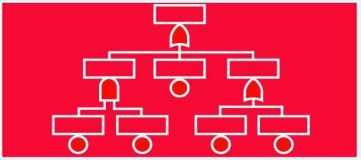


Maintainability

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The ability of a item, under stated conditions of use, to be retained in, or restored to, a state in which it can perform its required functions, when maintenance is performed under stated conditions and using prescribed procedures and resources [BS 4778].

The measure of the ability of an item to be retained in or restored to specified condition when maintenance is performed by personnel having specified skill levels, using prescribed procedures and resources, at each prescribed level of maintenance and repair [MIL-STD21C].

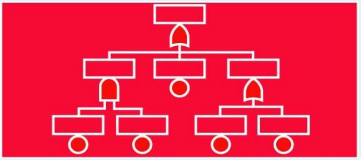


Maintenance

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All actions necessary for retaining an item in or restoring it to a specified condition [MIL-STD 721C]

- Maintenance can be corrective or preventive
- Maintenance should not be mixed up with the related concept “maintainability”



Availability

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The ability of an item (under combined aspects of its reliability, maintainability, and maintenance support) to perform its required function at a stated instant of time or over a stated period of time [BS 4778]

A measure of the degree to which an item is in an operable and committable state at the start of a mission when the mission is called for at an unknown (random) time [MIL-STD 721C].

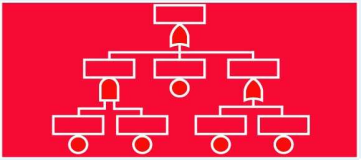
Availability at time t

$$A(t) = \Pr(\text{item is functioning at time } t)$$

Average availability (under certain conditions)

$$A_{\text{av}} = \frac{\text{MTTF}}{\text{MTTF} + \text{MTTR}}$$

MTTF = Mean time to failure, MTTR = Mean time to repair

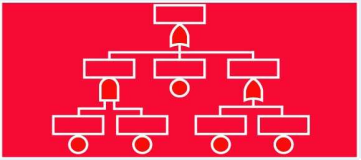


Safety

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Freedom from those conditions that can cause death, injury, occupational illness, or damage to or loss of equipment or property [MIL-STD-882D].

The expectation that a system does not, under defined conditions, lead to a state in which human life is endangered [DEF-STAN 00-56]

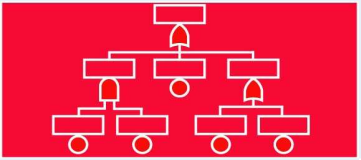


Security

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Dependability with respect to prevention of deliberate hostile actions.

- Security is often used in relation to information and computer systems. In this context, security may be defined as "dependability with respect to prevention of unauthorized access to and/or handling of information" [Laprie 1992].
- The security of critical infrastructures is thoroughly discussed in CCIP (1997)



Dependability

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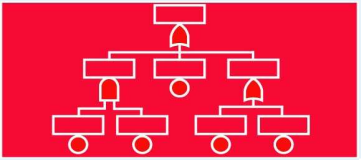
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The collective term used to describe the availability performance and its influencing factors: reliability performance, maintainability performance and maintenance support performance [IEC 60300].

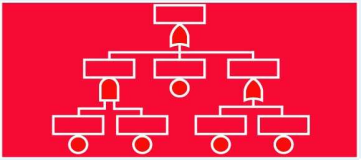
A measure of the degree to which an item is operable and capable of performing its required function at any (random) time during a specified mission profile, given item availability at the start of the mission. (Item state during a mission includes the combined effects of the mission-related system R& M parameters but excludes non-mission time) [MIL-STD 721C]



Reliability Measures

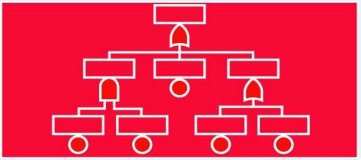
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- Mean time to failure (MTTF)
- Number of failures per time unit (*failure rate*)
- The probability that the item does not fail in a time interval $(0, t]$ (*survival probability*)
- The probability that the item is able to function at time t (*availability at time* t)



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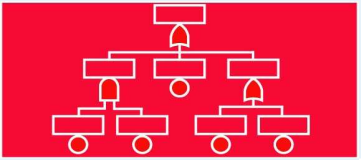
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Application Areas

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- Risk analysis
- Environmental protection
- Quality
- Optimization of maintenance and operation
- Engineering design
- Verification of quality/reliability

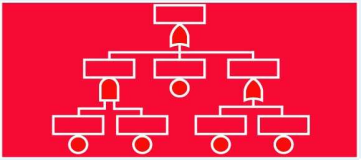


Models and Uncertainties

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> "...no model is absolutely correct. In particular situations, however, some models are more useful than others"
>
> G. E. P. Box

- The model should be sufficiently simple to be handled by available mathematical and statistical methods
- The model should be sufficiently "realistic" such that the deducted results are of practical use.



Model Figure

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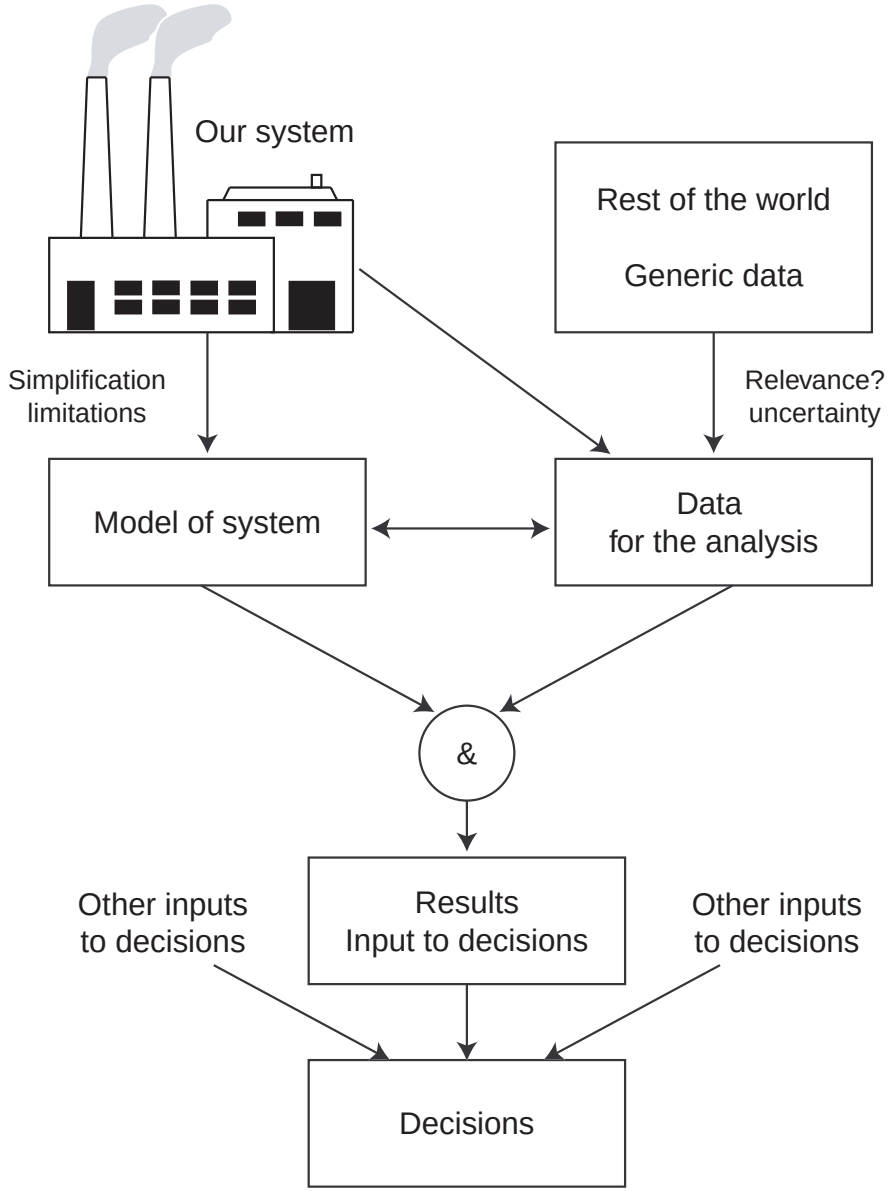
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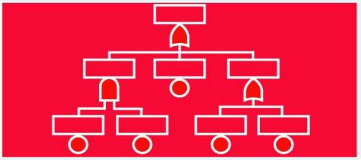
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RAMS Activities





RAMS Activities in Programme Phases - (1)

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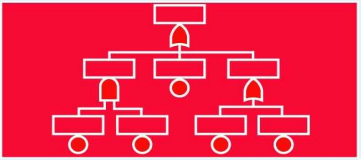
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Models and Uncertainties

Model Figure

RAMS Activities

- Feasibility phase
  - Definition of the system mission
  - RAMS requirements definition
- Definition phase
  - Technical specifications
  - Hazard identification
- Development phase
  - Compilation of definition file
  - Design validation



RAMS Activities in Programme Phases - (2)

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RAMS Activities

- Manufacturing phase
  - Product realization tasks
  - Assurance of RAMS performances
- Operations phase
  - Ensure that the RAMS objectives are reached
  - Data collection and analysis
- Dismantling phase