Reliability-centered Lift Maintenance

A Proposal for Research

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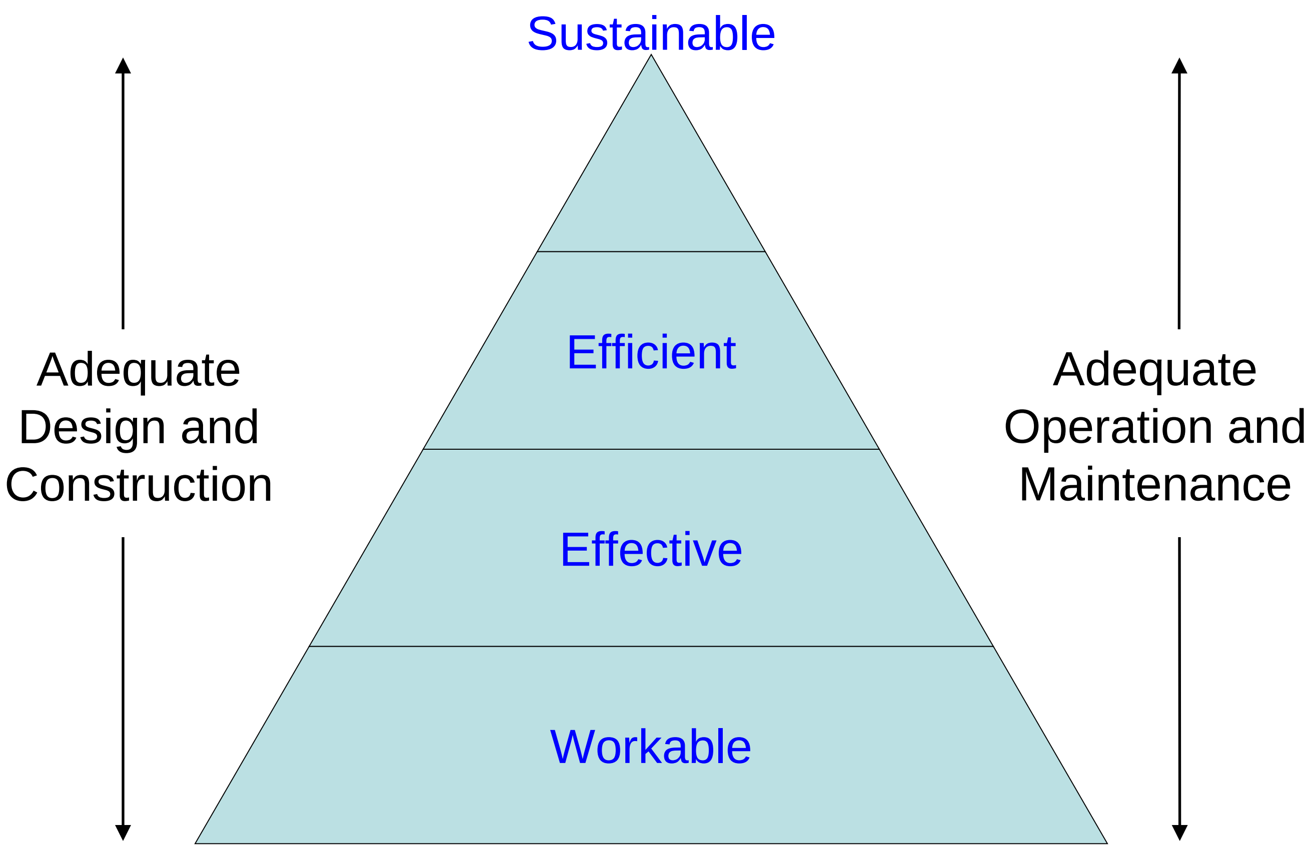
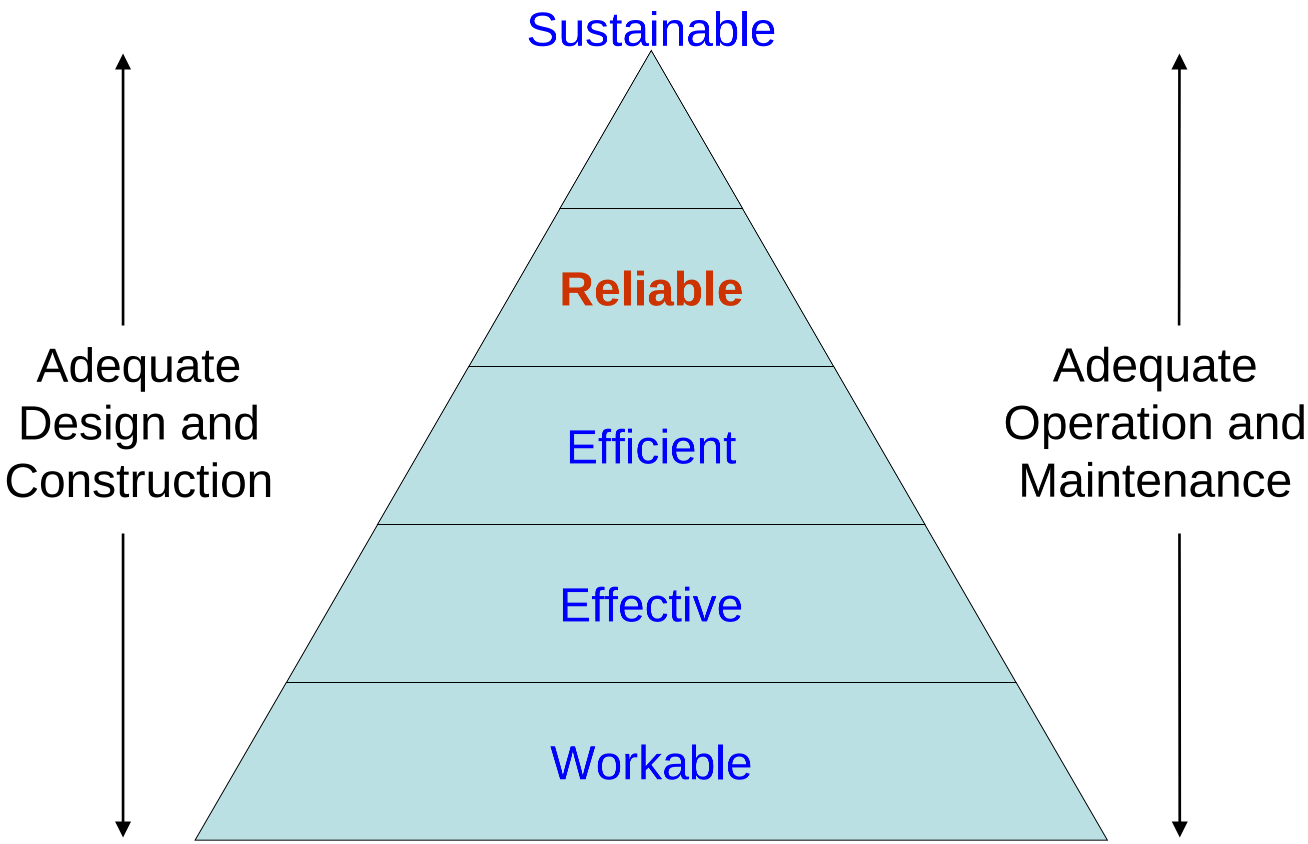
Levels of Building Performance



Levels of Building Performance



The Weakest Link

- Sustainable building entails integrated solution from a life cycle perspective
- Up-keeping in-use performance of buildings, especially their building services installations, entails:
  - Proper operation and maintenance (O&M) planning and execution
- This, in turn, needs to be underpinned by:
  - Reliability-centered maintenance
- So far, little attention has been given to O&M, not to mention reliability analysis of building services systems in buildings

Perceived Situation

- Building services installations are generally regarded as highly reliable, as they are typically equipped with:
  - Multiple units of equipment/component
  - Stand-by units
  - Consequences of failure not catastrophic
- The last point does not apply to Fire Services and Lift installations
  - But, regulatory controls on their maintenance are already in place to ensure they can operate safely and reliably at all times

Questions

- Are our building services installations sufficiently reliable?
- How to measure their reliability and do we have a minimum standard?
- Without measurement and benchmarks, how do we know we are using sufficient resources, and are using the resources efficiently, for their maintenance?
- Reliability analysis is needed for providing answers to the above questions (see example that follows).

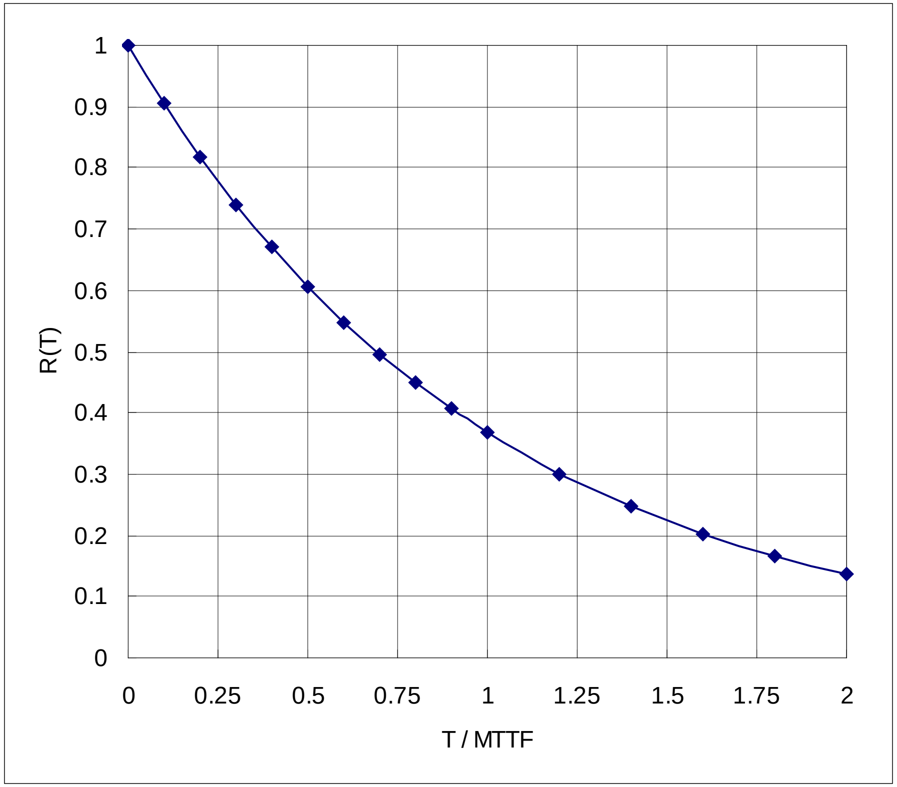
Example Reliability Analysis

- Basic concept:

- Reliability, r(t), is the probability that a system or component will continue to perform normally up to time t.

- r(t) drops with time of use but can be restored to a high value (e.g. as good as new) after maintenance.

- Availability, a(t), is the probability that a system or component will be able to perform normally at time t.



Example Reliability Analysis

- The following summarizes the events that would lead to failure of a lift and the related reliability data:

Basic Events (all in series)	MTTF (d)	λ (d^{-1})	r_{30}	MTTR (d)	μ (d^{-1})	$a(\infty)$
E1 Rope broken	6000	0.000167	0.995012	5	0.2	0.999167
E2 Pulley broken	6000	0.000167	0.995012	5	0.2	0.999167
E3 Door failure	150	0.006667	0.818731	1	1	0.993377
E4 Control failure	100	0.010000	0.740818	0.5	2	0.995025
E5 Motor failure	450	0.002222	0.935507	2	0.5	0.995575
E6 Elec. supply failure	300	0.003333	0.904837	0.5	2	0.998336

- For the lift as a whole, $r_{30} = 0.508309$; $a(\infty) = 0.980926$

Example Reliability Analysis

- Which component the failure of which is the most probable cause of out of service of the lift?

Basic Events (all in series)	MTTF (d)	λ (d^{-1})	r_{30}	MTTR (d)	μ (d^{-1})	$a(\infty)$
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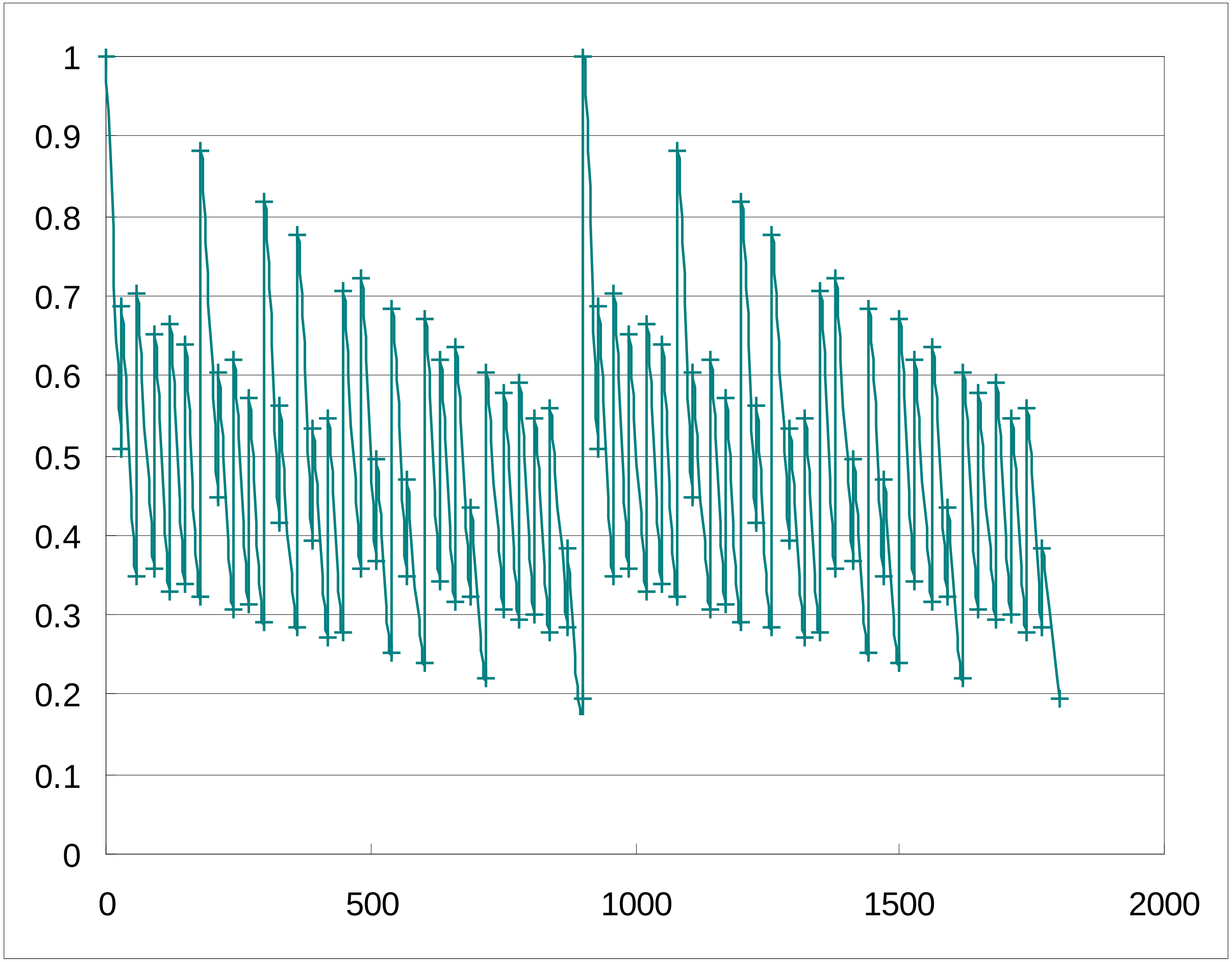
Example Reliability Analysis

- Assume that the lift is under preventive maintenance, with its components replaced periodically as follows:

Component	Cable	Pulley	Door	Control	Motor	Elec.
MTTF (d)	6000	6000	150	100	450	300
Replacement Period (d)	900	900	60	30	150	90

- The reliability of the lift as a whole will be as shown in the next slide.

Example Reliability Analysis



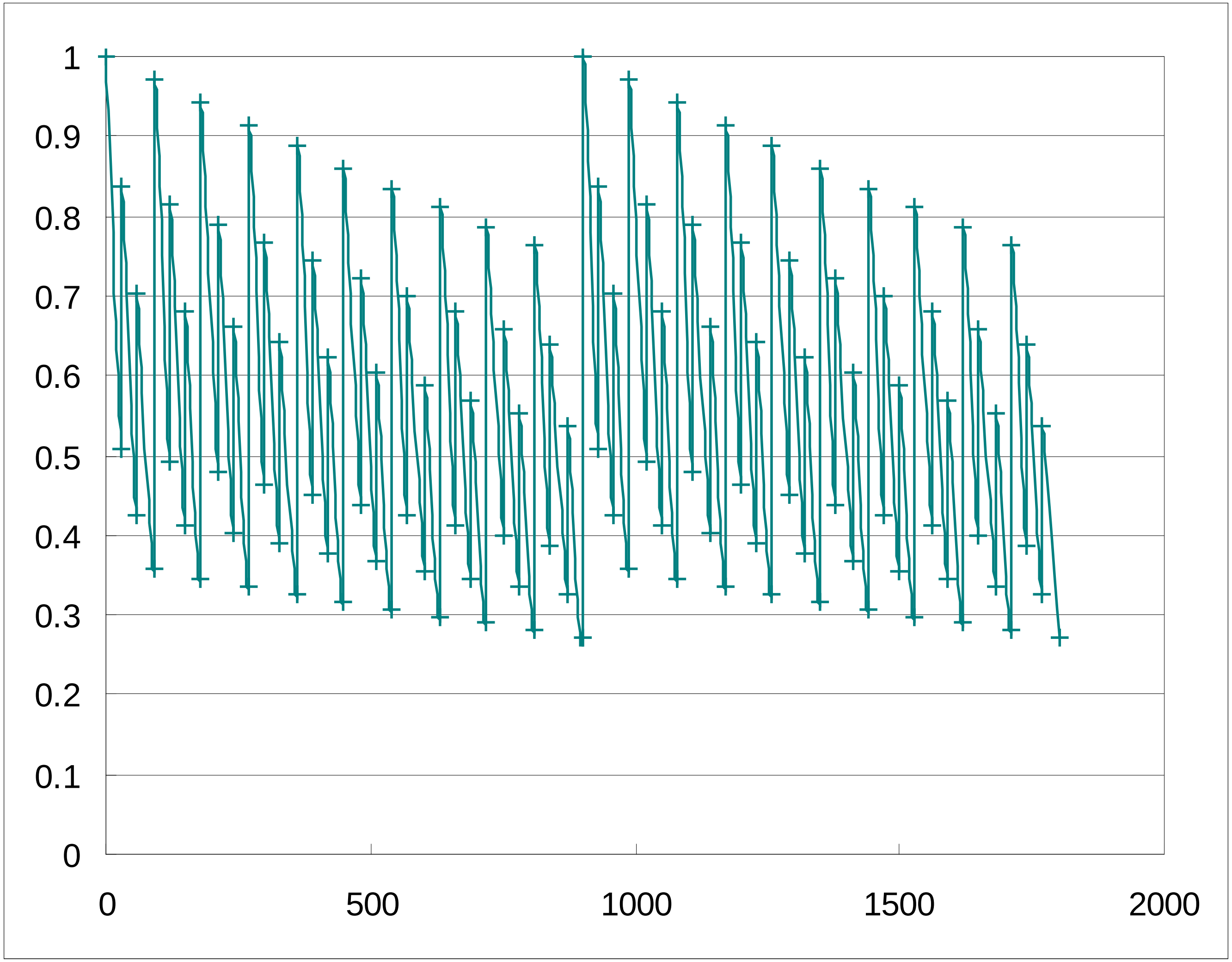
Example Reliability Analysis

- Suppose Doors and Motor are replaced more frequently, as shown below:

Component	Cable	Pulley	Door	Control	Motor	Elec.
MTTF (d)	6000	6000	150	100	450	300
Replacement Period (d)	900	900	**30**	30	**90**	90

- The reliability of the lift as a whole will be as shown in the next slide.

Example Reliability Analysis



Conclusion

- Much more can be done by applying reliability analysis but ...
- Such analysis requires availability of the failure and repair statistics, e.g. MTTF & MTTR of components as well as their maintenance and repair costs
- Unfortunately, such data are extremely difficult to obtain - the data used in the example above were all **MANUFACTURED** by me!
- *Would Housing Department be interested in a joint research study on lift reliability?*

End of Presentation

Thank you!