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Space Achievements vs. Aspirations

Space activities have continued for just over 50 years, with varying degrees of success. Everyone thinks or hopes that engineering and processes are improving. Moreton Hall has developed and maintains databases that log all launch attempts / outcomes and many spacecraft lifetimes, both planned and achieved. An extensive database of anomalies and failures complements these two master files. These data have been applied to analyse humanity's success record decade-by-decade to establish trends and explore the validity of assumptions.

The results clearly show the high failure rates that applied in the early years when defence programme missiles were being adapted for use as space launch vehicles. Missiles were mainly intended to be launched in large numbers, either in defence or attack, and a qualified majority had to succeed. With both military spacecraft launches and scientific missions, substantial losses through attrition were accepted. The manned missions and later the commercial communications spacecraft required much better individual launch reliabilities in marked contrast to the 'per-cent of many' approach used for missiles. New launch vehicles were developed or evolved with hoped-for better reliabilities. The improvement was largely achieved, but not quite to the extent that the Lussers Law calculations of reliability engineers suggested. There is some evidence that in the last two decades, launcher reliabilities have not continued to improve as was planned. All new launchers go through a phase of early high failure rates, which settle down to a lower long-term failure rate. Partly because of market pull, manufacturers do not stay with just one successful launcher; new variants are introduced to capture a share of a new market. This can (and sometimes does) introduce new areas of risk that threaten established reliability track-records. The results also answer the question:

> "Does a launch attempt immediately following a failure have a reliability better, the same, or worse than the general population of launches?"

Spacecraft too have evolved and new designs introduced to deliver improved mission products, such as more transponders, better/ more science, clearer / more detailed images, more life-in-service years. By using the ratio 'achieved life / design life' it is possible to remove the effects of the natural growth in mission lifetimes, to check whether planned mission aspirations are, in fact being delivered by the engineers and management in the spacecraft manufacturing companies. Measures of achieved life are not that easy to define, especially for 'Full-Spec' lifetimes, where commercial or military imperatives prevent release of information. But it is generally possible to determine the point at which 'Useful Life' ends. The accumulated post-facto data does exhibit the classical s-shaped curve typical of the analyst's 'system with repair'. This is to be expected as spacecraft normally carry much spare or redundant equipment to be switched in if and when a primary unit fails.

The overall conclusions of this review and analysis of historical and current data are these:

- like the poor, failures will always be with us.
- For both launchers and spacecraft, consequential losses are high.
- Launch vehicle will never achieve 100% reliability, not even man-rated vehicles.
- New vehicle reliability aspirations/calculations are generally not achieved
- Evolved launch vehicles generally have better reliabilities than new designs.
- Commercial imperatives limit too much the number of qualification /proving flights of new launchers
- A partly failed spacecraft payload is very often put to good use (but not designed for).
- Some spacecraft fail completely in early life despite extensive redundancy.
- Some spacecraft exceed their lifetimes by a huge margin.
- Design errors are repeated, though rarely by the same organisation