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Statistical Time and Market Predictive Engineering Design (STAMPED) Techniques for Aerospace System Preliminary Design

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For more than a hundred years, aviation technologists have systematically documented a myriad of aircraft design variables. These design variables describe a range of characteristics from overall system properties to aircraft geometry to subsystem performance. Often, aerospace preliminary design endeavors employ trends of these variables against each other for the purposes of arriving at aircraft sizing and/or performance determination. One of the more common types of aircraft design tools is an aircraft sizing chart. Figure 1 shows a typical sizing chart for an example aircraft from Roskam [1]. Although the chart itself provides useful information for the designer including physics-based constraints which take into account sizing criteria like balanced field length, FAA regulations and specified cruise speed, the values for lift coefficients and parasite area are essentially left as "logical choices" to be guided by rough "acceptable" ranges. Statistical Time and Market Predictive Engineering Design (STAMPED) engineering techniques allow the guesswork of simply selecting suitable ranges of variables to be eliminated. Instead, STAMPED techniques describe vector movement and changes as a function of time. Although STAMPED techniques can be applied to nearly any engineering variable, preliminary aircraft sizing is especially amenable to these methods.

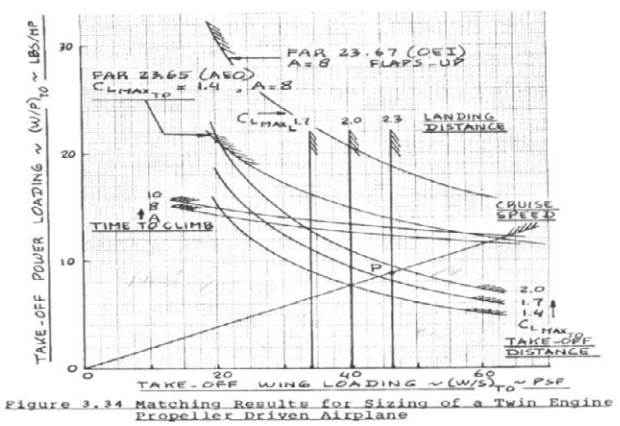

Figure 1: Typical Aircraft sizing chart [1].

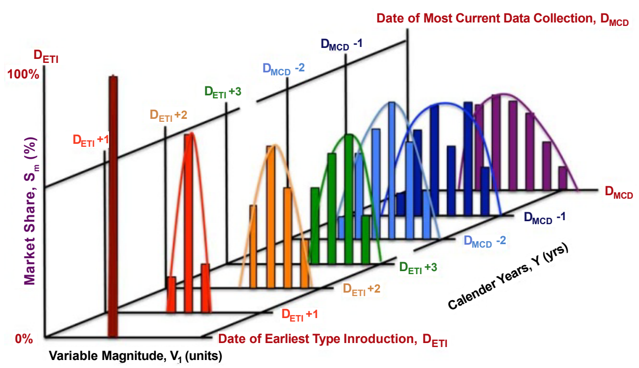

Figure 2: Typical Aerospace Market Evolution.

At the core of STAMPED techniques is a deep market analysis ideally, emanating from the beginnings of a given aircraft type, moving through the present date, extending to the date of planned performance optimization. Because STAMPED techniques are predictive, the date of planned performance optimization can be as close or as far into the future as desired. Of course, the farther into the future, the greater the uncertainty. If one examines a typical segment of the aerospace market, then finite trending can be seen in any individual or collection of variables. By counting the number and types of airframes, engines, and/or components, the market for a given aerospace product can be tracked through time from when a single product enters the market making for the most leptokurtic distribution to a fully developed, far more platykurtic distribution of a fully developed, mature market. Figure 2 shows this maturation process in terms of a hypothetical engineering variable tracked through time from its earliest inception to the date of most current data collection.

By determining the shape of a given market in terms of a finite statistical distribution, it is possible to determine what specific value for a given variable tends to dominate a given market. If one tracks this peak value through time, then it is easy to establish the trends for market dominance. Of course, one does not have to restrict his/her analysis to share of total market, but could look at a myriad of figures including profits, gross or net revenues and/or other optimization metrics. An illustrative example for this purpose is simply to examine market share (Figure 2).

If one takes the example to the next stage, then two variables can be tracked simultaneously as seen in Figure 3. These two variables clearly move through time independent of each other and can represent the points of peak profitability, peak sales or any other optimization factor. If one examines the example of an aircraft sizing chart, then one can see an example evolutionary trending line (Figure 3), compressed into a two-dimensional figure as in Figure 4. This flattened representation of Figure 3 shows both the speed and direction of the wing loading and power loading as projected through today's date, projected into the future at the "Design Fix Date" which, for these purposes is the date which corresponds to the time when the product is projected to design for optimal initial performance.

The reader will note that Figures 1 and 4 bear the same axes.

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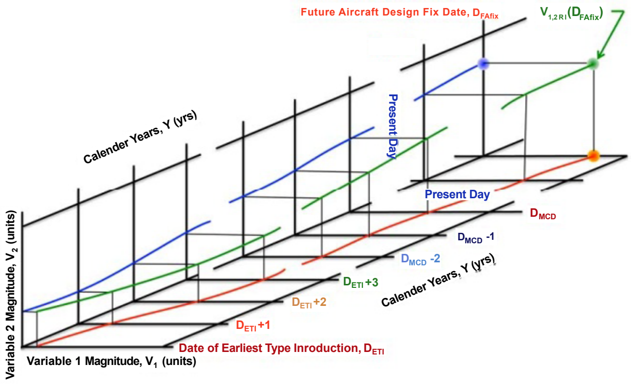

Figure 3: Bivariable Trending with Time.

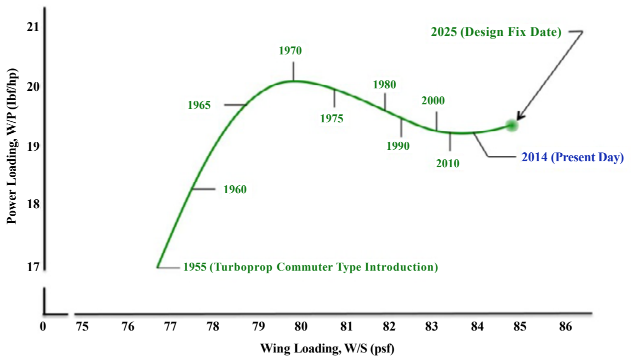

Figure 4: Example Design Point Trend on Sizing Chart with Time.

However, the major difference is that global market preference and their projections into the future result in the selection of the final design point. Accordingly, a major deviation from the principles laid out in [1] is that from the analysis of Figure 4, variables like maximum lift coefficients and parasite area are no longer "estimated," but can now be determined by examining market trending and projecting such trends into the future via a STAMPED vector analysis.

References

1. Roskam J (1997) Airplane Design: Preliminary sizing of airplanes Part 1 of Airplane Design. DAR corporation, Kansas, USA.