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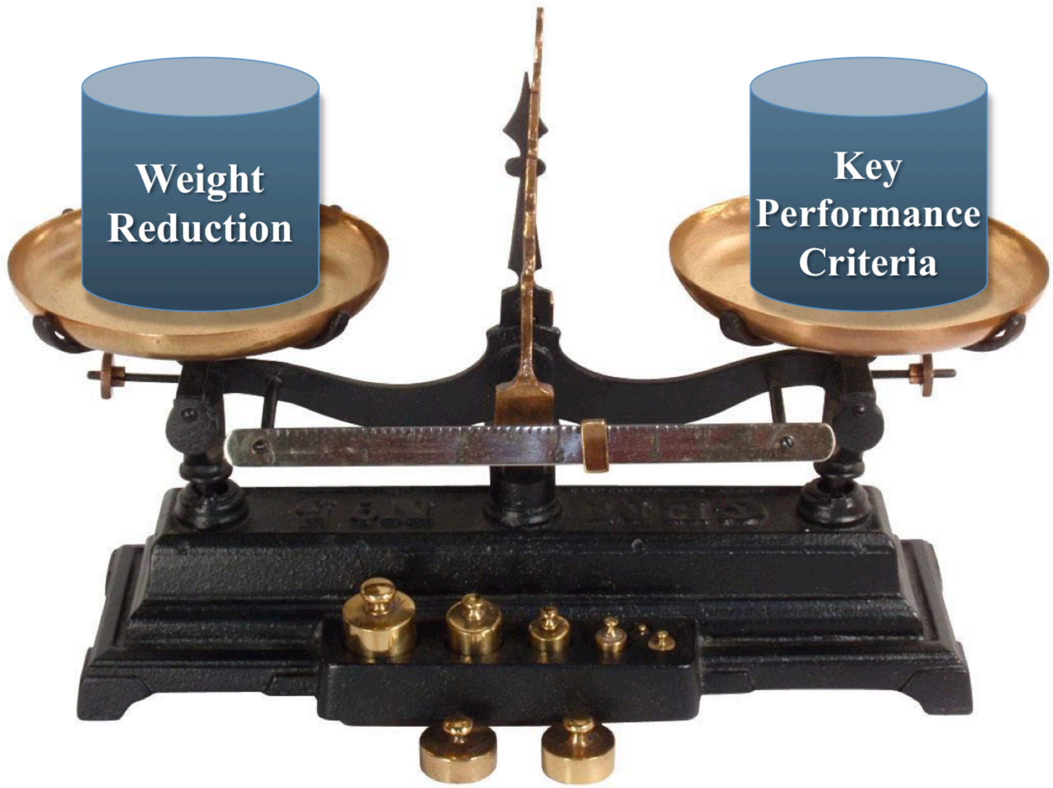

Aircraft Component Weight Control: Sensors and Switches

Weight is a critical consideration in aircraft measurement devices. Pursuing weight reduction goals must be clearly modeled and evaluated with respect to impact on performance criteria.

HydraElectric

Aircraft Component Weight Control: Sensors and Switches

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Abstract

The consideration of weight is among the key requirements typically defined for aircraft measurement devices such as pressure sensors, temperature sensors or combination devices. Robust modeling is important to understand and evaluate the trade-offs between weight limitation and performance criteria. Equally important is out-of-the-box thinking to identify design alternatives that allow for weight reduction goals to be achieved while meeting performance requirements of sensing elements.

Background

The focus on weight economy has become increasingly important over the past decade as there has been a growing number of sensing devices incorporated in the various monitoring systems throughout the aircraft.

For example, the number of units incorporated for health maintenance as well as control systems has quadrupled over the past 10 years. Consider that many of the monitoring systems are discretely located around the aircraft into smaller structures. More discretely distributed systems means there are more mountings required for holding the forces induced by vibration, shock or acceleration of even these small devices.

Evaluating Trade-offs

In evaluating the possibilities of reducing sensor weight and associated physical size, trade-offs must be considered, possibly compromising key performance features. These include important characteristics such as accuracy, EMI protection or lightning survivability, and dielectric strength.

To determine the relationship between performance features and weight economy, designers of sensors must turn to both mechanical and electrical CAD modeling tools to understand limitations during the initial evaluation. The feasibility of meeting an envelope given a certain mass, or conversely determining a maximum mass required to deliver the required function, may require a complex model to evaluate total performance. Furthermore, it is best to evaluate and model the requirements as early in the development process as possible and evaluate trade-offs.

Aircraft weight is a key factor in fuel economy, because more lift-generating drag (induced drag) results as weight increases. If airframe weight is reduced, engines that are smaller and lighter can be used, and for a given range the fuel capacity can be reduced. Thus some weight savings can be compounded for an increase in fuel efficiency.

Barney L. Capehart (2007). *Encyclopedia of Energy Engineering and Technology* 1. CRC Press.

A Representative Example

Consider the following example of a sensor's essential performance requirements.

✔	A dual sensor requires monitoring of pressure and temperature from -55 to +135 degrees C to 1% accuracy.
✔	The pressure in a hydraulic actuator is 6000 psi.
✔	A type 4 threaded pressure port requires sealing of the fluid with a face sealed o-ring.
✔	A hex is used with either a socket wrench or a flat torque wrench during assembly.
✔	The connector is a 38999 style with 6 pins, two for the temperature sensor, and 4 for power and signal output of the pressure sensor.
✔	The unit is to be placed in an environment where there is a high level of EMI exposure such as YG of section 20 of RTCA DO-160.
✔	Vibration requirements are to 25 G sine on random from 50 to 3000 Hz.
✔	Additional requirements for shock, acceleration, lightning and moisture protection are also defined.

The unit and its mounting must be capable of meeting the complete set of operational and environmental conditions. To evaluate this requirement, the unit is first broken down into functional components. These individual elements are each evaluated against the requirement through previous history, modeling, or test. The combined unit can then be configured in the CAD mechanical model, all materials defined and a maximum limit on weight determined.

Table 1 Element breakdown for the sensor described above

Assembly	Compliance	Weight Determination	Est. Weight in lbs. (Example)
Sensing element to 6000 psi	Analysis	Solid model	0.01
Signal processing and calibration for 1% accuracy	Analysis	Weigh existing unit	0.03
EMI protection to YG levels	Electronic Analysis (PSPICE)	Weigh existing unit	0.06
Lightning protection (DO160 sections 22 and 23)	Electronic Analysis (PSPICE)	Solid model	0.08
Pressure port interface	CAD Model	Solid model	0.09
Connector (38999 style)	CAD Model	Solid model	0.12
Hex (socket or flat wrench with torque requirement)	CAD Model	Solid model	0.08
Internal component mounting (mounting for vibration, shock, acceleration)	Design feature	Solid model	0.05
Wiring (robust interconnect)	Design feature	Solid model	0.005
Potting material (moisture protection)	Design feature	Solid model	0.10
		Total Weight	0.625 lbs.

Considering Alternative Ideas for Weight Reduction

The above example shows that functional parts needed to meet a specification will drive the weight. If further weight limitations are needed (for example, maximum weight is limited to 0.55 lbs), then compromises in a design or performance must be considered. In this case, potential ideas for design alternatives that can lead to reduced requirements and smaller, lighter weight structures include:

- Potting for moisture protection may be replaced by a lighter spray coating.
- An alternate connector assembly can be considered.
- Thinning up of the hex height may be possible.
- Relocation in the airframe to lower EMI or lightning exposure levels could be an option.

Considerations for specifications may become important in addressing weight. Over-specifying requirements can also lead to over-designing and increased weight.

Recommendation

In designing aircraft systems to meet weight reduction/ limitation goals, it is important for system engineers to work with a sensor designer that exhibits two key capabilities:

- The ability to model and evaluate the trade-offs between weight and performance criteria
- The capability to approach the weight limitation issue holistically and come up with creative design alternatives to address the weight issues, while still meeting the performance criteria.

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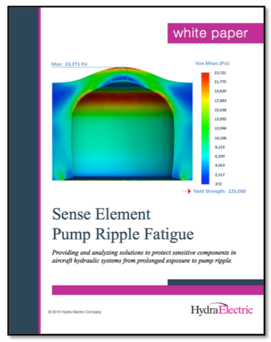
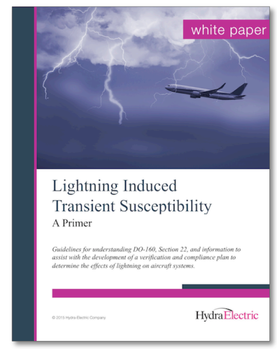


Lightning Induced Transient Susceptibility



About Hydra-Electric

Hydra-Electric is a provider of breakthrough technology in sensors and switches for the aerospace industry. Its suite of solutions includes pressure, temperature and multi-function sensors; and pressure, temperature and liquid flow switches. Hydra's high performance sensing technology is able to address problems which were previously thought to be unsolvable, including pressure spike damage, pump ripple, high speed impulses, burst diaphragms, broken wire bonds and more.

The company has been an innovator in the industry since 1948 when it introduced the snap action sensing of pressure by means of the negative rate disk spring, a design that remains the standard today for most aerospace pressure switches. Hydra-Electric's products have been used across hundreds of military and commercial applications, including fixed wing and rotary aircraft, missiles, rockets, ships, submarines, tanks and UCAVs.

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