Gapman Gen3 further reduces cost and schedule in Aircraft CFRP shimming process

Robert Foster and Bryan Manning

The Capacitec Gapman Gen3 technology was introduced in the March 2011 issue of Aerospace Testing International in an article entitled *Filling the Gap*. This covered the Gapman Gen3 portable electronic gap measurement system for aircraft applications that has replaced the feeler gauge method at all major commercial aircraft manufacturers worldwide.

To date the Gapman Gen3 has achieved a gap measurement/shimming operation schedule reduction of 5 times faster than the feeler gauges. This return on investment is well known at major aircraft builders. Additional benefits are: reduced overall cost, enhanced structural integrity of aircraft components and a gap measurement database to assist in process improvement. As an added benefit it reduces lead times while simultaneously measuring more gaps without the risk of manual data transfer.

Continuous customer feedback has driven Capacitec to develop additional features that further increase ROI and reduce gap measurement and shimming schedule times. This article will introduce new Gapman "Set to Standard" calibration software processes that will allow the Gapman Gen3 to be more easily recalibrated for a wide variety of target materials combinations such as CFRP (rough and shiny surfaces) metal (painted or non painted surfaces).

Here's some background. The Gapman functions using non-contact capacitive gap measurement. The physics behind this sensing technology is that there are 3 variables that can influence the reading. The first variable is the gap measurement that the users are trying to measure. Second is the sensor spot size - this area is typically constant. The third variable is the dielectric constant between the sensor and the conductive target surface. This is a combination of the air gap (characteristically constant) and the dielectric surface material on the conductive target, which can be a variable. These are introduced due to the plastic resins, glass laminate surfaces or paint between the conductive target and the sensor face. These coatings cause slight variability due to the thickness and dielectric constant values.

Let's concentrate on the dielectric coating materials that cause this variation and the effect on the accuracy of our measurement. The focus is on the use of CFRP painted, shiny or rough surface resins as compared to painted or clear metal. Fortunately these coatings are uniform through the manufactured structures being measured.

To minimize or eliminate gap measurement errors, aircraft users must have a rigorous policy for matched calibrations to the various targets combinations. These dedicated calibrations take into account the particular influences of each pair of gap targets. This matched combination provides a traceable solution for metrology calibration labs because they know that the data is certified to lab standards. The downside to this approach is the added time to support these multiple Gapman calibrations. An additional concern is the ability for calibration labs to build well controlled flat painted or CFRP targets. They are very costly to produce and very difficult to control the flatness to 25 -50 micron typical tolerances using readily available matched CFRP material for use as standards for calibration. These targets are typically cut from available stock and can have excessive radii. This is in conflict to the preferred metrology sample flatness goal is 1 micron for calibration target standards.

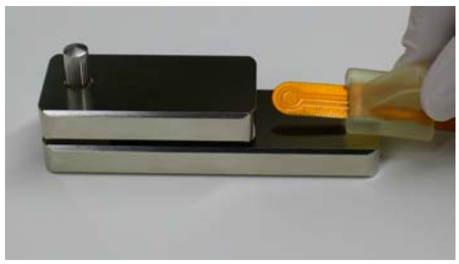

Figure 1: Metal to metal gap standard

An alternative solution to this dilemma is now available from Capacitec. It combines new custom Gapman "Set to Standard" software feature with a simple baseline metal-to-metal calibration. (See Figure 1: Gapman wand in metal-to-metal certified gap standard) When used in conjunction with certified metal calibration blocks as targets a well controlled highly repeatable certified gaps can be achieved. Capacitec performed a study comparing the metal-to-metal calibrations to a variety of different target material types focusing on CFRP combinations. The results showed that 80% of the deviations from the readings are simple offset value adjustments.

Results of Gapman metal/shiny CFRP calibration after offset

Location	Nominal	Raw Readings BEFORE Offset Gap (mm)	Metal to CFRP shiny Deviation	Corrected Readings AFTER Offset Gap (mm)	Deviation
1	0.200	0.233	0.033	0.208	0.008
2	0.400	0.423	0.023	0.398	-0.002
3	0.600	0.622	0.022	0.597	-0.003
4	0.800	0.823	0.023	0.798	-0.002
5	1.000	1.025	0.025	1.000	0.000
6	1.200	1.225	0.025	1.200	0.000
7	1.400	1.424	0.024	1.399	-0.001
8	1.600	1.624	0.024	1.599	-0.001
9	1.800	1.823	0.023	1.798	-0.002
10	2.000	2.022	0.022	1.997	-0.003
11	2.200	2.224	0.024	2.199	-0.001
12	2.400	2.425	0.025	2.400	0.000
13	2.600	2.627	0.027	2.602	0.002
14	2.800	2.830	0.030	2.805	0.005
15	3.000	3.033	0.033	3.008	0.008
		Average:	***0.026***	***Average:***	***0.008***

Figure 2: Test results of offset calibration

The table in Figure 2 shows the results of how Capacitec successfully takes advantage of this new "Set to Standard" software process using a series of custom offset adjustments correlating to the target material and finish. Figure 2 specifically shows the differences between the baseline metal-to-metal calibration and the subsequent nominal gap readings between metal-to-CFRP shiny combined targets. A unique best-fit offset, derived from the standard deviation for each material type, can be applied if the user requires tight linearity (25 microns or better). If the linearity is not as stringent (50 microns or better), one single average of all best-fit offset adjustments across all material combinations may work. The data shows that by applying this best-fit offset (0.026mm average deviation) to any of the data will result in greatly improved linearity of 0.008 mm shown in the right hand side of the table. CFRP-to-CFRP rough glass targets, tested by not shown here, represented the largest deviations (about 100 microns) in outputs due to the unique surface dielectric coatings of the materials used (and not being conductive metal).

The compromise of making just an offset adjustment leaves a slightly higher residual non-linearity due to the slope variation of the material combination. Engineers can investigate whether this offset adjusted variation meets the requirements for their particular assembly. This new approach to certified gap measurements creates added efficiency of the complete shimming process.

Furthermore, a new Gapman Gen3 wireless option has a higher level command set of communication protocols to allow an external software program to adjust this "Set to Standard" offset of any material combination (CFRP-to-metal etc.) being measured at any location. Customer designed database software could readily apply this offset value, by communicating via the wireless option. Calibration check standards can also be used in production to validate proper operation without the additional cost burden of special composite standards for each gap target combination.

The Gapman "Set to Standard" calibration process can have a high impact on improving gap measurement and shimming process throughput. It also improves the quality of calibration recertification as it is based on known metal/metal standards while reducing the time it takes to certify under normal metrology cycles.

Robert Foster is President of Capacitec and Bryan Manning is Commercial Director of Capacitec Europe. www.capacitec.com