A Functional Application Of RM In A Military Environment

Paul du Plessis
Design Manager
SAAB Avitronics

TCT Conference
Ricoh Arena
Coventry
21 October, 2008

Abstract

Positioning Statement:
The paper describes a project developed by Saab Avitronics and the benefits derived in the development of a hand-held test apparatus used in a military operational environment utilizing Rapid Manufacturing technologies, and in particular SLS technology and WINDFORM® materials of CRP Technology s.r.l..

Aims/Objectives
The project, environmental and performance criteria for the test enclosure are discussed, and Rapid Manufacturing offered as a solution, followed by a detailed report on the project milestones, various materials and technologies investigated as well as the results achieved.

Results/Conclusions
Some reference is made to the historic use of SLA,SLS and other technologies at SAAB Avitronics, and their role in the development of surveillance payloads used on unmanned aerial vehicles
Some thoughts on future applications of these technologies are shared. It is concluded that WINDFORM® is a material that offers a viable alternative to produce RM, quality, low volume high technology enclosures.

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1. **Introducing SAAB Avitronics South Africa**

Saab Avitronics is a merger of SaabTech within Saab from Sweden and Avitronics within Grintek from South Africa. As a joint business unit with our broad systems know-how and experience in design initiative, we are committed and even further able to provide cost effective solutions based on the latest technology for air, land and maritime applications.

Our Electronic Warfare product range includes jammers, ELINT/ESM systems and stand-alone or fully integrated self protection systems with radar, laser and missile approach warning functions and world renowned countermeasures dispensing systems.

We are equally focused on developing avionics for military and commercial aircraft.These products range from safety-critical utility and control systems to reconnaissance systems, display systems and a wide range of modular avionics.

2. Avitronics and RP / RM

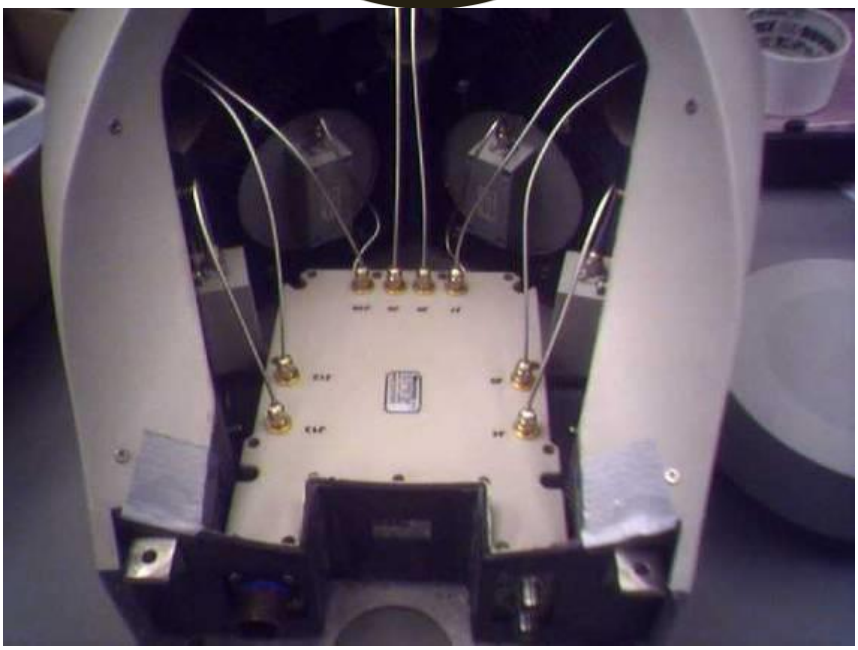
A Stereolithography (SLA) prototype of the LWS200 Laser Warning sensor marked Avitronics introduction to additive manufacturing.

RP was used on several projects that followed. The resins available at the time where rather brittle, semi-translucent, and had little use other than for the production of fitment and display models.

The technology, and materials improved over the next decade of course.

During 2005, a crash development program for a subsonic Unmanned Aerial Vehicle (UAV) required a compact, lightweight, rugged, waterproof enclosure.
Less than two weeks were available to complete the design and manufacture of two complete sets of components.
Funding was rather limited.

Having used SLS Polyamide components on earlier development projects, I opted for this technology as a possible solution.



The results were extremely positive.
We managed to meet all the requirements and within the allowed timescale and budget.

The method was also successfully employed on a follow-up project, and has since established itself as the way to produce deliverable, performance enclosures specifically for UAV's.

3. LS31 Laser Warner Tester

In addition to our range of avionics and Electronic Warfare systems, Avitronics produces an extensive range of test equipment for these products.

The strong growth in the land combat vehicle arena, heralded the need for a portable, hand-held test apparatus for the laser warning systems.

The LS31 would be a hand-held, testing apparatus for Laser Warning Systems on airborne, fixed and rotary winged platforms, maritime applications as well as for land combat vehicles.

Customer no.1 only required two prototypes, followed by a further eight production units.
To meet the expected delivery price, as well as the timescales required, traditional injection moulding could not be considered.

Machining the components from bar stock aluminium would also be to expensive.

3.1 Requirements

The LS31 enclosure had to meet the following specifications :

- Compact
- Comfortable to use
- Waterproof
- Rugged
- -25C to +85C working temperature range

- Low cost

LS 31 PCB assembly

3.2 Prototype 1

The geometry for the prototype was created in Solidworks, and 3-D Printing was considered as the fabrication method.

Advantages offered were:

i) Several bureaus in South Africa who offer this service
ii) Real ABS plastic
iii) Natural Black colour – no painting required.

LS 31 prototype 1

Prototype 1 Results

The prototype parts were received a few days after the STL files were e-mailed to the bureau.

Having seen excellent 3-D printed components before, the results were rather disappointing. The curved exterior surface had very pronounced steps, and the engraved characters were totally unclear.

A further problem was the strength of the material, and fitting the printed circuit board, the snap fits broke off.

LS 31 prototype 1

The supplier offered to grow new parts, which were only slightly improved.
He then set about doing hand finishing the parts, and painting them.

LS 31 prototype 1

It was decided that the parts were not of an acceptable standard to deliver to a customer. The pricing was approximately 25% higher than earlier quotations for SLS.

CRP Group

Via Cesare Della Chiesa 21 - 41126 Modena, Italy
Tel./Phone +39-059-330544/821135/826025
Fax +39-059-822071/381148
www.crp.eu

3.3 Prototype 2

The same geometry was used for the growth of the second prototype.
The parts were produced in SLS Carbon-filled PA material, Carbonmide.

Prototype 2 Results

The parts were delivered within two weeks, but were aesthetically rather disappointing as well.

The colour wasn't black as expected, but a dark grey colour and a rough surface tecture. Although less pronounced than on the 3-D printed parts, the exterior also had stepped facets. The engraved characters also lacked definition, and unclear in places.

LS 31 prototype 2

The components seemed very strong however.

Regrettably, these components were not of the quality we strived to deliver to the client.

3.4 Prototype 3

The decision was made to have the third prototype Grown in SLS PA Duraform and Duraform GF (Glass filled) We have had a lot of success with this material
On other projects like the UAV's.

The same geometry was to be used as on proto's 1 & 2.

Prototype 3 Results

The parts were grown by a local supplier, and delivered within five days.

Some faceting was evident, but less than on the previous prototypes. The definition of the engraved markings were also improved, and overall, the finish was better.

LS 31 prototype 3

The only real problem was the colour, which in the case of the Duraform was snow white, and a greyish white on the GF version. The parts would have to be masked and painted.

LS 31 prototype 3

In terms of strength, both sets seemed rather good, the GF version more superior of course.

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LS 31 prototype 3

The masking proved to be rather tricky, and unfortunately resulted in a rather uneven edge. After painting, the finished product was definitely the best we have had thus far, but not quite of the quality we were aiming for.

3.5 Prototype 4

At this point, the design of the LS31 enclosure was substantially modified to improve the aesthetics and ergonomics.

A internet search led us to the site of CRP, a company based in Italy.
Their Carbon-Filled PA material, Windform XT, seemed to offer the specifications we required.

CRP claimed a superior black finish, and high strength.

Introducing CRP and Windform® materials

CRP Technology is presently a reference point for clients whose first aim is hi-technology and Military and Aerospace sectors also show interest in the offered technologies.

Their continuous innovation pursued for more than 10 years allowed them to understand and grasp the racing world needs and dynamics first, and now for SAAB as well:

- Maximum support to the customer request,
- Excellent quality and reliability,
- Very short delivery times,
- Continuous research for innovative solutions with an internal constantly updated R&D Department,
- Right know-how in order to get involved at the earliest design and development stages to optimize design also.

The product we used for this study is **WINDFORM® XT**, that is created for Hi-Performance market, where the carbon fibre filled marks the difference. It is in fact carbon fibre filled PA and allows the creation of high-end functional prototypes and production parts.

Windform® XT Technical Data Sheet

For the Prototype 4 of the LS 31 LASER WARNER TESTER CRP used WINDFORM® XT.

Windform® XT material was chosen because better and most performing compared to the other materials previously used.

Windform® XT allows:
- To obtain an extremely lighter part in a very shorter time, as only RM can offer;
- To realize a more complex shape of the part;
- To save money on the cost of the machined part.

Launched at Euromold 2004, Windform® XT is created for Hi-Performance market and rapresents the real challenge for the other RP materials, and so far unsurpassed, therefore leading to Rapid Manufacturing applications.

Here you can see the Technical Data Sheet, also available on line: www.windform.eu.

Prototype 4 Results

The parts were delivered a couple of days after the order was placed.

We were astounded.
Even though the new design had a much curvier shape, no faceting, or steps were visible on the outside, or on the nside for that matter.

The parts had a beautiful, black, "spark erode" type finish,
as if they were produced in a injection tool.

LS 31 prototype 4

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Via Cesare Della Chiesa 21 - 41126 Modena, Italy
Tel./Phone +39-059-330544/821135/826025
Fax +39-059-822071/381148
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The engraving had good definition, and the parts seemed to be quite strong.

An added bonus was the conductivity, we accidentally discovered whilst trying to figure out why the onboard battery of the LS31 kept running flat (A solder joint touched The inside of the enclosure).

LS 31 prototype 4

This property would offer a certain level of EMI suppression.

The only changes we envisaged, were small detail design improvements to ensure better sealing, and fit of the switches and led's.
The font size of the engraved characters were also increased, and made deeper.

The cost was very similar to that of the locally produced SLS components used in prototype 3.

LS 31 prototype 4

Prototype 4 was very definitely the quality standard we were hoping for, and certainly the level of product we felt comfortable delivering to a customer.

CRP's Quality

Certificate of Conformity:

•All WINDFORM® materials are regulated by the EN 10204: 2005 Type 3.1 normative

•Certificate of Conformity attached with each batch of the WINDFORM® product, which guarantees the consistency of the technical characteristics

4.0 What Did We Achieve ?

- Compact Design
- Rugged
- Waterproof
- Ergonomic, comfortable
- Aesthetically pleasing, matches injection moulded products
- Lightweight
- Conductivity which offers some EMI shielding
- Low cost

CASES	MATERIAL	COLOUR	SURFACE	FINISHING	ENGRAVING	STRENGHT	COST
Prototype 1	ABS plastic	Black	Pronounced facets on curved surfaces	General finish not acceptable to customer	Engraving not clear	Low	Very Expensive
Prototype 2	Carbonmide, SLS carbon filled polyamide	Grey colour – required masking and painting	Pronounced facets on curved surfaces	General finish not acceptable to customer	Engraving very bad definition	Medium-High, max 72 MPa	Medium
Prototype 3	SLS Duraform & Duraform GF	White colour – required masking and painting	Some faceting on curved surfaces	General finish better than Prototypes 1 & 2 But not acceptable for production	Improved definition of engraving, compared to prototypes 1&2	Medium, maximum 44 Mpa	Medium
Prototype 4	Windform XT, SLS carbon fibre filled material	Black – no painting required	Zero facets on curved surfaces	Superb finish – Great improvement of Duraform / Duraform GF. Authentic "Spark Erode" type finish	Definition of engraved characters very good	High, 77 Mpa	Medium

Summary – Prototypes 1,2,3,4

Rapid Manufacturing versus Traditional Injection Moulding

Parts manufactured directly on a SLS machine have the benefit of zero tooling cost, and the first batch can be produced in a matter of days.

Deliverable, performance parts are now a possibility due to the availability of more suitable RM materials.

Customer specific customization is possible, by cloning and modifying the 3-D CAD geometry only, and then growing them in the machine.

A high level of complexity and features can be incorporated in a design, without the added complexity and cost using injection moulding tools.

Although it requires many weeks and even months to produce a traditional injection tool, and significant financial outlay, it is by far the more economical choice for larger production volumes.

	Injection Moulding	SLS
Tooling Cost	$ X (high)	$ 0
Price Per unit/Qty10	$ Y (high)	$ - 25%
Price Per unit/Qty1000	$ Z (low)	$ +1000%
Delivery Qty 10	16-18 weeks	1-2 weeks

5.0 Conclusion

Rapid Manufacturing is a versatile technology that enables the manufacture of low volume, high performance, deliverable enclosures.