Creating an industrial start-up straight out of university

by

Clémentine Gallet
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Overview

Coriolis Composites was founded in Lyon in 2001 by three engineers who loved sailing. Two years later, the company moved to Lorient in Brittany where the environment was better suited for a start-up whose initial aim was to develop an automated technology for the manufacture of boat hulls made from composite materials. It started as a student project in 1996 and had a complicated beginning. The Lorient economic development fund was the entrepreneurs' last hope. The engineering graduates bought their first robot arm and tested their software for two years at the end of which they signed their first contract with Airbus. The sailing world, however, chose to ignore this technology. This enabled the start-up to take off. Today, Coriolis Composites has more than one hundred employees. It has become one of the world leaders in its sector. It supplies robots to numerous aeronautical factories throughout the world, engine parts for Safran, fuselage panels for the A350 aircraft, and tails for the Bombardier CSeries in Canada. But nothing whatsoever to the sailing industry...

Report by Élisabeth Bourguinat • Translation by Rachel Marlin

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I was born in Lyon into a family which has worked in the weaving industry for many years. One of my grandfathers was the first industrialist to use a weaving machine for composite materials. My other grandfather founded the Lyon Mechanical Engineering IUT (University Institute of Technology) where I studied. After graduation, I spent three years in a German *Fachhochschule* (university of applied sciences) alternating between the classroom and practical factory experience in prestigious companies such as Bosch and Mercedes. I spent my end-of-studies placement at SGL Carbon, BMW's principal partner and supplier of carbon fibre.

A student project

I met my future husband, Alexandre Hamlyn, at the IUT. He was very keen on sailing, and after the IUT he continued his studies at the IPSé (Institut Polytechnique de Sévenans, which later became the Belfort-Montbéliard University of Technology) and did all his work experience in shipyards because he wanted to be a naval architect. These placements helped him to realise that techniques for producing boat hulls were still hand-crafted. Workers rolled out carbon fibre into very large moulds, and glued it on by hand with resin before baking the moulds in large ovens. The working conditions were very difficult, and the results were variable: the finished product on the Friday did not weigh the same as the same model produced on the Monday, for example.

In 1996, Alexandre developed the idea of automating these manufacturing systems using two techniques: starting directly with bobbins of thread rather than fibre which had already been woven; and producing the hull and the ship deck from a single length of fibre thereby ensuring maximum strength and solidity.

We decided to launch this venture with a third engineer, Yvan Hardy. It was out of the question to create a company straightaway. Our aim was simply to build a mini-transat, 6.50 metres long and 3 metres wide, in order to cross the Atlantic.

The first models

We discussed the direction of the fibres at length, and started by practising on DLR (*Deutsches Zentrum für Luft-und Raumfahrt*: German Aerospace Centre) winding machines which the DLR laboratory had agreed to lend us for six months. A winding machine is equipped with a box of bobbins. The bobbin thread unwinds and covers a rotating mould on the spool. With help from the DLR, we were able to produce our first model (on a scale of 1:20), but we were not satisfied because we had to subcontract the work to DLR teams, and were not able to use the machines ourselves. As a result, we did not know the exact procedures.

We started looking for machines which we could use ourselves. In 1998, the *Lycée de la mer* in Gujan-Mestras (in the *département* of Gironde) lent us one. It was quite basic, but we could programme and handle it ourselves. This meant that we were able to make a new model and register our first patent. With traditional winding machines, it is difficult to make tapering cross-section shapes as there is too much material on one side and not enough on the other. Our patent provided a solution to this problem by programming the machine in order to obtain a consistent width throughout.

In 1999, we were able to use machines situated near Brussels and we created a full-scale model. It was then that we realised that rather than an eyelet to hold the fibre so it gets wound onto the mandrin spool, it would be better to have a robot arm which would place the fibre precisely and directly on the desired area.

The creation of the company

We entered this new model in the French Ministry of Research's 'Emerging Companies' category competition. We received initial financing to work on the technological development and business plan.

We took a six-month training course at the Lyon Business School in order to understand how a company works, because during our engineering studies we had not learned how to keep accounts or to draw up a financial balance sheet.

At the end of this training, we entered the competition again, this time in the 'Company Creation' category, and we were awarded additional financing. We had six months to create the company and to look for investment funds.

We founded the company in 2000 and named it Coriolis Composites.

Hanging by a thread – Part One

On paper, our aim was very clear. We had to manufacture a support on which the fibre could be placed, fix it to a robot arm, and design the relevant software. We asked for quotes for the various pieces of equipment we needed, especially the robot arm which alone cost 40,000 Euros.

I tried to meet all the venture capital investment companies in France. I was told the same thing every time, 'You are only 24. You are much too young to start in this field. Furthermore, you do not have a degree from a well-known university, and also you do not have any industrial experience in France. Above all, you do not have any money to invest in your company. Try to get a job in an industrial group and come back to see us when you have put some money aside.' I tried hard to explain to them that the three of us had been living off the minimum wage for the past four years, and that this in itself demonstrated that we were motivated. However, this argument fell on deaf ears.

It took me two years to find someone who was ready to invest in our company. Jean-Yves Le Drian, the former mayor of Lorient and, at the time, MP for the *département* of Morbihan and regional councillor for Brittany, had raised a local fund for economic development in Lorient, a city which had been badly hit by the closure of its submarine base and the transformation of the DCN (*Direction des constructions navales*: shipbuilding division of the French Ministry of Defence) into a public limited company. He was ready to finance our project provided we establish our company in Lorient. We thought this was a sensible idea because this creation would bring us closer to the sailing market and allow us to ship our finished products due to Lorient's deep-water port when the time was right. Therefore, we left Lyon for Lorient and, in December 2002, we had our first fund-raising.

Hanging by a thread – Part Two

After January 2003, we began experimental development. We bought the equipment, installed it, tested it, and developed our software. Two more people joined our team. In 2005, we had a machine capable of placing four fibres simultaneously. We contacted the leaders in the sailing world, including Bénéteau and Jeanneau, and let them know that they could finally install robots in their factories.

To our utter disappointment, none of them was interested! Bénéteau, in particular, was undergoing an internal economic crisis and did not want to invest in robots. The same was true for the others. We only had six months' worth of cash flow, and the client on whom we had pinned our hopes and who seemed the most likely client had refused us.

We decided to look into the wind turbine market, and General Electric, which had bought Enron's subsidiary in this sector, came to see our machine. The result was just as disappointing. 'Your machine can only place four kilogrammes of fibre per hour. Come back to see us when it can place one ton', they said.

A miracle: an order from Airbus

It was at this time that we realised that in the United States, where these technologies have existed for twenty five years, it is essentially the aeronautical sector which uses automated production of objects made from composite materials. Consequently, we invited Airbus, Dassault, Eurocopter and all the members of the GIFAS (*Groupement des industries françaises aéronautiques et spatiales*: the French aerospace industry association) to a meeting during which we explained to them that we only had six months' worth of cash flow and that if we did not find a client very quickly, we would have to move to the United States.

It so happened that Airbus, whose A350 should have initially been made from aluminium, was in the process of changing its strategy. Boeing had just announced the launch of an aeroplane made completely from composite materials, and this information alone had resulted in a record number of orders for Boeing. Airbus, therefore, decided to increase considerably the amount of carbon fibres in its A350s, but there was still one concern: since the only available machines were American, how could they be sure that these machines were as good as those at Boeing? It seemed more sensible to look for an available technology in France. In these circumstances, what we had to offer could not have arrived at a better time. Six months later, in 2007, Airbus placed its first order with us.

As far as I was concerned, this was like a miracle. It had been far from easy to convince Airbus that five 'nit-wits' from the suburbs of Lorient could win such a contract. Furthermore, when the contract was signed, we had a slight moment of hesitation. We were a very small team, our surfboards regularly dried at the back of our workshop, and now we had to elevate ourselves from being craftsmen to handling industrial production and being capable of making parts of aircraft fuselage. This was a major change!

We had to keep to several deadlines throughout the process. For example, we had four months to produce a fibre placement head which was capable of placing twelve fibres instead of four. We had increased the number of employees from five to twenty-five over six months, and then to about forty in the months before production began, while managing the cash flow correctly. Our most difficult and important challenge was to deliver the order on the specified date because everybody was waiting for us to make a mistake. We succeeded, and were able to overcome the major risk often encountered by start-ups like ours, to remain constantly at the R&D stage without advancing to the industrial production stage.

Coriolis' clientele

Once we had demonstrated our ability to carry out this operation correctly, orders started flooding in. From 2008 onwards, we started working with Safran on a feasability study for engine nacelles for Neo aircraft. This was our second important victory because the Neo programme is a bit like Safran's 'goose which lays the golden egg'. We then had an order from Bombardier to work on an aircraft which is a rival to the A320. We are also taking part in the Russian MS-21 programme, another rival to the A320. Additionally, we provide expertise to the Falcon 5X, the Rafale, and Ariane 6.

These industrial programmes only really started in 2012. Before then, we equipped research laboratories such as the ThermoPlastic Composites Research Center and the National Aerospace Laboratory in Holland, the Augsburg Fraunhofer Institute, the University of Munich, the DLR in Stade, the Bristol National Composite Centre, the Bayonne Compositadour platform, the Aerolia Méaulte in Picardy, the Chinese Comac laboratory, the KCTech laboratory in Seoul, and so on.

These machines and the Coriolis staff involved in their installation and the training of their users served as a showcase to sell our technology. For industrial groups, it was complicated for them to progress from manual technology to robotic technology, and also from aluminium to composite. We had to show them that we were able to provide them with the engineering and support they needed to take this step. It is due to our contracts with laboratories and research platforms that we succeeded in convincing them to integrate our technology.

Coriolis' products

We sell fibre placement heads for 8, 16 or 32 fibres. The fibre placement heads for 8 fibres weigh aproximately 30 kilograms. Those for 16 fibres weigh between 50 and 70 kilograms.

As a support for these heads we use standard Kuka robots, like the ten thousand bought by the car industry every year. We adapt the heads which place the fibres onto the moulds as well as the bobbin cabinet (or creel) and the tubes which guide the fibres towards the head. Our American rival uses machines which place the fibres using a pulley system. We quickly realised, however, that if we used pulleys on a robot which moves a great deal, the fibres would most likely end up in a mess on the floor. Our most important patent is the one for these tubes which guide the head: our inspiration came from the breaking system on a bicycle.

Our machines are sold with various configurations, for example in a column to make aeroplane noses, or as a cross-bar to make flat pieces. When we started, we used the digital command (the 'brain'), included in the robot, to control it. However, we exhausted the digitally-commanded robot and wanted to change and use a control tool made by Siemens which was compatible with all types of robots and machines. We took out the robot's 'brain' and replaced it with the Siemens control tool. We developed specific algorithms which allowed us to pilot the robot and the fibre placement heads extremely precisely.

Our machines make very complex parts like the fairing, a piece of cowl which covers the mechanical systems which operate aircraft wing tips. For this product, the fibre placement head places 8 fibres, 6.35 millimetres wide. The robot works on six different axes, as well as the axis of the rail on which it is fixed and the rotation axis of the part. An infrared lamp heats the carbon to 50° C. A cutting system cuts the thread in motion making hollows at certain places in the part to make it lighter, and places the thread further away. There is a 0.2 millimetre margin of error. Each aeroplane has four parts like this and so therefore this is an important market for us.

We also use Siemens software which makes it possible to simulate how the machines work. Finally, our software is integrated into Dassault's CATIA software to manage how the machines will be installed in the factory before they are delivered.

The company today

Today, Coriolis employs one hundred and ten people, most of whom are engineers. We neither practise mechanics *per se* nor machining in particular. All components are subcontracted and arrive in our factory pre-assembled. Our assembly workstations only occupy 1,000 m^2 and the four teams who work on them deal mainly with configuration, cabling and automatisation.

Coriolis' turnover was 13 million Euros in 2014. We aim to turnover 25 million Euros in 2015. This rapid increase is linked to the start of the A350 industrial programme, and the fact that we now no longer deliver R&D machines but industrial machines which make mass-produced series parts.

We have been lucky to remain independant, and we are very happy about this. Contrary to creators of other start-ups, we did not need to sell 90 % of our shares to raise the necessary funds. This was also preferable because if we had had more money our machines would probably not be as competitive. Our American rivals, whose funding was subsidised by the Ministry of Defence, produce huge steel structures compared to our machines which are very light and flexible. This is typical of French culture: when one does not have the money, one has to find the idea instead.

We have protected our innovations with about twenty patents covering both the mechanical systems and the software. These patents were registered in all the countries which carry out aeronautical production.

Tomorrow, diversification

The forty machines which we have sold to date were mostly intended for the aeronautical sector, apart from those ordered by the Koreans. We would now like to diversify and have clients in the car industry.

The car

Over the next five years, car manufacturers are supposed to reduce the weight of cars by 200 kilograms. They could save 100 kilograms by using aluminium and alloys, and for the remaining 100 kilograms, they will have to use composite materials. For the past two years, we have been working with several car manufacturers and parts manufacturers on various projects. These include work with Faurecia on seats, Cooper on connecting rods, and Audi on structural components.

This new market has a number of challenges for us. In the aeronautical sector, machines only need to make one part per day, whereas in the car industry, it is more a case of one part every minute. Furthermore, our software must be compatible with that of the design offices and even incorporate crash simulations, a factor which has not yet been taken into account for aeroplanes. We should also continue our work on new materials and in particular on thermoplastics which are often substituted for resin in cars because of their recycling properties. Finally, and above all, this new market will represent a huge change of scale. Up until now, we sold on average twelve machines every year. If we were to get a contract in the car sector, we would have to increase our capacity considerably. We are not worried about this: once we have finished the plans and made the first prototype, we will be able to hand over the rest of the work to companies specialising in mechanics and robotics integration.

Other sectors

Other forms of transport may be affected by composite materials, especially trains. However, for the time being, we are clashing with the aluminum lobby and the TGVs in particular. As far as the nautical and maritime market is concerned, we have still not managed to break into these sectors.

Similarly, wind turbine blades are still being made by rolling out material into moulds, a process which results in a loss of 30 % of the fibre compared to only 1 % when one uses thread directly woven on the mould. For a wind turbine blade weighing twelve tons, this would be a very important saving. It is very difficult for us to get into this market, mostly because it is the shipyards which make large structures from composites such as wind turbines, and we do not yet have a presence in the maritime market.

Monitoring

Our robots are able to make very high-quality fuselage panels in three hours. It then takes a week to inspect them because control technologies are still very unsophisticated using ultrasounds, a basin of water, and sensors operated by two people at opposite ends of the room ('Are you ready, Roger ? OK, let's go'). We intend to develop automated control tools of a similar quality to our manufacturing techniques.

Discussion

Making an aeroplane with just one length of fibre?

Question: *Why continue to assemble panels rather than manufacture cylindrical sections of aircraft cabins like Boeing?*

Clémentine Gallet: It is the aircraft manufacturers who decide on the parts to be built with our technology. At Boeing, the choice of assembling cylindrical sections posed huge problems. On the Internet, one can see photos showing how technicians are able to put their hands between two sections whereas it should be contiguous. This sort of difficulty almost led Boeing to file for bankruptcy. Airbus chose a more conservative option which was less risky.

Q.: *Was it not possible to make the entire cabin from a single length of fibre as you wanted to do for the sailing boats?*

C. G.: Not currently. But I am sure the aircraft manufacturers' design offices will come up with this solution one day.

Q.: *I get the impression that it tends to be start-ups like yours which create the most innovations.*

C. G.: This is very often the case and it sometimes irritates our clients. We recently presented Airbus with a patent which makes it possible to drape the fibre from inside the fuselage. This would greatly reduce the number of panels needed for assembly. This produced a rather indignant reaction from Airbus: 'Who do you think you are? Since when does Coriolis think it can design aircraft?' I answered that it was very good news that it was us, rather than Boeing, who had registered this patent…

Composite materials and additive manufacturing

Q.: *Is there not some sort of convergence between your technologies and the boom in additive manufacturing (also known as 3D printing)?*

Alexandre Hamlyn *(Coriolis Composites)*: *The two technologies are complementary. It is possible to manufacture parts using the same materials with a 3D printer and strengthen these parts by adding fibres in various places. We already do this with certain car parts which are injected in plastic. With the addition of a few grams of fibre, one can increase the tensile strength from two tons to ten tons which potentially may be a matter of life or death especially in the event of a crash. The interaction between composites, plastics manufacturing and textiles opens up very exciting prospects.*

Recruitment and employment

Q.: *Is it hard to recuit the people you need?*

C. G.: We take a maximum of six months to find someone, and there is very little staff turnover in our company. Lots of Bretons who had to leave their region to work in Toulouse, Paris or Vélizy are very pleased to come back to Brittany.

Q.: *Will the technologies which you are developping result in a large number of job cuts?*

C. G.: It is unquestionably a sign of progress to free people from work conditions which were very difficult, and, in any case, the jobs in question have already been relocated to Morocco, China and Malaysia.

Robotisation opens huge perspectives for the 'iPad generation'. Young people today will be able to invent programmes to make robots more intelligent and communicative, and even buy an autoclave and create their own company which manufactures composite parts.

Q.: *What will happen to the employees who had manual jobs?*

C. G.: The people we employ do not need to be very highly qualified. We use the term 'engineer' in the English sense of the word, and in fact many of our engineers are graduates from IUTs (technological university courses). We want them to have had some practical experience, and be sure that they are not afraid to put on safety shoes and test their systems. Our other employees have professional school-leaving certificates. In both these cases, these people could have been employed to carry out the manual draping process.

Being a woman in industry

Q.: *What are the advantages and disadvantages of being a woman in industry?*

C. G.: At my mechanical engineering IUT, I was one of two girls in a class of two hundred boys, and there were never any problems. I never felt that I was being disregarded.

Inside the company, I think that it is an asset to be a woman, especially in this industry which is predominantly male. Men do not address women as they address men: they tend to moderate their language and make more effort to reach a consensus.

This is perhaps because women in general, and certainly in my case, are not particularly attracted to power or having control over something. I love my job, but what makes me really happy is my four children. I realise that I should be at home more often now. The eldest, who is now in secondary school, is a very good sailor, but does not do much work at school. Our second child will be entering secondary school next year, and I would like to follow what he is doing at school more closely. This is why I delegate more and more of what I do so that I can free up time for my family.

Consequently in Coriolis I do not play the traditional role of a boss. I listen to everyone in order to try to feel what is going on and to make life better for everyone involved. This gives a very human touch to the running of the company.

Q.: *There are more and more women who are at the head of important companies or who occupy important positions in large cities or in the government. This may be explained by the fact that they are clearly better equiped than men to handle difficult, worrying and unpredictable situations. Is this linked to the fact that they are mothers?*

C. G.: Having given birth, women are always frightened that something will happen to their children and that they might die. This makes them constantly anticipate what might happen in any area of life. This is undoubtedly an asset in business or in the management of a government. When we created Coriolis, I was always saying to myself 'If we do nothing, in six month's time we are dead. We've got to move!' It was a little over the top because the situation generally was not that disastrous. But I was always on my toes, ready to make changes should it be necessary.

Allocating roles

Q.: *How was it decided that you would be the boss, rather than your husband?*

C. G.: Of the three founders, I was the one who was the most outspoken. My two colleagues were perfectly happy for me to be in charge of all the sales side of the business and the contact with the bankers. Alexandre got the dossiers ready and then I tried to sell them.

A. H.: *For an inventor, it is a luxury to get out of doing these sorts of tasks. I never knew exactly how much money we had in the bank account.*

C. G.: If he had, he would have bought himself a flashy car!

Luck or energy?

Q.: *The current trend is for everyone to create their own company, but not everyone has the necessary qualities to handle stress well when you do not know how you are going to pay your employees at the end of the month, or when your banker asks you to mortgage your house. To manage a company one must be able to anticipate, join forces, be daring and, finally, take the necessary actions. You also need to have a little luck. I have been in a situation where I have not hired someone because he quite clearly has had bad luck both in his personal and professional life. Do you think you have been lucky throughout your career?*

C. G.: I often thought that I was lucky, but each time that I talk about this to people they say 'you make your own luck, and you spend your time questioning yourself and asking other people for ideas and advice.' To be lucky, one must have some 'get up and go'. Before I met Jean-Yves Le Drian, I spoke to one hundred and fifty people who all ignored me. That could have discouraged me. Rather than luck, I would say it is a question of energy.

Why stay in France?

Q.: *Why did you decide to stay in France? If you had gone to the United States, you would not have had any problem finding the money you needed.*

C. G.: There was a steady and constant flow of clients which made us stay in France, firstly Airbus, then Dassault Aviation, and so on. In any case, we're happy in France! After a week in the United States where I set up our machines at the Bombardier site and basically ate only hamburgers, I came back to Brittany and saw my children playing in rockpools before eating lobsters and wonderful cheeses, and frankly I had no desire to move them anywhere else. A move might have been a possibility had we really found ourselves in a difficult financial situation.

Furthermore, we owe a debt to the French authorities who have helped us a great deal since we started. The Franche-Comté region gave us our first grant and this financed the DLR to create our first model. Having said that however, it has now been three years since we began contesting a tax payment regarding a 2009 research tax credit, and I currently spend more time explaining what I do than actually doing it, and this is becoming rather irritating.

In addition, since the company has grown and we have gained a degree of credibility, we are starting to consider the idea of spending two or three years in Seattle. Today, 70 % of the world aeronautical market is in the United States and our strongest rivals are American. When Airbus was not our client, we knew that any efforts we made with Boeing would come to nothing, but now that will undoubtedly be different.

Innovating in a camp site

Q.: *When you mentioned that the three of you were living on one person's income support, were you exaggerating?*

C. G.: No, it's the absolute truth! We lived in a camp site for a year, and also in a host family.

Q.: *In that case, can you explain exactly what you mean when you say 'a difficult financial situation'.*

C. G.: While the project was moving forward, everything was fine. We always found what we needed for the project. When we entered the competition for the Ministry of Research prize, I typed out the project on an old 1990s Toshiba computer my father loaned us. When we made our model in the *Lycée de la mer* laboratory, the fact that people there trusted us enough to lend us the keys to the workshop was much more precious than giving us money. The person in charge of the composite department at the *Lycée* came to see us every morning. We felt supported, encouraged and pampered. When we needed to buy a robot, we also found the necessary funding.

Q.: *There have always been stories of entrepreneurs beginning their business in garages. Now, we know about a company which had its beginnings in a camp site!*

Staying independent

Q.: *Despite the lack of your own resources, how have you succeeded in remaining independent?*

C. G.: Various industrial groups have shown interest in buying our company, but the three of us are very independent and we would find it hard to have to answer to a boss. Luckily, especially at the beginning, we have always managed to find partners who let us make tools, do some machining, and gave us carbon fibre bobbins for free.

A. H.: *If we had been bought out, we would not have managed to create the same innovations which were very simple. How could we have explained to a client like Airbus or Bénéteau that we were going to buy our first guiding tubes at Leroy Merlin (a high street DIY shop)?*

C. G.: Between 2003 and 2006, despite it all, we had to sell some shares to venture capitalists when the Lorient economic development fund asked us to join them. Every six months, two project managers came down from Paris to see me. They did not understand a single word of what I was saying, and after a while they said 'Just remind us. How much money have we already invested in you?' The closer we came to the date when they were due to quit the company's capital, the more worried I became. Luckily, by a series of coincidences, we had come across Hervé Arditty who was an aeronautics and sailing enthusiast. He is an engineer who, having sold the company he created, started an investment fund. He said to me 'Listen Clémentine, I love what you do, it's great. I want to become a share-holder. However, I do not want to be rubbing shoulders with any venture capitalists, so I will come in when they pull out.' He is still with us today.

Presentation of the speaker

Clémentine Gallet: mechanical engineer, graduated in 1997 (University of Technology, Esslingen, Germany). She began her career with work experience opportunities in the industrial sector in Germany before carrying out a R&D programme which won the Ministry of Research prize encouraging her to create Coriolis Composites. She completed her engineering degree with a training course at the Lyon Business School in its 'Enterprise creation' programme in 1999.

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