# Achieving the impossible: the unlikely beginnings of the composite aeroplane seat

by

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**Overview**

The aeronautical sector is known for being a hi-tech area where teams of engineers design highly complex wing profiles and engines with unparalleled reliability. By contrast, the passenger-side of the aircraft, the cabin, seems to be technologically less advanced. There are plastic partitions, basic floor coverings, metal seat structures partially covered in plastic moulds, fragile tray tables, and screens with applications which are always out-of-date. The very strict regulatory framework and conservatism of airline companies, as well as the current oligopoly, strongly limit innovation in this area. Rather naively, in 2011 three engineers decided to design a passenger airline seat made from composite materials and titanium. This seat is much lighter than the usual seat and reduces fuel consumption by 3 to 5 %. Because they did not know that it was impossible to do it, they did it

Report by Élisabeth Bourguinat • Translation by Rachel Marlin



Seminar organised with help from the Directorate General for Enterprise (Ministry of the Economy, Industry and Digital Data) and thanks to the sponsors of the École de Paris:

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After I graduated from the École normale supérieure and the École des mines, I worked for a few years for ENGIE (formerly GDF SUEZ). After that, I wrote a physics thesis about random walks in confined spaces, following which I got caught up in the Expliseat project. This project was started by two engineers; Benjamin Saada from the École des mines who had worked in the wind-turbine industry and then in the start-up business in California, and Jean-Charles Samuelian from the École nationale des ponts et chaussées who was working in finance. Both were dissatisfied with their professional experiences and wanted to create an innovative company. They chose the aeronautical sector which they thought was likely to have enough money to buy new technologies, thereby making it possible to create start-ups.

## The 'un-innovative' environment of the aircraft cabin

Our initial observation was that the equipment in aircraft cabins is light-years away from what one might expect from machines like aircraft which are extraordinarily complicated and costly (an aeroplane costs approximately 100 million Euros). The internal partitions are made from plastic which is of a lower quality than that used in cars. The floor is covered with basic carpeting. The metal seats are partially covered with plastic moulding and are manufactured using very simple techniques. All the pieces used are heavy: large compression parts, large extrusion parts, large bolts and screws.

We decided to concentrate on the seats, and made models in composite materials to make the seats lighter and to save on fuel. An A320 aeroplane weighs 45 tonnes when empty. The seats alone account for 3 tonnes. If one divides the weight of the seats by three, the mass when empty would be reduced by 4 to 5%, and this represents a reduction in fuel consumption of between 3 and 5%. Initially, we worked on the seats which were the easiest to manufacture, those in Economy Class on medium-haul flights.

## Three sorts of objections

Once we started talking about our project, we were faced with three objections.

The first objection came from people who said that if it were possible to reduce the weight of the seats by two-thirds, it would have already been done. This was not enough to stop us. We were sufficiently naïve to believe that we were really the first ones to have thought of this.

The second objection focussed on the cost and the time taken for innovations to become reality in the aeronautical sector. People thought that the reason that an aeroplane was expensive was not because the buyers were incompetent, but that the development cycles and certification processes were long and the industrial equipment costly, especially since the volumes involved in the aeronautical sector were smaller than those in the car industry. Our response was that the aircraft manufacturers had nonetheless managed to put composite materials into the fuselage and the wings which was a more complicated process than making the seats lighter. Furthermore, we were convinced that a small structure like ours would be more flexible, and able to react faster than a large industrial group.

The third objection concerned our total lack of experience in the aeronautical sector. Actually this handicap turned out to be an asset. We did not know that what we wanted to do was impossible, and so we tried it, and it worked.

## An attractive market

A strong argument to embark on this venture was the relatively attractive character of the market for aeroplane seats.

In our discussions with the airline companies, we learned that it was difficult for them to obtain aircraft seats. Often they have to buy second-hand seats and change the upholstery. This current under-capacity is true for all sectors of the aeronautical industry, but especially that of seats, because when a company buys a new aeroplane, it generally wants to provide the same fittings for the entire fleet.

The aircraft seat market is dominated by two parts manufacturers, B/E Aerospace (Boeing's supplier), and Zodiac Aerospace (Airbus' supplier). The third important organisation is Recaro, the German car seat manufacturer, which now operates in the aeronautical sector. As well as these large manufacturers, there are small, innovative companies which regularly appear in the market and which get bought by the larger companies when they reach a certain size. There is therefore room in this market for new companies such as ours.

## A series of disappointments

Once the project had been launched, we started to realise why no-one had made aircraft seats in composite materials before: there are a number of difficulties.

### *Difficulty in finding a partner*

The first stage consisted of finding an industrial partner because we had chosen a 'fabless' model (in other words, we were concentrating on purely the design and sale of the seats and not their manufacture). We contacted Safran which uses composite materials in its engines, but this company does not manufacture elements made from composite materials for external partners, and we quickly got lost in the internal workings of the decision-making. We then met the subcontractors for Airbus, but they only made small production runs at a prohibitive cost, and it would have been difficult for us to find the millions of Euros necessary to create our own production capacities.

### *Difficulty in developing a technology*

At the same time, we carried out some experimental tests to understand how the composite materials should be used. The first three technologies we tried were total failures.

Having managed to develop something which almost worked, we found partners in the car sector whose production chains were not working to capacity, and who could implement this technology with quality control standards which were sufficiently robust.

### *Difficulty in certifying a new product*

There was worse to come: the certification of the product. Since there was no precedent for the manufacture of these types of seats in composite materials, no-one in the European Aviation Safety Agency (EASA) had ever certified this type of product.

This body employs mainly engineers who used to work in the aeronautical industry, and who are convinced that composite is a dreadful material and that it would be best if we did not use it at all. When we presented our innovation to them, they explained that it was not even worthwhile carrying out tests because, with all the constraints they were going to place on us, in the end our composite seat would be heavier than one made from aluminium.

They applied the same standards to our composite seats as to seats made from metal. One of the tests consists of distorting the seat and then throwing it against a wall at 50 km/hour. This is supposed to imitate the scenario of an aeroplane crashing to the ground and continuing to slide along the ground at great speed before hitting a building. The aim is to make sure that in a 'survivable' crash, in other words, one where the passengers have a chance of survival, they do not die unnecessarily because of a broken or badly attached seat. As a result of the test's pitiful results, we decided to add titanium to our composite seat.

Our investors let it be known that not only is titanium expensive, but it is difficult to obtain. This material

is used mostly in the aeronautical industry, and when one buys it in small quantities, there are significant price fluctuations as well as disruptions in supply, for example when Airbus supplies take priority. We were lucky to meet a young engineer who had worked in a titanium factory and was looking for a job. He succeeded in creating a supply chain as reliable as that of Airbus, and guaranteed us delivery times and affordable rates.

We presented the certification board with a new version of our seat made of composite materials and titanium which stood up well in the tests for metal seats.

The next stage consisted of having the parts made from composite materials undergo tests devised for fuselage parts and wings also made from composite materials. In one of these tests, a pallet truck weighing a tonne was projected at a speed of 10 km/hour at our seats. In another test, the seats were subjected to the equivalent of a sandstorm. We tried to convince the certification jury that a collision between an aeroplane seat and a pallet truck was not a very likely scenario, no more so than a sandstorm inside an aircraft cabin. However, they remained sceptical, even asking us to imagine a scenario where we had placed our seats in a desert during a sandstorm.

In fact, these tests were the only ones which existed, and the certification inspectors did not know how to certify our seats without using these tests. We needed a great deal of patience to make them admit that seats in composite materials were no less exposed to these types of test than aluminium seats which the jury did not even subject to this kind of test.

### *Difficulty in selling seats which had not yet 'flown'*

Having overcome all these obstacles and launched production, we thought that we were out of the woods. We went to present our product at the Hamburg Aircraft Interiors Expo. Several airline companies showed interest, but immediately asked us how many seats had already 'flown'. We explained that this was a launch and that we had not yet sold a single seat. They replied that in that case they would come back and see us in a year's time. They made it clear that they could not take the risk of one of their aeroplanes being grounded because of a seat failure.

After a series of discussions, Air Méditerranée gave us our first order. This airline company has about ten aeroplanes and operates low-price charter flights. Its customers are principally pilgrims travelling to Lourdes or Israel, and migrant workers to North Africa. Air Méditerranée considered that the potential risk involved in our product was low compared to the predicted fuel savings and other risks possible. In fact Air Méditerranée entered receivership in January 2015, but our order was delivered and paid for, and this company helped us have 'lift off'.

## Expliseat today

At the present time we have six clients and our order book is full for the next six to eight months.

Expliseat employs 25 people and hires about 75 operators on its production line. The production chain starts in the centre of France, has an operation in the Aquitaine region and ends with assembly near Toulouse.

We intend to reach our objective of supplying seats in about one hundred cabins per year quite quickly. This will represent 10% of the market of new aeroplanes, taking into account the fact that Airbus and Boeing each deliver nearly five hundred aeroplanes per year. There is also the market for renewing existing seats in cabins: this represents about ten thousand aeroplanes in the world.

## Lessons learned

This experience has helped us to understand why current electronic equipment in aircraft cabins is generally obsolete or does not work very well. Since it takes almost three years to certify a product, and that the product has to have 'flown' for at least two years before airlines agree to buy it, most of the equipment currently present in aeroplanes was designed at least five years ago.

With hindsight, I am convinced that only a start-up could have done what we did. In two years of trial and error, we spent a great deal of money, and only a combination of obstinacy and luck allowed us to succeed. Had we been employees in a normal company, we would certainly have been sacked. Start-up shareholders are more tolerant of failure than those of an industrial company which has been established for a while. The fact that we did not know that certain obstacles were in our path was definitely an advantage. Having spent two years on this project, it seemed silly not to spend a further year eliminating the rest of the barriers in our way.

We completely underestimated the certification aspect. Clearly standards exist so that all products are identical, and this discourages the manufacture of a variety of products which could lead to the expected result in terms of security. Our aim is to make the certification body understand the specificities of composite materials and to take them into account. However, if other technologies develop tomorrow, it will be very difficult once again to take them on board and for them to be accepted.

# Discussion

## Ergonomics

**Question:** *Aeroplane seats are more and more uncomfortable because the airlines try to 'cram' in as many passengers as possible into the cabins. Have you studied the ergonomics of aircraft seats?*

**Vincent Tejedor:** One of the advantages of composites materials is that they can give the moulds almost any sort of shape which is not always possible with metal. We asked the Institut français des sciences et technologies des transports, de l'aménagement et des réseaux (IFSTTAR), a laboratory linked to the École des Ponts specialising in ergonomics of road transport, for help, and we have adapted their models for air transport.

Because the backs of our seats are not as well padded as the usual seats, this should mean that there is more space for passengers' legs, but we cannot dictate to every airline company how to install its seats.

## Analysing clients' needs

**Q.:** *How have you taken your customer's needs into account?*

**V. T.:** Our shareholders encouraged us to meet the experts in this sector at Dassault, Airbus and even Air France from the outset. In the beginning we were young and stupid. For example, we thought we would get rid of armrests and tray tables, but they made us see sense. Quite early on, we contacted Ryanair who we thought had the most demanding customers which we were targeting in the air travel business. The Ryanair people to whom we spoke were very critical of our model and this helped us to identify the points which they thought were non-negotiable. These included the sturdiness of the seat, delivery times, maintenance, spare parts, guaranties, and so on.

For example, the question of maintenance is really crucial. In this sort of company, each aeroplane flies on average 12 hours per day, which represents a usage rate greater than that of any other means of transport. Wear and tear sets in very quickly, and it is not feasible to take out a row of seats because one seat is no longer working. This made us work a great deal harder on these sorts of questions.

## Perfecting the technology

**Q.:** *The composites world is very complex. There is a great choice of fibres and resins, and there are numerous rigorous checks and controls. How can you be certain about the quality of your product?*

**V. T.:** In the aeronautical world, there are only a few fibres and resins which are approved, so the choice is in fact greatly reduced. We chose those which are the best value for money. The most difficult stage was to perfect the braiding of the reinforcements. We started by asking people in the aeronautical sector who were experts in composite materials, but the results were not very satisfactory. We then started doing our own checks, assembling by hand and using a kiln before carrying out rudimentary tests. This was not a scientific approach, but it was relatively successful. Once we managed to get a result which was quite satisfactory, we wanted to find out how to make it on an industrial scale, and we developed a technique for which we won the JEC Innovation Awards prize in 2014. The industrialisation phase helped us to optimise certain parameters, but we did not systematically explore all the possible methods.

**Q.:** *Might it have been beneficial for you to have worked with the École des mines' composites laboratory?*

**V. T.:** It was a bit too expensive for us because a partnership costs at least 100,000 Euros.

## Certification

**Q.:** *How did you negotiate how to be exempt from certain tests with the certifiers?*

**V. T.:** In some cases, like the sandstorm scenario, we were able to show them that the hypothesis was absurd. However, many scenarios are highly improbable without being completely implausible. Take the example of a piece of baggage weighing 20 kilos falling from the height of a metre. This object may have pointed sides or angles and, as a precautionary measure the certifying agents choose a very sharp angle. One may then question the likelihood of something like a 20-kilo-screwdriver falling onto a seat, but it is not as absurd as a sandstorm taking place in a cabin. In this area of 'unchartered waters', it is normal that the certifying agent, in other words the person who has to sign the document and thereby assume responsibility, is careful. We are the ones who have to be imaginative and suggest a method to assess the probability of the event and its seriousness, which then allows us to judge if the risk is acceptable or not.

If not, a certifying agent might be tempted to impose such a large number of constraints (for example, 50 to 70 % of additional constraints for a composite seat compared to a seat made from metal) that if the aeroplane were to crash it would disintegrate but the seat would remain in a perfect state. How would this benefit the passenger?

Typically, the seats are made to remain intact if they are thrown against a wall, but this is not the case for the partitions which separate the different class sections on the aircraft, or even the aircraft itself. In the case of a crash, the passengers risk being knocked unconscious by flying parts of propeller blades or any other part of the aircraft, but at least they will be seated and well attached to their seats. But does it make any sense to be comfortably seated if you are dead?

This question has never been asked because when an accident takes place, very thorough investigations are made to discover who is responsible, ranging from the aircraft manufacturer, to the certification body, the airline company, the maintenance companies, and so on. The level of requirement is extremely high: for an aeroplane engine the error rate is one catastrophic failure for one billion hours of flight, and the same rate is applied to aircraft seats.

**Q.:** *Is it possible for you to change the standards? For example, could you one day omit titanium from your seats?*

**V. T.:** It would be very complicated. Currently, the EASA is preparing a standard on composite seats, and we are taking part in discussions to make sure that future standards cover what we are currently working on.

## The role of manufacturers

**Q.:** *What roles do the manufacturers and the airline companies play in the choice of equipment manufacturers for cabin interiors?*

**V. T.:** For the aircraft in which we are interested (the Airbus A320 and Boeing 737), the seats are bought by the airlines, and not by the manufacturers. The latter are happy to install them on new aircraft. A large part of the market concerns renewing or upgrading seats on aircraft which are already in service. In these circumstances, the manufacturer does not play any role at all.

For some aeroplanes, like the A350, Airbus requires that the equipment manufacturer is authorised by Airbus themselves before it can sell its products to companies in order to avoid having delays in delivery or other problems. Airbus is in favour of the arrival of new equipment makers, joining the three principal companies which already exist.

## Sales development

**Q.:** *Apart from sales fairs and salons, how do you find new clients?*

**V. T.:** Because there are only two hundred airline companies in the world, it is possible to contact each one in turn even with a small team. We see them at salons and we also try to discover the inner circles within which the buyers tend to move. For the time being, we are especially interested in companies which have about ten aircraft. We have made ourselves known to the big companies, but as we know that they do not like taking risks, they will not become interested in our products until they have 'flown' for several years.

## Go international or remain French?

**Q.:** *If your aim is to take a large market share on a global scale, then should you not already be thinking about becoming international? This is even more necessary if you want to ensure the maintenance of your equipment throughout the world.*

**V. T.:** Because of standardisations which are universally implemented, we can sell our seats everywhere without any problems. After Air Méditerranée, we found our second client in Congo Kinshasa. The limit to our growth might come from the financial side because our activity requires a great deal of working capital, or from the industrial side because of the size of production. Having said this, our product is really very simple (it only has about thirty pieces) and its manufacturing process is largely automated. We can therefore create additional production lines without having to train operators to carry out complex techniques, contrary to other uses of composite materials which require manual draping. Therefore we should be able to handle quite rapid growth. In view of the small number of operators necessary to assemble the seats, labour costs are low, and there is no reason for us to locate to countries with low labour costs such as China. Not only would it be more difficult to manage a production site from a distance, but we might get worried that we would be copied in our sector relatively soon after we had set up business there.

The airlines maintain the seats themselves using the instructions we give them. As for the spare parts, there are grouped service providers which can supply companies everywhere in the world in less then twenty-four hours.

## Exploring other markets?

**Q.:** *Why do you limit yourselves to Economy Class on medium-haul flights?*

**V. T.:** For the time being our seats do not recline, and they do not have any electronic equipment. We wanted to start with the most simple kind of seat which required the shortest possible development time in order to market our product very quickly. More complicated seats will come later on.

**Q.:** *Do you intend to look at other markets in the seat sector?*

**V. T.:** There are two possible plans. The first is to stay in the seat sector and expand our range, for example with the addition of seats for babies. This is what one of our rivals, Recaro, is doing. Originally Recaro made bucket seats for racing cars. Our second plan is to remain in the aeronautical sector and diversify the range.

This is what our rival Zodiac Aerospace did. Zodiac makes seats as well as galleys (kitchen spaces in aeroplanes), toilets, evacuation slides, and so on.

We have not yet settled our plan. We hope to begin by getting a return on our investment and identifying the opportunities which will allow us to broaden our market without additional financing.

The most likely scenario is that we will start by going upmarket or by manufacturing seats for other types of aircraft, rather than change our market because this option would be very costly.

## Rivals

**Q.:** *How do you stand in terms of price compared to your rivals?*

**V. T.:** Prices are not made public and there are no calls for tender. Everything happens by mutual agreement. The most expensive item is not the structure of the seat, but its features (the texture and colour of the upholstery, the shape of the cushion in Premium Economy – a class between Business and Economy – and so on) and the certification of changes made to the seat. From what our prospective clients tell us, our prices do not seem to be unreasonable compared to those of our rivals. This is important because despite the expectation of fuel savings, companies are not ready to accept higher additional costs, especially as they also have to take on a number of risks. These include the fact that we are a young company, our seats have not 'flown' for a long time, that we may not be able to deliver on time, and so on.

**Q.:** *How do your rivals react to the rapid growth of your company?*

**V. T.:** Most of our rivals hardly know that we exist. The aeronautical market is worth several billion Euros, and we are only worth a few million. Furthermore, we are in the medium-haul Economy Class market which is not considered to be a very buoyant market. Finally, the seat industry had not reached its full potential: there is space for everyone.

**Q.:** *At some point in the future the metal seat will be completely 'old hat' and you will start to be copied. Are you ready for this?*

**V. T.:** In view of the length of the development cycle, this still leaves us some time. Because the market is not at full capacity, newcomers are generally happy to reproduce tested models rather than create their own. Those who do, tend to target Business or First Class. As for the more important manufacturers, they are not necessarily very flexible nor as pig-headed as us to follow this sort of project to the end. Johnson Controls, a very well-known company in the car industry, tried a few years ago and had a partnership with Airbus, but abandoned it after having invested three or four million. Tony Fernandes, the CEO of AirAsia which makes seats in composite materials for Lotus, his car racing team, tried to produce aircraft seats and failed. It is not necessarily in a rival's best interests to try to copy us. We would have to monopolise the seat market for other companies to try to rival us in composite materials.

Furthermore, metal seats still have a bright future because they have numerous assets not only in terms of solidity but also, for example, as they conduct electricity. As far as the weight is concerned, other alternatives exist such as magnesium or a radical transformation of the way in which seats are designed. I do not think that we are heading towards a 'hegemony' of composite materials but rather towards a diversity of solutions.

## Financing

**Q.:** *Who are your financial backers, and how much money have you raised?*

**V. T.:** When one creates a digital start up, one can live off one's parents and just pay the Internet bill. When it is an industrial start-up, it is more complicated because each mould costs between three and five hundred thousand Euros.

We have raised considerable funds and reached five million Euros, mostly with help from private individuals.

Our first shareholders invested nearly one million Euros based on a simple Powerpoint presentation we made to them. No investment fund wanted to support us, at least not until we got certification. Now that we do not need as much money, lots of people have been wanting to invest in our business.

Through time, things became easier, for example when we had to invest in the manufacturing chain: our shareholders knew how the money was being used and what assets they could recoup in case it all went wrong.

**Q.:** *What did you sell your first shareholders? A dream?*

**V. T.:** Our shareholders were almost as ignorant as we were about aeronautics. They did not know that the standards were as strict as they were, and that it was practically impossible to introduce new materials.

Apart from this, our business plan was relatively credible. We were aiming to get a small market share in a market worth several hundreds of millions of Euros. It was possible to calculate objectively the market value of making seats lighter by basing our price on what Air France was prepared to pay in order to reduce the weight of its aeroplanes by one kilo, (these figures can be found in its annual reports) or conversely what the company makes its passengers pay for one kilo of baggage over the baggage allowance.

Furthermore, before the company was even created, and between the various fundraisings, we were careful to register patents which are part of the company's assets.

Once we obtained the certification, our shareholders were certain that the company was worth something in terms of assets even if we had not been able to complete our project.

**Q.:** *You were lucky that they had enough money to be able to put money back into the company each time that it was necessary.*

**V. T.:** When the initial shareholders did not have enough money, we asked other people.

**Q.:** *When the trajectory of a start-up is a little bumpy, those who arrive last often have better choices than those who were among the very first shareholders, and this may lead to difficulties. Were you faced with this sort of situation?*

**V. T.:** Our first shareholders were sufficiently alert not to feel upset by the newcomers.

## What is the shareholding scenario?

**Q.:** *What is the most likely future for your company: will it be bought out by one of your rival?*

**V. T.:** This is not what we have in mind but the possibility may arise if one of them is ready to sign a sufficiently large cheque. As we are not majority shareholders, the answer will not depend solely on us.

**Q.:** *Have your shareholders fixed the date when they will sell their shares?*

**V. T.:** Our shareholders are private individuals, and they do not have the same constraints as investment funds. Furthermore, the shareholders' agreement is relatively strict. Both the sale to a rival and the flotation of the company on the stock exchange would need our consent. When we launched the company, our shareholders asked us to promise not to leave the company. We agreed but asked in return that they should not be able to sell their shares easily. All the share-holders are more or less in agreement that the strategy is for to the company to succeed rather than maximise the investment in the short-term.

## Managing failure

**Q.:** *How did you decide on your different roles as associates?*

**V. T.:** To start with, everyone did a bit of everything, and then our shareholders explained to us that we were being very inefficient! We gradually divided up the tasks. Jean-Charles Samuelian is in charge of finance, fund-raising,

sales and administrative affairs. Benjamin Saada handles negotiations with subcontractors, and I am in charge of the innovation side, the certification and intellectual property.

**Q.:** *I have been lucky enough to have met the three of you regularly since you launched your company here in the École des mines. It is a very solid team which has shown two crucial qualities: the ability to acquire a wide variety of skills, and the ability to overcome failures.*

**Q.:** *What personal, family or other sort of resources have helped you not to become discouraged in the face of obstacles?*

**V. T.:** As a researcher, I have experienced a number of failures. I spent six months in Japan studying proteins in rabbit muscles, and none of the costly experiments which I carried out there led to anything at all. I learned not to let failure affect me too much.

As we all know, there are several ways to fail. One can make a mistake because one crashes head-on into a brick wall like an idiot, but one can also make mistakes for 'good' reasons, and these reasons are still valid even after the failure. When one starts working with a technology which does not exist, with people around you who do not know the technology, and there are no guidelines for this technology, it is not very surprising that one will come across a few obstacles. This does not mean that you will not try to overcome them. Sometimes, however, the failures were a bit hard to take and we were close to giving up. But there was always one of us who was able to lift the spirits of the other two. Finally, the most important thing was to reassure our shareholders by explaining to them what we had learned from our mistakes and getting their agreement to move in a new direction.

## Presentation of the speaker

**Vincent Tejedor**: graduate of the École Normale Supérieure, engineer of the Corps des Mines, PhD in theoretical physics. He began his career by regulating the high-pressure gas network at ENGIE (GDF SUEZ). After his Masters in Administrative Law, he founded Expliseat SAS with two engineering friends. He is the Managing Director.

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