

1. WHY IS 2016 OUR CENTENARY?

Dassault Aviation is celebrating its 100th anniversary in 2016.

The production of the first aircraft part designed by its founder, Marcel Dassault, the Éclair propeller, was used on French airplanes during the first major aerial combat in history, in the skies over Verdun in 1916.

The aim behind this centennial celebration is to illustrate the company's human, technical and industrial experience and capabilities, which will continue to be used during the next century, plus its unique role in the French economy and its resolutely global stance. The story of Dassault, which started with aeronautics, has since expanded to include other high-tech sectors, such as electronics and digital design.

2. ÉCLAIR, A NEW PROPELLER

1917 ad for the Eclair propeller, published in L'Aérophile
9171215_Helice_Eclair_Aerophile_PXXLT1.jpg
© Dassault Aviation



World War I ace, Georges Guynemer, in front of a Spad VII equipped with an Eclair propeller
18597_T.jpg © Service Historique de la Défense

After graduating from the École supérieure d'aéronautique et de construction mécanique engineering school, Marcel Bloch (later known as Marcel Dassault) was drafted into the French army in October 1913, in an aeronautical engineering regiment. In January 1914, he was assigned to the Chalais-Meudon aeronautical research lab, comprising several workshops that studied all the technologies needed for the budding field of aviation.

Working on his own, Marcel Bloch set out to improve the Caudron G3's propeller, whose performance was deemed mediocre. He had a prototype made by his future father-in-law, Hirsch Minckès, a furniture-maker in the Faubourg Saint-Antoine neighborhood of Paris. Marcel personally supervised the process, as he later recalled: *"I made the design of my propeller, then traced sections of it onto the wood so that the carpenter could follow the outlines. I stayed right at his side while he planed down the propeller, guiding his hand along the harmonious lines I was trying to achieve."*

An immediate success

First tested in Buc, southwest of Paris, the new propeller was then submitted to the aeronautical test center in Villacoublay, which concluded that it was superior to all other models tested. An order for 50 propellers was placed in November 1915, and it was dubbed Éclair, or "Lightning".

The Éclair was first used on the Caudron G3 reconnaissance plane, powered by an 80-horsepower Le Rhône rotary engine. With the battle of Verdun raging since February 1916, France ordered more planes, and naturally more propellers. As workload grew, Marcel Bloch asked his friend Henry Potez to join him.

An employee at the engine manufacturer Clerget provided a contact for the Nieuport 12 pursuit plane, powered by a

110-hp Clerget engine: all of these aircraft would be fitted with the Éclair type 2 propeller. The type 3 model, 500 of which were ordered, was used on the twin-engine Caudron G4. The type 5 would be used on the Farman 40 with its Renault 130-hp engine, which recorded a large number of orders. Many of the cabinet-makers in the Faubourg Saint-Antoine district were put to work on Éclair propellers. A trademark was filed on June 19, 1916 by a new company called Hirsch et Cie.

A propeller for "Le Vieux Charles"

The venture was a striking success. More than 4,000 Éclair propellers were ordered in 1916 for the British Sopwith twin-seat scout and bomber (types 17, 17B, 17C and 27). They were also used on the Dorand twin-seat scout, powered by Renault 170 or 190-hp engines, the Letord LA3, and above all the Spad VII pursuit plane flown by French ace Georges Guynemer. Marcel Bloch later recalled a very moving moment (in a magazine interview in 1976):

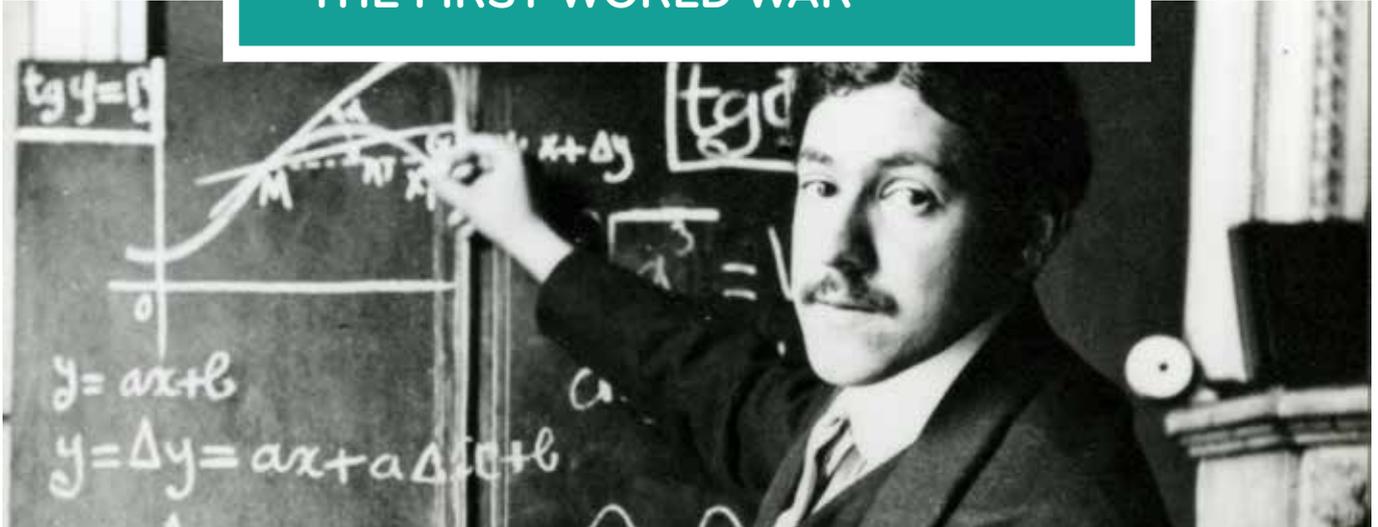
"When Guynemer's plane, 'Le Vieux Charles', with its 19 victories, was presented at the Invalides as a witness to his glory, I went to see it. Naturally I saw the propeller, one I had designed and built. I felt a lot of satisfaction, and maybe just a bit of pride."

By 1917, Marcel Bloch was the fourth largest propeller manufacturer in France, out of a total of 40, behind just Chauvière, Régy and Ratmanoff. The armed forces aviation equipment inspection unit decided to offer no more than three types of propellers for each airplane type. The Éclair propeller was chosen for 10 out of the 20 aircraft types listed.

The following year, this propeller would be used on Marcel Bloch's first airplane, the SEA IV twin-seat pursuit and observation plane.

1. Marcel Dassault, *The Talisman*, Arlington House, New York, 1971, page 30
(Marcel Dassault's autobiography, published in French in 1969)

3. MARCEL DASSAULT DURING THE FIRST WORLD WAR



Marcel Bloch doing calculations on a blackboard (1912-1913)
92-233.jpg © Dassault Aviation - DR

In January 1914, Marcel Bloch, a recent graduate of the *École supérieure d'aéronautique et de construction mécanique* engineering school, was assigned to the French army's aeronautical research lab in Chalais-Meudon. He soon became familiar with the state-of-the-art in aeronautical engineering, spanning balloons, kites and airplanes.

First assignment: Caudron G3

At the outbreak of the First World War, Marcel Bloch was given the task of coordinating construction plans for the Caudron G3 observation plane, sent to four different factories in charge of making this machine. He checked the drawings and made sure they were consistent, oversaw parts production and also supervised changes requested by pilots.

Participating in the flight testing programs made him realize the importance of the pilots' reactions to a new airplane. He learned this first lesson, one that would be reiterated throughout his long career: never ignore the pilots' opinions. Marcel Dassault also chalked up experience in the design departments and on the shop floor, and became familiar with the entire aircraft construction process.

Éclair, a new propeller

Marcel Dassault set out to improve the Caudron G3 propeller, whose performance was mediocre. The young engineer first designed a new propeller. To make it, he thought of a friend's father, Hirsch Minckès (later his own father in law), who was a furniture-maker in the Faubourg Saint-Antoine neighborhood of Paris: *"I made the design of my propeller, then traced sections of it onto the wood so that the carpenter could follow the outlines. I stayed right at his side while he planed down the propeller, guiding his hand along the harmonious lines I was trying to achieve."*

1. Marcel Dassault, *The Talisman*, p. 30.
2. Marcel Dassault, *The Talisman*, p. 31.

He called his propeller *Éclair*, or "Lightning". The French army ordered 50, at about 150 francs each. This promising start would soon be confirmed, because the battle of Verdun, which had been raging since February 1916, led to more aircraft orders, and therefore propellers. *"All the furniture-makers of the Faubourg Saint-Antoine were put to making Éclair propellers²."*

Éclair propellers would be used on Sopwith reconnaissance plane, built under license in France, and above all on Spad pursuit planes, especially the Spad VII flown by France's most famous ace, Georges Guynemer.

By 1917, his success was confirmed. Marcel Dassault headed one of France's four biggest propeller manufacturers.

First airplanes

Just making propellers wasn't enough to satisfy Marcel Dassault's appetite for aviation: he wanted to take the biggest step and design and build his own plane! Along with Henri Potez he created a new company, the *Société d'études aéronautiques*, or SEA.

They designed a twin-seat plane to replace the Sopwith scout from England. It was to be powered by a 200-horsepower engine that Clerget was developing. But the test results were disappointing: mounting this new engine on the SEA airframe was problematic and the project was abandoned.

Marcel Dassault learned his lesson: you should never combine too many new elements on a prototype. Throughout his career he would apply a technical policy based on "small steps". Prototypes incorporated known components, with any innovations introduced gradually, step by step. However, the successor to this initial project, the SEA IV, enjoyed a much better fate – at least initially! At the end of 1917, the French Minister of Arms and War Production, Louis



SEA IV on the ground

18995_T.jpg © Dassault Aviation - DR

Loucheur, ordered 1,000 SEA IV planes. Marcel Dassault had just won his first aircraft order.

The first production SEA IV was rolled out on... November 11, 1918! The order for 1,000 aircraft was cancelled, and only the 100 or so models already under construction were delivered. For the next ten years Marcel Dassault worked outside the aviation sector, returning only in 1929. After the Second World War he would become the largest and best known privately-owned aircraft manufacturer in France, in large part due to the legendary Mirage jet fighter.

Irreplaceable experience

"I came to know the characteristics of all the planes being constructed at the time. I followed their development from the moment they were conceived until their final preparations in order to make sure that my propellers were functioning correctly. I was continually visiting airfields and carefully noting down the little mishaps that occurred with either a plane's engine or body and how these problems were later ironed out. That was how I learned the techniques of flight testing and the final preparation of a new aircraft.

Having learned which new models succeeded and which ones failed, I was able to acquire a great deal of experience in deciding what should and should not be done to make a good airplane."

Marcel Dassault, *The Talisman*, p. 33.

4. THE AIR BATTLE OVER VERDUN



A French Nieuport 17 and German Fokker E.III face off over a reconstituted battlefield
Verdun_0001.jpg © Jean-Marie Mangeot

Aerial combat over the Verdun battlefield can be considered the first real "air battle" in history, since it opposed two fleets of combat aircraft fighting to achieve superiority in a given airspace. It was also the first time that this idea of air superiority was acknowledged and applied by the armed forces of the two adversaries.

Aviation pioneer and visionary Clément Ader had already described the use of combat aircraft for fighter, bomber and tactical reconnaissance missions in his 1911 book, *L'Aviation Militaire*. But even at the start of the war, just about everybody in the military had considered aviation as more of a sport than a potential weapon.

Germans achieve air superiority

The Germans deployed nearly 280 airplanes around Verdun in early 1916 to destroy French observation systems, especially balloons. Against them, France could only muster about 70 planes, hardly enough to contain the German offensive. Because of the qualitative and quantitative superiority of the German fleet, French squadrons could no longer reach the battlefield, and Germany's big guns were destroying their airfields. For the first time in military history, the German forces had achieved "mastery of the air", or air superiority.

The French would riposte however. On February 28, 1916, General Pétain sent a short message to Commander Tricornot de Rose, one that would echo through the years: "*De Rose, I am blind, sweep the skies for me.*" Pétain placed de Rose in full charge of aviation for the Verdun sector. Commander de Rose organized an independent combat group, which would be operational in just two weeks.

These pilots were assigned a very simple mission: their aircraft were organized in patrols, and they were to systematically find, engage and shoot down the enemy.

That triggered the beginning of a merciless air battle between German and French pilots in the skies over Verdun – the first large-scale air battle in history. Whoever could master the sky would have an advantage in winning the battle on the ground.

New tactics, new techniques

While solitary "dogfights" tended to disappear because of this new organization, a number of aces would still emerge at Verdun, including Charles Nungesser, Georges Guynemer, Auguste Le Révérend¹ and Jean Navarre, the "Sentinel of Verdun".

Results were not long in coming: the Germans stopped attacking so they could protect their own airplanes and balloons. While Germany's air force was technically and numerically superior at the beginning of the year, by June 1916 the two forces were more evenly balanced.

All aspects of aviation logged steady technical progress. The "war in the air" was also waged in design departments and factories. Each new machine rolled out of the factory had to be better than the enemy's latest model. Another fierce battle took shape, this time in terms of technical performance, starting with weapons, especially the ability to fire a machine gun through the spinning propeller, and of course in engine power and handling qualities. Marcel Dassault contributed to this effort with his higher-performance Éclair propeller.

1. Auguste le Révérend joined the company Avions Marcel Bloch in the 1930s, and became the company's general manager in 1951 when Marcel Dassault entered the political arena.



Nieuport 17 aircraft equipped with an Eclair propeller
Verdun_0004-1.jpg © Jean-Marie Mangeot

A turning point in French military aviation

The air battle over Verdun would mark a turning point in French military aviation. French armed forces quickly learned their lesson, especially in the use of pursuit planes (subsequently called fighters). A new organization was instituted on May 21, 1916, emphasizing the importance of achieving air superiority.

In fact, everything deployed during the battle of Verdun, including patrol flights of pursuit planes, constant patrols, division into air sectors, etc., had already been developed, in theory, right from the first months of the war. But Verdun, by placing France in extreme danger, encouraged leaders to urgently deploy these innovative arrangements.

The battle of Verdun also clearly reflected the now predominant role played by aviation in war. It was the first land battle that started with a fight for air superiority. As Marshal Pétain would say a few years later: "*Verdun, as has been repeated often since then, was really the 'crucible that forged French aviation.'*"

5. DASSAULT AVIATION: FROM THE DAWN OF AVIATION TO THE PRESENT



A world-first formation flight of three Dassault aircraft: nEUROn, Rafale and Falcon 7X
0331QA_140320_0057r.jpg © Dassault Aviation - K. Tokunaga

Since the dawn of aviation in the early 20th century, Dassault Aviation has stood out through the design and construction of a large number of aircraft of all different types. From the Éclair propeller in 1916 to the Falcon 8X in 2015, Dassault has turned out over 100 prototypes reflecting the steady progress in advanced aeronautical technology.

A manufacturer before WW2

As early as the First World War, Marcel Bloch, who would change his name to Marcel Dassault in 1949, formed a trusted team of collaborators. He created a company to manufacture Éclair propellers in 1916, then in 1918 he founded the Société d'études aéronautiques (SEA). This company designed and built the SEA IV twin-seat pursuit plane, and the French army placed an order for 1,000.

After stepping away from the aviation sector during the 1920s, Marcel Bloch formed a new team in 1930. They would build a series of airplanes, ranging from the all-metal MB-60 trimotor postal plane to the MB-200 and MB-210 heavy bombers, along with the MB-160 four-engine transport and the MB-152 single-seat fighter. His company was nationalized in 1936, but he continued to run a separate design firm, the Société anonyme des avions Marcel Bloch (SAAMB), which designed the aircraft built by the state-owned companies.

During the Second World War, Marcel Bloch refused to collaborate with the occupying forces. He was first imprisoned, then deported to Buchenwald.

Shortly after returning to France, in April 1945, he got back into business, quickly designing a new model for the French air force, the MD 315 Flamant transport aircraft. But it was in the emerging field of jet aircraft that the newly named Dassault company would earn its credentials.

Mirage IV (right) and Mirage III (left) on the ground
90-1949-1.jpg © Dassault Aviation - DR



The magic years

The MD 450 Ouragan, predecessor to the Mystère – Étendard family, would record the French aircraft industry's first post-war export sales, to India and Israel. The Mystère II was the first French plane to break the sound barrier, while the Mystère IV provided solid recognition of Dassault's expertise, when the United States ordered 225 of these jet fighters, to be retroceded to France within the scope of a NATO agreement. The Étendard IV M and its successor, the Super Étendard, were deployed on France's aircraft carriers, the *Foch* and *Clemenceau*.

The Mirage III program kicked off in the mid-50s, marking the introduction of Mach 2 capable fighters, along with a decisive breakthrough in export markets for the Mirage family. Aerial combat during the Six-Day War in 1967 would seal, once and for all, the global reputation of Dassault jet fighters.

Dassault then participated in France's nuclear deterrent force by building the Mirage IV strategic bomber, allowing the company to learn new techniques, especially concerning high-temperature materials. Dassault also diversified its scope of research, including such advanced areas as vertical takeoff (Mirage III V) and variable geometry wings (Mirage G). These two achievements, a world first for a single company, clearly showed the ability of its design engineers to develop solutions combining originality and high performance.

At the same time, Dassault's development of swept wing models would give rise to the Mirage F1, deployed by 11 countries worldwide.

At the cutting edge of technology

Dassault was perhaps better known at the time for its military

Designing the Rafale using Catia V6 software in the Saint-Cloud design department

SR_020_NKA1937.jpg
© Dassault Aviation / S. Randé



A Pan Am delegation including Charles Lindbergh visits Dassault's Mérignac plant on May 4, 1963 to check out the Mystère 20
70632_T-1.jpg © Dassault Aviation - DR

aircraft, but it also turned out excellent civil models. Technical solutions developed for the Communauté twin-engine liaison plane were combined with solutions from the Mystère IV, enabling Dassault to create the Mystère 20 business jet, the first model in the Mystère-Falcon family. Once again, it was the United States that sealed the reputation of a Dassault product, since Pan Am was the first to order this model, initiating a breakthrough in the American market. This first bizjet would lead to a smaller derivative, the Falcon 10 twinjet, and the larger Falcon 50 trijet, offering transatlantic range. The success of the subsequent Falcon 900 and Falcon 2000 models in the 1980s and 1990s confirmed Dassault's technological expertise in premium business jets.

Dassault even entered the commercial transport market with the Mercure, a single-aisle commercial twinjet with 150 seats, operated for many years by French airline Air Inter.

In 1969 Dassault merged with Breguet Aviation, creating Avions Marcel Dassault - Breguet Aviation (AMD-BA). This merger expanded the company's international reach, through the maritime patrol aircraft Atlantic, then the Atlantique 2, the Jaguar ground attack model and the Alpha Jet trainer. Dassault continued to incorporate state-of-the-art technologies during the 1970s, with the delta-wing fighters Mirage 2000 and Mirage 4000, which saw the introduction of innovations such as composite materials and fly-by-wire controls. The company also developed a computer-aided design and manufacturing (CAD/CAM) system known as CATIA. Now used worldwide, this sophisticated system largely confirms Dassault's high-tech expertise.

Dassault was also active in the space sector, starting in the 1960s, with the MD 620 missile, design studies for the TAS 1 and 2 space vehicles, and a thermal protection project for the U.S. Space Shuttle. Dassault Aviation makes the main components in the pyrotechnic system on Europe's Ariane launch vehicle.

The story continues

Serge Dassault became Chairman and Chief Executive Officer in 1986. Four years later the Société des avions Marcel Dassault - Breguet Aviation was renamed Dassault Aviation. Charles Edelstenne became Chairman and Chief Executive Officer in 2000, followed by Éric Trappier in 2013. Part of the Groupe Industriel Marcel Dassault, Dassault Aviation is the only aerospace company in the world that still belongs to its founding family

Today, Dassault Aviation offers a family of combat aircraft (the Rafale, in single- and twin-seat, air force and naval versions), along with the Falcon family of business jets (Falcon 2000LXS, Falcon 2000S, Falcon 900LX, Falcon 5X, Falcon 7X and Falcon 8X). The Falcon's proven capabilities and operational flexibility are behind the Japanese coast guard's selection of the Falcon 2000 MSA (maritime surveillance version) in 2015.

In just 15 years, fast-paced progress in information technology has moved design departments from drawing boards to computerized 3D design. Physical models have disappeared, replaced by virtual digital models, enabling the first item produced to be directly operational. This industrial revolution was made possible by product lifecycle management (PLM) software from Dassault Systèmes. This approach is already widespread in the aerospace and automotive sectors, and is expanding to many other sectors.

Dassault Aviation is now gearing up for the future as prime contractor for nEUROn, a European program for an unmanned combat air vehicle (UCAV) technology demonstrator, leading contributors from Sweden, Greece, Switzerland, Spain and Italy. Drawing on its skills and expertise, Dassault



Europe's nEUROn UCAV technology demonstrator taking off from Dassault's flight test center in Istres, southern France
AP_PGXI704.jpg © Dassault Aviation - Alex Paringaux

Aviation has also shown its interest in developing combat drones, especially within the scope of the French-British FCAS (Future Combat Air System) program, as well as medium-altitude, long-endurance (MALE) drone systems.

As a major player in the French industrial landscape for many years, Dassault Aviation boasts proven high-tech expertise that makes it one of the world's leading plane-makers. The company's two-pronged success in high-performance combat aircraft and Falcon business jets is largely due to the outstanding men and women who work for the company.

6. CENTENARY CELEBRATIONS



A poster announcing the show in Paris celebrating Dassault Aviation's 100th anniversary

LCDLA_GP_AMACLIO_4X3_29_10_2015.jpg © RMN-Grand Palais / Jérôme Prince - conception Amaclio & agence Anastase

Commemorating 1916

Verdun, 1916: the first large-scale air battle in history. Caudron scouts and Nieuport pursuit planes from France are fitted with a brand-new propeller, the Éclair, combining simplicity, robustness, efficiency and... beauty! It was designed by Marcel Dassault, only 24 years old at the time.

The Verdun Memorial honors his contribution to France during the First World War. It displays an Éclair propeller and, at the entrance to the building, renovated thanks to a contribution from Dassault Aviation, four films are shown to give visitors a quick portrait of the company.

The air show at the Istres air force base in southern France, on June 4 and 5, 2016, will pay tribute to the young American volunteers who fought alongside the French in the famous La Fayette Escadrille – now the name of one of the French air force's leading squadrons, flying the Mirage 2000N. Our company's aircraft will be in the spotlight during one of the top public air shows in France, at La Ferté Alais on May 14 and 15, 2016.

A really big show in Paris

Dassault Aviation is a partner in a major show at the Grand Palais in Paris, from April 9-14 2016: *La conquête de l'air: l'épopée Dassault, une aventure française* ("Conquest of the Air: the saga of Dassault, a French adventure"), which recounts a century of adventures in the air. The nearly hour-long show features highlights from the first century of aviation, with a large focus on our aircraft, combining archival records, graphics and videos, all projected on a giant 360° screen, spanning 3,000 square meters, with special laser effects and surround-sound. Dassault will donate part of the receipts to charitable organizations.

A showcase with the Eclair propeller.

Verdun_0002-1.jpg

© Jean-Marie Mangeot



At the same time, the auction house Artcurial, part of Groupe Industriel Marcel Dassault, will organize an auction of historic objects concerning Dassault and aircraft parts converted into artworks. It will also include a charity auction of three Falcon models decorated by artists.

A new book called "The Dassault Adventure: A First Century of Aviation", published by Les éditions de La Martinière, will be released on April 7, 2016. This handsome book uses photos to retrace the company's history.

At the end of the year, a documentary called *L'épopée Dassault* ("The Dassault Story"), directed by Daniel Costelle, will be broadcast on French TV.

Communications honoring the centenary

Dassault's website (www.dassault-aviation.com) will feature historic photos and the centenary logo on its home page. The section called "100 years" features an augmented reality app, DassaultAir3d, and a paintbox for plane liveries, MyPlaneDesign.

Also online will be a historical timeline of the Dassault story, videos based on memories by Dassault's former leaders, and new 3D screen-savers.



The cover of the new book, "The Dassault Adventure: a First Century of Aviation".

Livre-100ans_COUVERTURE.jpg

© Editions de La Martinière

7. DASSAULT AVIATION TODAY AND TOMORROW



The three aircraft used in Dassault's innovative formation flight: nEUROn, Rafale and Falcon 7X
0331QG_140321_0041r-1.jpg © Dassault Aviation - K. Tokunaga

Chairman and Chief Executive Officer: Éric Trapplier

Dassault Aviation financial and operating highlights (2015)

- Sales: 4.2 billion euros (83% in export markets)
- Orders: 9.9 billion euros (96% in export markets)
- Net income: 482 million euros
- 12,000+ employees at 28 offices and facilities worldwide
- 2,200+ Falcon jets and 1,000+ military aircraft in service
- 8,250+ civil and military aircraft delivered since 1949
- 100+ customer countries since the outset

Under development

- Falcon 8X, a business trijet with very long range (6,500 nm/12,000 km); entry into service in 2016.
- Falcon 5X, a wide-cabin business twinjet, entry into service in 2020.
- nEUROn, European technology demonstrator for a stealthy combat drone (first flight on Dec. 1, 2012).
- FCAS: Future Combat Air System, a feasibility study in conjunction with BAE Systems of Great Britain.
- Medium-altitude, long-endurance (MALE) drone solutions.
- Joint research projects: Clean Sky, ALCAS, FACE, COINS, CREDO, etc.
- Space design studies.

Product lines

- Falcon:
 - 4 business jets offering ranges from 3,350 nm (6,200 km) to 5,950 nm (11,020 km) :
 - Falcon 2000S twinjet
 - Falcon 2000LXS twinjet
 - Falcon 900LX trijet
 - Falcon 7X trijet
 - Multirole Falcon: maritime surveillance, medical evacuation, cargo, etc.
- Military aircraft:
 - Rafale, the omnirole combat aircraft
 - Modernization of military aircraft and conversions for new missions

8. A DUAL TECHNOLOGY COMPANY



A Falcon 7X and Rafale C on the ground in Mérignac
_STR4104r.jpg © Dassault Aviation - Ph. Stroppa

Dassault Aviation has always applied a dual (civil-military) technology strategy, an integral part of its DNA that ensures the company's balance. The products for these markets are complementary, providing effective protection against fluctuating political and economic conditions.

The Éclair propeller from 1916 marked the start of aviation designs by Marcel Bloch, who was already building both civil and military aircraft between the two world wars. Marcel Bloch's company turned out a long string of aircraft, ranging from the all-metal MB-60 trimotor postal plane, to the MB-174/175 reconnaissance planes and bombers, as well as the MB-200 and MB-210 bombers, the twin-engine MB-220 and four-engine MB-160 commercial transports, and the MB-152 single-seat fighter.

After returning from a concentration camp in April 1945, Marcel Bloch changed his name to Marcel Dassault. Since then, the company has delivered more than 8,250 civil and military aircraft to over 100 countries.

Dassault first earned its post-war reputation for the Ouragan-Mystère family of jet fighters, followed by the legendary Mirage family. From the early 1960s, the company added the Falcon family of business jets to its business portfolio.

Dassault Aviation harbors experience and expertise that is unrivaled in Europe. The same design department and factories design and build both military aircraft (Rafale, drones) and Falcon business jets. The advanced technologies developed for defense are applied to products for the civil sector. In turn, the latter contributes a number of industrial innovations. Thanks to these broad synergies, Dassault Aviation maintains a level of competitiveness far exceeding the industry norm in France and Europe.

All of the programs led by Dassault Aviation as prime contractor form a network of more than 500 partners who contribute to the technological development and economic growth of France, along with its strategic independence.

9. 100 YEARS OF TECHNOLOGICAL PROGRESS



A patrol flight of four MD 450 Ouragan fighters
86-1017_T-1.jpg © Armée de l'Air

The advanced aerodynamic design of the Éclair propeller in 1916 gave it unprecedented efficiency. It was only the first link in a long chain of technological advances that would mark the history of Dassault Aviation. Whether Dassault invented these innovations, or was just one of the first to apply them, they are one of the underlying factors in the company's development. Furthermore, one of Dassault's defining characteristics is that it has built up this experience and expertise almost without interruption – an essential advantage for long-term survival in the demanding aerospace industry.

Propulsion

Propulsion is one of the primary factors in the quest for perfection. All Bloch airplanes and the first Dassault model, the Flamant transport aircraft, were powered by piston engines with propellers. In 1949 Dassault made the transition to jet power with the MD 450 Ouragan fighter. Most of its aircraft use jet engines, with the notable exception of the turbo-prop-powered Atlantique 2 maritime patrol aircraft. Over the years, Dassault has tested a variety of configurations: one, two, three and four engines, even up to nine on its vertical takeoff aircraft. The Mystère II was the first French airplane to break the sound barrier, and the Super-Mystère B 1 was the first aircraft in Europe capable of sustained supersonic speed (Mach 1) in level flight.

Because of the technical requirements inherent in the rapidly rising speed of these aircraft, changes were needed in their aerodynamics, flight controls and materials.

A variety of configurations

The wings were first straight, then more and more swept

Checking flight control components at Dassault Aviation's Argonay plant
SR_130611_081147.jpg © Dassault Aviation - S. Randé



(Ouragan, 1949: 14°; Mystère II, 1951: 30°; Mystère IV, 1952: 38°; Super-Mystère B-2, 1956: 45°). On the Mirage III and IV they became delta wings (60°), which quickly became the design signature of Dassault combat aircraft, up to and including the Rafale. The service entry of the Mirage III C in 1960 marked a turning point in the history of the French air force. It signaled the Mach 2 fighter era in Europe, capable of flying at twice the speed of sound. Then in 1964 Dassault's Mirage IV strategic bomber became the first operational military aircraft in Europe capable of long-range sustained flight at speeds exceeding Mach 2.

In fact, Dassault Aviation has tested just about all configurations, even when they didn't go into production: high and low-mounted wings, high and low tailplanes, or even tailless, and all degrees of sweep, including variable geometry, vertical takeoff and landing (VTOL), ballistic missiles, stealthy drones.

Flight controls

From its first hydraulic flight controls in 1952, all the way to the latest digital fly-by-wire controls, Dassault Aviation has always applied state-of-the-art technologies in this all-important area.

After Bloch airplanes, fitted with conventional mechanical flight controls, this story really started with the Mystère II. Following the initial flight tests, it was obvious that pilots would have a hard time using manual controls, because of the constraints inherent in higher speeds. Hydraulic-assisted controls were needed. Marcel Dassault therefore acquired servo-controls for the Mystère, but they were unsatisfactory, so he decided to design and build his own. The first fly-by-wire flight controls appeared on the Mirage III and Mirage IV at the end of the 1950s, but with backup mechanical controls. In 1978, the Mirage 2000 was the first production military



Mirage IV in flight
3014_T-1.jpg © Armée de l'Air

aircraft in Europe fitted with full fly-by-wire analog controls, without a mechanical backup system. Its successor, the Rafale now in service, represents a further leap in technology. The aircraft is totally computer controlled and uses digital technology. The backup controls are analog, and mechanical controls have disappeared for good. The Falcon 7X and 8X bizjets also feature this technology.

New materials

The ongoing challenge in the aircraft industry is to find materials offering the best combination of weight and strength, with the ideal of course being the lightest and strongest materials.

When Marcel Bloch returned to the aviation sector in 1929, although the aircraft he had built at the end of the First World War were of wood, he immediately plunged into all-metal construction using duralumin, a technique that was still relatively new at the time.

New materials made their appearance at the end of the 1960s, reducing structural weight by up to 30% at a cost often comparable to conventional techniques.

For example, Dassault Aviation produced the following:

- High-lift flap rail for the Mercure of titanium (20% lighter).
- Rudder of laminated carbon for the Mirage III (23% lighter).
- Flap for the Mirage F1 of laminated boron fiber (27% lighter).
- Composite Falcon 50 aileron (first aircraft in the world certified with a critical component made of this type of material)

As early as 1978, the Falcon V10F was the first and only civil transport aircraft in the world to be certified with a carbon wing. Since then, all Dassault aircraft have used composite materials. They account for fully 25% of the Rafale's weight.



EASy II flight deck
IMG_7103-1.jpg © Dassault Aviation - M. Lystseva

Systems integration

With the Mirage IV nuclear bomber at the end of the 1950s, Dassault had to create an integrated weapon suite for the first time in France. Before, the different functions were handled by unrelated systems, and it was the flight crew that had to coordinate all of this information. On the Mirage IV, because of the imperative for absolute precision, all of the components in the weapon system (the plane itself, the navigation system, the bomb release system and the bomb itself) had to act interdependently.

Developments have continued since then, for example on the Super Étendard, the first French combat aircraft to boast a modern weapon system, and the Atlantique 2 maritime patroller, which integrates all sensors and navigation equipment in a single system.

In the early 1970s, the Mirage 2000 featured the integrated operation of the flight controls and radar. The next step was the integration of all systems around a central computer, as on the Rafale.

These trends were also impacting the business aviation sector, including a head-up display (HUD) in the cockpit, a purely military development. The HUD enhanced flight safety by placing critical navigation and flight data at the pilot's eye level, enabling him to keep his eyes straight ahead, and not have to look down at his instruments. The Falcon 2000 was the first bizjet equipped with a HUD, allowing it to land even under very limited conditions of visibility.

In the early 2000s, Dassault worked with American company Honeywell and extensive pilot feedback to develop the EASy (Enhanced Avionics System) flight deck. It capitalizes on Dassault Aviation's extensive experience with combat aircraft, in areas ranging from terrain following and data fusion, to the ability to evaluate complex tactical situations. EASy gives the flight crew an optimized representation of their environment, and allows pilots to know the results of a decision in advance.



Falcon 5X - Immersive Reality Center (IRC), Saint-Cloud, France
118_Falcon5X_2013DVD43.jpg © Dassault Aviation - Ph. Stroppa

Dassault Aviation's plant in Biarritz, southwest France
_DSF8702.jpg © Dassault Aviation - S. Randé



Computer-designed and manufactured aircraft

Until the 1980s, industrial design facilitated the understanding of a technical concept or product by standardizing how it was represented. With the advent of powerful computer systems came 2-dimensional design software that greatly simplified updating designs. As early as 1970, Dassault Aviation plunged into the world of computer-aided design (CAD) by acquiring a dedicated 2D design software package. It was unable to represent complex shapes, but Dassault had to think in 3D – and that triggered the creation of the 3D design software known as CATIA (*conception assistée tridimensionnelle inter-active*).

CATIA makes it possible to design real geometric shapes, and then uses this model to considerably facilitate the programming of machine tools and assembly robots. That establishes a direct link between design and production, a link that is continuously strengthened. This software shortens cycles, enhances quality and improves productivity. A new company was created in 1981 to develop and market this system, Dassault Systèmes.

The company took a major step forward in 1990 with the digital mockup, or DMU. What this meant was that engineers no longer needed actual tests on physical models or prototypes. The DMU became the sole reference model for a given product throughout the company, incorporating the full range of complexity inherent in any industrial project. In 1991 the Falcon 2000 became the first aircraft in the world to go directly from computer design to production, without requiring a physical mockup of the interior layout.

The next major step came in June 2000 with the implementation of Product Lifecycle Management (PLM). The Falcon 7X was wholly designed and built using this seamless process, ranging from initial design concepts to entry into service.

Today, Dassault is developing an industry model that ensures the continuity of digital information between all sectors: the

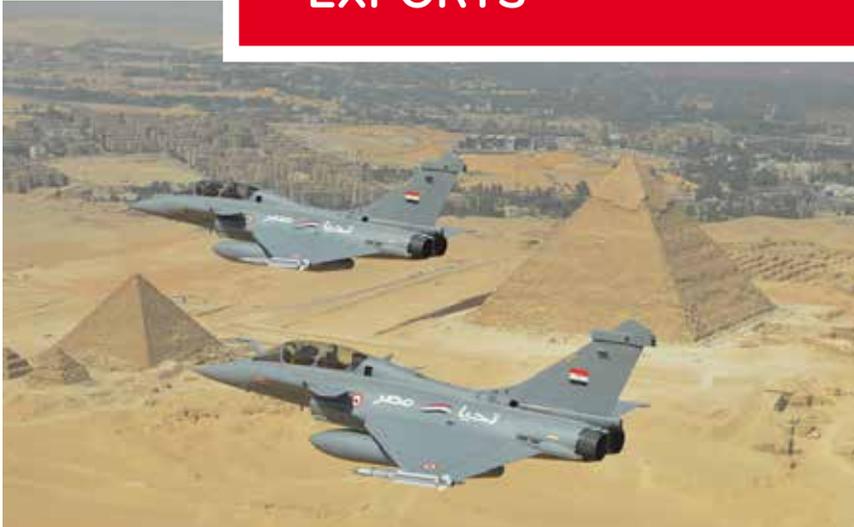
digital factory. It is gradually deploying a digital chain spanning design, purchasing, production, support and customer relations. All data is kept in a single database, set up when the program is launched.

Tomorrow

Dassault Aviation is funding research on tomorrow's Falcon jets so they will incorporate even more innovative technologies: composites, aerodynamics, energy savings, etc. At the same time, Dassault is a full-fledged partner in international research programs. In Europe, for instance, it is involved in the Smart Fixed Wing Aircraft (SFWA) integrated technology demonstrator (ITD), one of six in the vast Clean Sky research program. Dassault is also representing the European Business Aviation Association (EBAA) in the air traffic modernization program SESAR.

Dassault Aviation is contributing to research on approach procedures using an augmented vision system, as well as the integration of military aircraft and unmanned air vehicles (UAV) in air traffic. In France, Dassault Aviation is a partner to CORAC, the civil aeronautics research council.

10. THE IMPORTANCE OF EXPORTS



An Egyptian Rafale B flying over the pyramids
DR_150930_DSC_0064.JPG © D.R.



Indian Air Force Mystère IV
09-b662888.jpg © Dassault Aviation - DR

For the last 50 years, Dassault Aviation has exported about 72% of its production to a hundred countries. For Falcon business jets, this figure climbs to over 90%. Since the French market for both civil and military aircraft is necessarily limited, Dassault has always focused on exports.

As early as the 1930s, the Société des avions Marcel Bloch had sold some of its products abroad. The MB-200 bomber went to Czechoslovakia, the first country to buy and then construct these aircraft under license, while Romania bought the MB-210 bomber and Greece the MB-152 fighter.

After the Second World War, the MD 450 Ouragan was the first French jet fighter to be exported, to India and Israel. India has remained a loyal customer, with purchases of the Mystère IV, Alizé, Jaguar and Mirage 2000, and has stated its intention of acquiring the Rafale. Israel was the main export customer up until the late 1960s. The Mirage III's success during the Six Day War in 1967 and the French government's deployment of this modern fighter to support its foreign policy created an explosion in demand for Dassault fighters. The French government is of course the mandatory intermediary for relations with other countries in this type of contract. The *Commission interministérielle d'études des exportations des matériels de guerre* (CIEEMG), the defense export committee reporting directly to the Prime Minister, allows the government to control and authorize all of Dassault's relations with countries that want to purchase military aircraft.

Dassault was ranked as the third leading French industry exporter in 1976, and No. 1 in aerospace. In 1977, Dassault recorded 11 billion francs in export orders. Including associated orders for engines, radars and weapons (going to Snecma, Thomson-CSF and Matra), Dassault generated more than 16 billion francs in export orders, equal to one-fourth of France's oil bill.

Export sales for civil and military aircraft enable the French government to acquire these aircraft at more affordable

prices, because they increase production runs. The benefits for the national economy were obvious, as explained by former company head Benno-Claude Vallières: "*Take the case of the Mirage III. The amount invested by the government to purchase this plane, plus production tooling, in relation to export revenues, comes to only 1.58%. In other words, for every 1.58 francs invested, France saw 100 francs in exports.*"

At the same time, starting in 1965 sales of Falcon business jets in the United States, via Pan Am as distributor, began to grow. A joint U.S.-based company, Falcon Jet Corporation, was created in 1972 to keep pace with demand. As the economy became increasingly global, the Falcon 20, 10, 50 and 900 business jets enjoyed international success. The customers were mainly large international corporations and governments, who operated one or more aircraft. In the 1990s the new Falcon 2000 helped the company, which had shifted its focus more to the civil sector, to survive the global aviation crisis and deep cuts in military budgets following the Soviet collapse.

Sales in the civil sector exceeded those in the military sector for the first time in 1999. However, Rafale sales to Egypt and Qatar in 2015 will reverse this trend, once again demonstrating the importance of exports for Dassault Aviation's business and income. These sales will also have a positive impact on French exports in general.