

Ejection seats have saved thousands of aircrew's lives over the years. **Alan Warnes** visited Martin-Baker in Denham, Buckinghamshire, to see how it's maintained its position as a world-leader in escape systems for more than 70 years.

BANG!

YOU'RE ALIVE

The pilot of an RAF Harrier GR9 escapes over the runway at Kandahar Airfield in Afghanistan in May 2009. As the jet slid along the tarmac, the pilot turned the aircraft away from a formation of four aircraft waiting to take off, then ejected as it slowed down, but before coming to a stop. A fire then engulfed the entire aircraft. Martin-Baker



The majority of fast jet pilots would agree that the most important part of their aircraft is the ejection seat.

'Banging out', as it's sometimes called, is usually the only option when staying with your aircraft would likely lead to death. Pilots who have ejected often speak of the apparent eternity between pulling the ejection handle and being jettisoned – in reality it's around a tenth of a second.

The pilot or rear-seater is then propelled through the canopy with a force of between 15 and 20g.

If they keep their arms tucked in, and with their legs restrained by a harness at the bottom of the seat, they should escape harm during ejection. A helmet with the visor down provides protection for their head and face.

Left: This sequence shows the function of the Martin-Baker Mk18 seat from a test rig. The company has developed the seat to meet the emerging Next Generation Escape System requirement and it's also designed to be fully compliant with all USAF T-X programme contenders. Martin-Baker

After around two seconds, depending on altitude, the parachute opens, and the seat falls clear of the pilot, who will now float down to earth.

Unfortunately, ejection is not always successful. There have been tragic accounts of pilots with longer torsos who have been killed on ejecting through the canopy, and there needs to be adequate space – typically at least three fingers' worth – between the helmet and canopy so that the seat's breaker smashes the glass first.

However, a more common reason for failure is ejection outside a seat's specific safety envelope. These days, most high-tech models are described as 'zero-zero', which means they permit ejection at zero speed and zero feet altitude, giving pilots a degree

of confidence they could escape if required during take-off or landing.

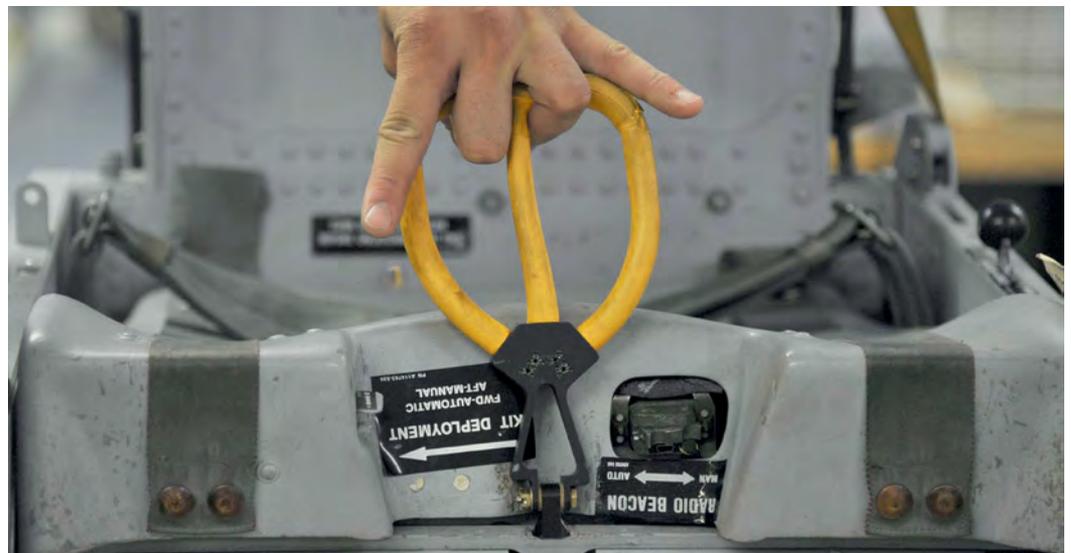
A stunning photo of a Royal Air Force pilot ejecting from a Harrier GR9 at Kandahar, Afghanistan, back in 2009 shows his departure as the stricken aircraft skids across the ground. Martin-Baker still uses the image today whenever it's marketing the capabilities of its escape systems.

Some aircraft, including the F-111 and B-1A, were designed with a crew escape module rather than individual seats. For these supersonic bombers, the US Air Force included a requirement for emergency crew extraction at 100ft (30m) and Mach 1. After departure from the aircraft's fuselage, the crew members, still strapped into their seats, would float down to earth within the capsule. If it came down into the sea a flotation

system would prevent it sinking.

Today, however, there are no crew escape modules in operational use, and ejection seats are produced by manufacturers around the world, including the Aviation Industry Corporation of China (AVIC), Russia's Zvezda, UTC Aerospace Systems in the US and, of course, the UK's Martin-Baker.

The British company, located just inside London's main M25 ring road, is the world's leading escape systems specialist with a 53% share of the market. At its base at the end of a leafy housing estate in the country, 18 types of ejection seats have been designed and built since 1945. More than 90,000 of them have served 95 air forces, saving 7,500-plus lives, and more than 17,000 are in service around the world today. ▶



Above: How to eject from an F-16. The pilot pulls the yellow handle, starting an explosive chain of events in the cockpit. This begins with the canopy blasting off the aircraft, giving just enough time for the seat itself to rocket out of the framework before putting the pilot through forces of 14g. USAF/Airman 1st Class Patrick S Ciccarone

Left: AVIC's TY-5B seat equips the FC-1 exported to Myanmar. While Pakistan Air Force pilots consider the seat comparable with the Martin-Baker Mk16, it's significant that Pakistan opted for the tried and tested British product to equip its Thunders. Alan Warnes

Right: A US Navy F/A-18E pilot strapped into a SJU17A NACES (Navy Aircrew Common Ejection Seat) at Naval Air Station Lemoore, California. The NACES is known to Martin-Baker as the Mk14 and is currently in service in the F/A-18 and T-45. Deliveries continue to support overseas sales of the Super Hornet. Jamie Hunter



The competitors

With all fast jets requiring crew escape systems, there's considerable competition among ejection seat manufacturers. In China, AVIC has to satisfy a huge demand due to the number of fighters and jet trainers being produced there. With military embargoes in place, the country has no option but to produce its own seats to cope with the domestic demand.

Martin-Baker is aware of the fact that Chinese industry has a reputation for copying the 'best of the West', but there's little it can do.

Back in the early 2000s, when China and Pakistan were building the JF-17 (FC-1) Thunder prototypes, AVIC's TY-5B seats were found in the cockpits. All three prototypes flew with the seats, because China was keen to sell them to Pakistan. Meanwhile, Martin-Baker – a long-term supplier of seats to the Pakistan Air Force (PAF) – was eager to get its Mk16 seats into JF-17s.

All PAF fighters have Martin-Baker seats – except its F-16s, which are fitted with the UTC Aerospace Systems ACES II – and MB systems are found in Pakistan's Chinese-built MiG-21 copies, the Chengdu F-7P and F-7PG.

It wasn't a surprise when the UK firm, after intense lobbying, won a multi-million-pound contract to supply 150 seats for the PAF's JF-17s. All eight of the initial batch delivered to the PAF with TY-5Bs



Sailors check the landing gear of a T-45C Goshawk assigned to Commander, Naval Air Training Detachment during flight operations on the deck of USS 'Abraham Lincoln' (CVN 72) earlier this year. Martin-Baker is already eyeing the opportunity to provide ejection seats for the T-45's successor. US Navy/ Mass Communication Specialist 3rd Class Jacob Smith



were retrofitted with Mk16s, as was at least one of the prototypes.

The PAF is one of many air forces with a strong tradition of using the British seats dating back to the mid-1960s when large numbers of pilots were losing their lives in Shenyang F-6s due to the apparent unreliability of the Chinese ejection systems.

Today things are different. As one senior PAF test pilot told *AFM*: "The TY-5 is just as good as a Mk16 seat and it's cheaper, but it's our tradition to stick with MB seats."

Owing to military embargos, China couldn't supply the Mk16 to Myanmar (formerly Burma) for its small batch of FC-1 fighters, so they fly with the TY-5B instead.

In the mid-1990s, Russia's Zvezda was keen to export its K-36D seat to the US, and at one stage it appeared there would be some industrial collaboration.

As serious thought turned to launching production in the US, a remarkable Su-30MK ejection at the Paris Air Salon in June 1999 provided a marketing coup for the Russian manufacturer. Fortunately, the Sukhoi pilot and navigator both escaped safely, ejecting at spectacularly low level after a command sequence blew the canopy off.

Zvezda's General Director and General Designer, Professor Guy Severin, told the author at the time that the company hadn't adopted a 'through the canopy' ejection sequence because

"the polycarbonate glazing was too tough and would retard the initial acceleration of the seat".

At the time, IBP Aerospace Group was keen to build the more advanced K-36D-3.5A seat under licence in Hartford, Connecticut. It's designed to provide safe ejection at speeds up to Mach 3 and to operate in a range from ground level to 82,000ft (24,993m).

Sled tests of the Russian seat were carried out at Holloman Air Force Base, New Mexico, when the US was considering fitting a lightweight version in the Joint Strike Fighter but, despite limited investment, the US opted for the Martin-Baker Mk16 instead. The British firm demonstrated that its US16E version was the best option and won the competition to install the seat in around 3,000 aircraft – F-35A, B and C variants.

F-35 seat

Pilot escape systems have to continually evolve to remain at the cutting edge. It's no longer a case of 'banging out' and hoping for the best, and Martin-Baker's US16E had to meet key performance parameters such as safe terrain clearance limits, physiological loading limits, pilot boarding mass and anthropometric (the measurement of the human individual) accommodation ranges to satisfy the F-35 escape system requirements.

Meanwhile, UTC Aerospace Systems has been keen to get its ACES 5 seat qualified for the

Aero Vodochody's upgraded VS-20 under test in the Czech Republic. A live test from the rear seat of an L-59 took place on March 27. Alan Warnes



VS-20 test

Aero Vodochody in the Czech Republic is responsible for designing ejection seats, while the seat frames are built by Zlin.

The original VS-1 seat was used in the L-39 and later in Poland's Iryda, and ejections can be made independently by each of the two crew members.

With the more modern VS-2, which equips the L-59 and L-159, a command ejection mode (both seats) was added, but this can only be initiated from the rear seat. If the rear-seater

is incapacitated for any reason, the front seater can't eject them.

The latest VS-20 is effectively an upgraded VS-2 that originated from a requirement for the Czech Air Force's upgraded L-159T2 dual-seaters. In this aircraft, the air force wanted the flexibility of command ejection from either seat. The previous, extremely complicated, pyrotechnic system in the VS-1 and 2 has also been replaced by a more reliable electrical system.

F-35 in a bid to oust the US16E. This followed a ban on any F-35 pilots weighing less than 136lb (61kg). Lighter pilots were found to be at risk of serious, potentially fatal neck injuries on ejecting from the aircraft.

In 2016, Lt Gen Arnold Bunch, the military deputy for the Office of the Assistant Secretary of the Air Force for Acquisition, directed the F-35 Joint Program Office to study the potential cost and schedule impacts of qualifying the ACES 5 in the Lightning II. However, it turned out that the issue stemmed largely from the weight of the 5.1lb (2.3kg) Rockwell Collins helmet, which was eventually reduced to 4.6lb (2kg).

Martin-Baker also inserted a head support panel to cradle the pilot's helmet, and the USAF now allows pilots weighing between 102 and 245lb (46 and 111kg) to fly the jet.

Next generation

It looks likely that UTC Aerospace Systems and Martin-Baker will soon go head-to-head again. Both are developing a Next Generation Escape System (NGES), aimed at replacing the existing systems in the current USAF combat fleet – A-10s, B-1s, F-15s, F-16s and F-22s.

All of them are now flying with ACES II systems, and while it seems unlikely the A-10s and B-1s will go through an expensive upgrade, there's plenty of potential work on the F-15 and F-16 fleets.

Andrew Martin, Martin-Baker's Business Development Director, told *AFM* in late March: "Our main



Above: A US Marine Corps safety equipment mechanic replaces an ejection seat in an AV-8B Harrier II deployed in support of Operation Inherent Resolve last year. US Marine Corps/Staff Sgt Jennifer B Poole

focus in the design department over the last 12 months has been NGES. It's the holy grail of retrofit programmes for Martin-Baker."

Some customers operating newer F-15s and F-16s are concerned that the USAF is exchanging its older frontline fighters equipped with ACES II for the F-35 with Martin-Baker seats. What will this mean for those still operating the ACES II? Andrew Martin notes that increasing numbers of operators have asked him if the company plans to develop a product to replace the American seats.

"It's always been a bit of a challenge to get the appropriate data to do a proper job, and then a couple of years ago the USAF launched the NGES initiative," he said.

Martin-Baker has been forced to come up with a new product and the challenge has been avoiding expensive cockpit or aircraft modifications. "We could not possibly compete

with our rival [UTC Aerospace Systems] if it meant costly mods. We have to ensure any comparison will come down to the seat itself," said Mr Martin.

"We purchased some ACES rail seats from the USA and tested them at our Langford Lodge track in Northern Ireland. In December we're running a 600-knot twin-seat ejection at Holloman AFB with a heavy and light mannequin being tested at the same time."

Mr Martin explained how the business has survived against all the big corporate players: "We're a family-owned brand, sitting at the table with everyone – the manufacturers of the aircraft, the customer – which is a unique position: meeting everyone's needs is paramount.

"Last year we delivered 380 seats to 12 manufacturers for 14 different manufacturing types that were sold on to 18 different countries. That kind of exposure puts us in a position where we get

excellent visibility for the future.

"Right now, we've identified 16 future programmes with requirements for ejection seats. One example is the US Navy's T-45C Goshawk which will need replacing around 2030.

"One of the challenges we have at Martin-Baker is looking far enough ahead to put in the groundwork at the right time, as we really need to be in the prototype. There have been cases like India's Tejas and Indigenous Jet Trainer, as well as Pakistan's JF-17, where we were not selected for the prototype but still got our seats in them when serial production started.

"There've been times we were in the prototype and secured our position to have the aircraft almost built around us.

"We also invest a lot into research and development, by working closely with our partners and primes at the earliest phase, so we can offer up a compliant escape system. We invest in primes, but it doesn't always pay off – there are plenty of failed aircraft out there!"

Future requirements

Predicting changes in future requirements is one of Andrew Martin's many responsibilities. He currently has 12 programmes that are referred to as 'stage 1' – "where we've been selected and the aircraft is approaching first flight, in prototype mode or working on a launch customer. Aircraft like the L-39NG, M-345, JF-17B, Indian HJT-40 and Paramount Mwari."

Clearly there's a lot of competition out there, and Martin-Baker will face even stiffer challenges from its Chinese, Russian and US counterparts in the future. **AFM**



Above: The F-35's Martin-Baker US16E seat is a further development of the Mk16 that is found in the T-6 Texan II, Typhoon and upgraded USAF T-38s and NASA T-38Ns. It uses a "through the canopy" ejection sequence, with the canopy fractured by a pyrotechnic cutting system. Jamie Hunter