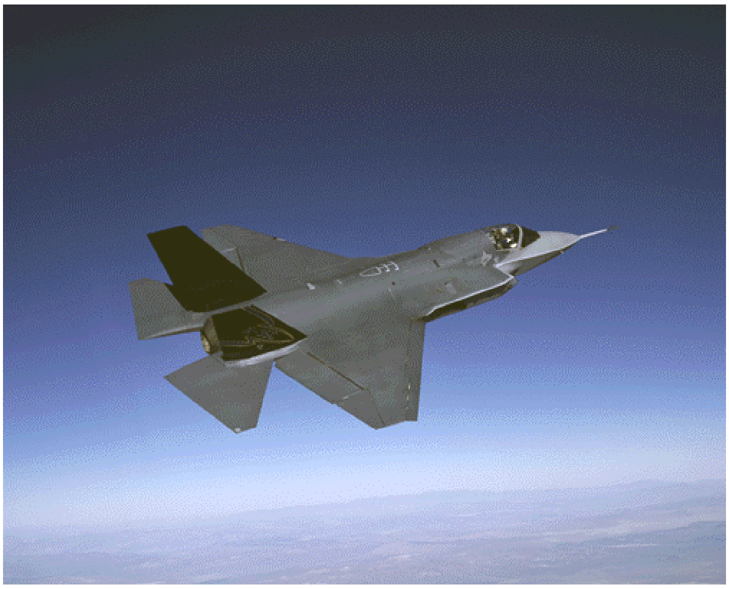
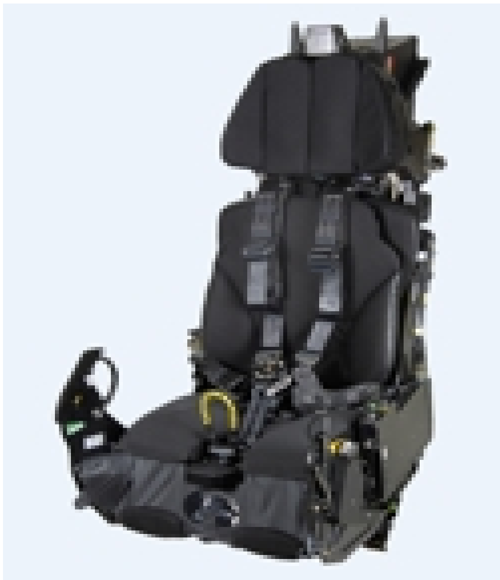
Synopsis of Lecture to RAeS Loughborough Branch on 08 Mar 2011

Martin-Baker: the JSF story so far by Steve Roberts, JSG IPT Lead, Martin-Baker Aircraft Company Ltd

The Joint Strike Fighter (JSF) Program came into being in 1996 as a result of the amalgamation of the Common Affordable Lightweight Fighter (CALF) and Joint Advanced Strike Technology (JAST) Programs. The aim of the JSF Program was to develop one aircraft to fulfil the roles previously carried out by several different aircraft. Martin-Baker's involvement commenced in 1995, i.e. before the start of the JSF Program. The JSF top level requirements were that it had to affordable, be easily supportable and deployable, offer maximum survivability in conflicts, and lethal, i.e. the aircraft must deliver its weapon first time. The ejection seat was required to cost no more than 0.5% of the overall aircraft cost.



The Joint Strike Fighter (JSF)



Martin-Baker 16E Ejection Seat

Initially there were three Prime Contractors; Boeing, Lockheed-Martin and British Aerospace (now known as BAE Systems). At the start of the Concept Development Phase (CDP) in 1997 this was reduced to two; Boeing, Lockheed-Martin with BAE Systems being a sub-contractor to Lockheed Martin. Each of the two Prime Contractors was required to develop a prototype aircraft. The Lockheed Martin/BAE Systems LM-35 solution was selected as the aircraft to go forward into Full Development.

It was not found possible to have a single LM-35 solution to meet all requirements, however the three LM-35 solutions have 80% commonality in their design. The three variants are F-35A (CTOL), F-35B (STOVL) and F-35C (CV).

The ejection seat was required to be common to all three aircraft variants. It was also required to have superior ejection performance to all previous seats, meet new neck injury criteria and provide an auto-ejection capability when used in the F-35B (STOVL) aircraft. The last requirement demanded early firing of the ejection seat in the event of an aircraft malfunction in a manner similar to that used in the Russian YAK 36, 38 and 141 aircraft. An additional complication was the need for the seat to accommodate pilots ranging from a small female to a large male.

The seat was designed using the Unigraphics Computer Aided Design (CAD) Tool which in turn permitted Computer Aided Machining (CAM) using 5-axis machining tools.

The seat incorporates a parachute and drogue located behind the pilot's head. It also incorporates a life support system, an integrated harness together with arm and leg restraints. It has five separate operating modes which are a function of aircraft height and speed. The rate of descent is lower than for any previous ejection seat being less than 7 m/s even for the largest male pilot.

The US Navy required the ejection seat to be modular in construction such that it could be removed from/fitted to an aircraft on a sub-assembly basis. This necessitated a re-design of the parachute container to allow the seat harness to be removed without the need to unpack the parachute.

Martin-Baker ran a US/UK competition for the supply of the Personnel Location Beacon. The competition was won by H R Smith in the UK. The Beacon provides a signal which can be picked up by low earth orbiting satellites. This in turn allows a pilot who has ditched into the sea to be located anywhere in the world within two minutes.

The pilot's helmet incorporates a Virtual Head-Up Display which provides him with an image of the scene around the aircraft. This image is derived from a variety of day camera and infra-red cameras located on the aircraft fusalage. It was essential for the Display to be plugged into the aircraft avionics data bus and for the plug to be extremely reliable. The ejection seat incorporates a plug which meets all the reliability criteria and is suitable for data rates up to 1.6 GBaud.

Neck protection is provided by means of a "Catcher's Mitt" inflatable device which supports both sides of the pilot's helmet and also provides support to the top and /back of the helmet. This device is also held in a container located behind the pilot's head. The device is vented before the parachute is deployed. The device has been tested and proved to inflate under simulated 50,000 ft altitude conditions.

The ejection seat for the first prototype aircraft was delivered in August 2006 and installed in F-35A (CTOL) prototype aircraft 2005-AA-1 in November of the same year. The ejection seat for the F-35-B (STOVL) prototype aircraft was delivered and installed in the aircraft in March 2008. A prototype ejection seat was also installed in the F-35 Full Motion Simulator. Trials with the Simulator showed that the seat became uncomfortable if pilots remained seats for prolonged periods, especially in excess of 8 hours. As a result the seat design was modified to provide additional calf support.

Further trials were carried out at the High Speed Sled Test Range at Holloman Air Force Base, New Mexico. These allowed the seats to be tested over the full F-35 aircraft speed range.

It was a UK requirement for the seats to be tested for decontaminatability following chemical attack. This test has been carried out recently at DERA Porton Down.

A further test seat was installed in the Co-operative Avionics Test Bird (CATB). CATB is a converted Boeing 737 being used for avionics testing. It enabled a pilot seated in the ejection seat to carry out the full range of avionics control functions.

The F-35-B (STOVL) aircraft has additional failure modes associated with Lift Fan, Vane Box, Lift Fan Drive Shaft, Roll Duct and Turbine failures. A typical pilot takes two seconds to react to the ejection klaxon or one second if warned in advance of a likely failure. In the case of a STOVL related failure, ejection must take place within 0.6 seconds. Hence it was necessary to install smart failure sensors on the aircraft to automatically fire the ejection circuit mounted in the back of the seat.

The first production seat is due to fly later during March 2011 although some concurrent development is scheduled throughout the aircraft's Low Rate Initial Production (LRIP) period.