Case Study A-7: ESCAPES: Ejector Seat Control

You have been approached by a large defence contractor in Stevenage to develop the software for an automatic ejector-seat control system for military aircraft. The following is a very brief statement of requirements for the proposed system, provided by your potential customer, together with some background technical information to help you to understand the problem.

Ejector-Seat Control and Parachute Employment System (ESCAPES)

The Ejector Seat Control and Parachute Employment System (ESCAPES) will maximise the chances of the pilot surviving a bail-out in all foreseeable circumstances, by ensuring the correct timing of detonation of ejector charge, cockpit canopy release, firing of parachute opening rocket, and detachment of seat from pilot, in conditions where no conscious action can be expected from the pilot after the eject lever has been pulled in order to initiate the bail-out sequence.

The pilot can theoretically survive bailing out at any air-speed from zero to mach 2, and at any height from zero to 100,000 feet (with breathing apparatus). In a high-speed ejection, the force of the air-stream is sufficient to cause serious, but survivable, injury. However, it cannot be assumed that the pilot is even conscious at any time after leaving the cockpit.

The ejector charge which blows the seat, with the pilot in it, out of the cockpit is sufficiently powerful to raise the seat and pilot to an adequate height to allow parachute descent even after ejection at zero feet. A rocket is fired to drag open the parachute to ensure that it can be opened fully and quickly in all flying conditions. The seat remains attached to the pilot until the parachute opens, after which it detaches and falls away.

The terminal speed (the limiting speed through the air which a falling body will eventually reach under the accelerating force of gravity and the decelerating force of air resistance) of the pilot with seat attached is 170 mph. If the parachute opens while the air-speed of the pilot plus seat is greater than 400 mph, the cords will break, or the parachute canopy will tear.

After a high-altitude ejection, the pilot (plus seat) must free-fall until the altitude is 5000 feet maximum, in order to minimise the length of exposure to low air temperature and pressure.

The system must therefore control the following sequence of events:-

- Initiate bail-out in response to manual action of the pilot on the ejection handle or automatic detection by the instruments that the aircraft is in a non-survivable state.
- Detonate “det-cord” to shatter and remove the cockpit canopy.
- Gather data from aircraft instruments on airspeed, altitude, attitude, speed of rotation, etc.
- Detonate ejection charge to lift seat clear of aircraft. (An extensible ramp will ensure that the seat clears the tailplane.)
- Continually measure airspeed, altitude, attitude, rotation, etc., of the seat with the pilot in it until conditions are “safe” to open the parachute canopy (see above) or until impact with the ground is too imminent to allow further delay.
- Fire rocket to open parachute canopy.
- Release the pilot from the seat.
- When pilot reaches ground, activate beacon to alert rescuers.

The timing of each event in the sequence must be chosen with due regard to prevailing conditions to optimise the chances of the pilot’s survival.