International Federation of Airline Pilot Associations

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Unmanned Does Not Mean Un-Human

There is a conception that the state of electronics and automation has matured to the extent that the requirement for an on board human intervention capability has declined that in truth, it is no longer a requirement. This hypothesis is fundamentally flawed. The removal of an on board pilot does not remove human failure from the safety equation.

This may seem a pretty significant assertion to make since aviation history is littered with the wreckage of accidents of aircraft manned and unmanned that were caused by human failures. How many times have we seen the phrase 'pilot error' in accident reports? Of course, deeper analysis often reveals that, while the final link in the chain may have been a human error in the cockpit, in fact the real failure may have been in training or operating procedures and environment. In the 1970s, before the days of cockpit resource management, two high profile crashes were the result of the crews, distracted by warning lights that may or may not have been spurious to lose special and situational awareness with the result that the aircraft crashed. More recently there was a loss of a B-Hunter UAV which resulted in the death of a woman on the ground. Analysis of the sequence of events revealed that the operating crew had, as a result of a loss of situational awareness, believed the aircraft to be on the ground and shut down its engine. The human element is just as present in unmanned as manned aircraft.

Let's take this assertion further; there have been a number of cases where the human error has occurred earlier in the chain than the cockpit for example during maintenance or perhaps even earlier as the result of a coding error by a software engineer during system development. As an example to the first type of error, in 1995 an Embraer Brasilia operated by Atlantic Southeast Airlines was operating a routine flight when one of the propeller blades on its left engine separated. This led to an extreme imbalance and in turn, caused the affected engine to partially separate from its mounting. The resulting drag rendered the aircraft unable to sustain level flight, and, unable to reach any airport in the vicinity, the crew had no option but to make a forced landing in a farmer's field. Sadly a number of passengers and the aircraft's captain succumbed to the post crash fire. Investigation into the crash revealed that the primary cause was human error, but not by the flight crew rather, in this case by a technician that worked on the propeller assembly when it had been overhauled some months before. Yet like the pilot errors discussed above the engineer's error proved to be not as result of negligence but because of poor training. Using an example from the NASA space programme of the 1960s, man's first landing on the moon came within seconds of total failure because of a software coding error in the lunar module's guidance computer. (Incidentally, a small digression, this example is a good case for a human in the cockpit because of this and other guidance errors - Neil Armstrong & Buzz Aldrin flew the approach manually).

The point is these errors and hundreds like them occurred because there is a potential for failure or error in any system. This of course is magnified with system complexity. Of course, in aviation manned or unmanned, we are dealing with extremely complex equipment and operating environment. Aircraft and equipment which have performed flawlessly for many years will, on occasion, produce failures which will have engineers and other technicians scratching their heads and remarking «we've never seen THAT before». Again, these issues could easily be found in unmanned as in manned aircraft.

What Can Go Wrong Will Go Wrong

The English have a phrase called Murphy's Law. Murphy's Law says «that what can go wrong will go wrong». As we have seen any aircraft or system developed will have flaws as a result of the human element. What can be done to mitigate effect of Murphy's Law? Clearly, it is important to eradicate as many systemic failures as possible. Naturally training has a vital role to play in the avoidance of error as does adherence to established and tested operating procedures, but what of the final bulwark against an accident; the ingenuity of the crew? Let's begin with a caveat: «The introduction and use of automatics in manned aviation has done much to improve air safety is beyond question. In normal flight modes the automatics will do a far superior job of 'flying' the aircraft freeing the crew to focus their energies on managing the safe progress of the flight.»

The Upside Of The Human Element

However in the non-normal environment the human pilot comes into his or her own. As yet synthesised systems are unable to deal with the rapidly evolving situation that may be the result of major system failure. The main thing that they lack is the ability to learn and reason – even when the cause of the learning is not necessarily reasonable! What is the point in learning a technique that you are 'never' going to use? Surely this is unreasonable?

Take this example of 'unreasonable' learning. Transport category aircraft are designed with multiple failure system redundancy but some failure modes are so radical that they are not possible to resolve. Take for example a total hydraulic loss in a large transport aircraft. Surely not a reasonable scenario to train for what with three fully independent systems and the availability of a back up power source even if all engines were to fail? A DC-10 lost all its hydraulics after an uncontained engine failure but by using differential thrust the crew were able to crash land the aircraft at Sioux City and in the process saved the lives of 186 passengers and crew.

More recently a crew of a cargo flight hit by a surface to air missile which caused their aircraft to lose all hydraulics were able to regain control of the aircraft and land it safely using differential thrust – unreasonable learning? Perhaps the technique was not taught in the airline's training but it happened that the Captain had only weeks before seen a documentary about the Sioux City accident and applied the lessons he learned from watching the show. While the events are still under investigation it is extremely unlikely that the logic of an automatic system would have been able to achieve the successful forced landing by a 777 in January in London. So it is clear that while undoubtedly automatics have their place in aviation safety, and indeed, it's a vital place, they are at present no match for the flexibility of the human operative's logic.

The Synthetic Element Downside

We often discuss the human factors element in flight safety, and as a result over many years of study a mass of knowledge has built up which considers human performance, it abilities and limitations. This knowledge base is by no means complete and without flaw, how could it be? The human condition is a very complex one and the data was created with the human element! But even so, it remains a vital and hard won cog in the flight safety machine. Making errors, their causes and results is explored in the present manned aviation environment, much less understood in unmanned flying and almost unknown in the field of hard- and software-design, which naturally becomes more important when incorporating pilots abilities into hard- or software. Errors performed by an operator, pilot or ATC-controller, should be 'caught' by a number of methods: most error-types are understood, many of them alleviated by mitigation-means: redundancy, procedures, warning systems, design of the hardware.

But what about the software-designer? Isn't he a human as well as the pilot, the controller? Doesn't he make mistakes like anyone else? To what extend is his working environment explored as of the possibility to avoid mistakes? Mistakes, that show up much later; probably years later and unexpected... It is well known how complex the process of proving the robustness of software against safety-critical failures is: It is almost impossible! Even if it is possible, it is almost beyond price. And the examples of failures of so called safety-critical 'intelligent' software are numerous: Take the tragic event of a full-automatic canon used in an exercise in South Africa in October last year: Without possibility to shut down the cannon it shot without command until the magazines were empty: the result: 10 soldiers dead, 14 wounded. There is a long list of other software 'going crazy'. By the way, until now, the operator – pilot or ATC-controller – is used to trap most of these 'latent' errors. Obviously, also in future unpiloted aircraft, a human is somewhere in the chain, depending on the level of achieved autonomy. But is he, in case something goes unexpected, at the right place? Does he have the necessary information right at hand?

There are the results of extensive studies on the value and/ or importance of, information derived from sensory stimuli. Here the remotely located UAS pilot is at a disadvantage compared with his counterpart in the cockpit. The UAS pilot experiences a partial deprivation of optical cues, his field of vision is limited by the scope of the on-board camera. And that is the good news! Compared with an on board colleague the UAS pilot in his or her ground control station experiences total deprivation of senses of sound and smell. In addition they are unable to experience sensations of jolts or changes in velocity, of temperature or humidity changes all of which may be early indicators of something amiss with the aircraft.

For example, the on-board pilot will often note an uncommanded change of velocity 'through the seat of his pants' which will trigger a cross check of instruments in order to confirm a deviation ahead of beginning the solution process. He will smell the smoke from a possible fire or hear the bang of an explosion - cues denied to the remote pilot. Like his cockpit counterpart, the UAS pilot suffers from all the shortcomings of being a human being yet he is further denied the ability to use all his faculties to analyse and deal with an abnormal situation and as result is hampered in the ability to use the upside of the human element because as asserted earlier it remains true that the human brain is yet to be matched operating in an ambiguous situation - generally speaking it might be this that makes aviation safe!