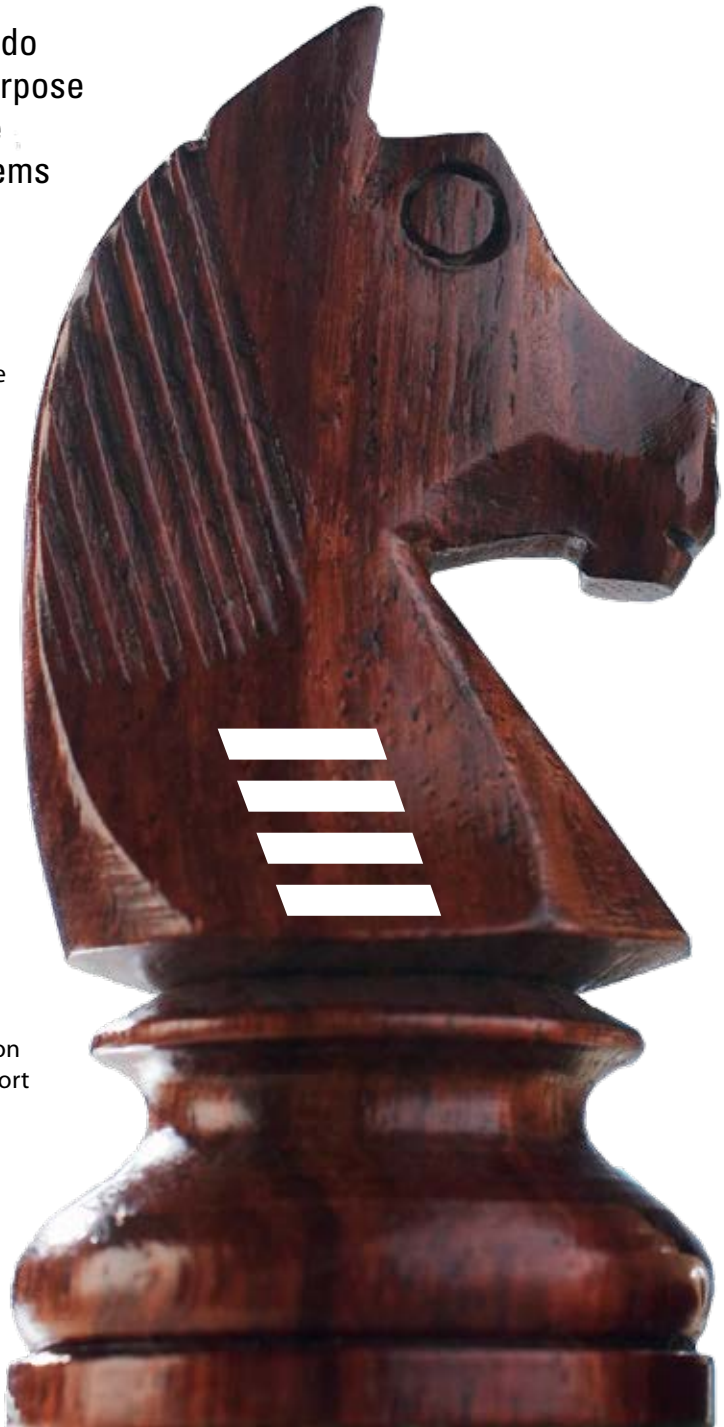
HOW TO SYNCHRONISE **DIFFERENT SAFETY NETS**

by Captain Wolfgang Starke

Today's technology is delivering opportunities for safety nets covering nearly every possible scenario from different points of view. These features can be ground-based or airborne applications; they can be directive or informative and adherence can be mandated or the indication can be on a "for information only" basis. Most of these systems do work well, are pretty reliable and serve their purpose – enhancing flight safety. However, there is one big problem, what to do if several of these systems generate an alert at the same time, providing different ways of resolving the problem?



Looking back to the early years of aviation, flight safety was hardly comparable to the high standard of today. The only safety net known at that time was the brain of the pilot. Later, when air traffic control was introduced, a second safety net was added - the brain of the air traffic controller.

Today we have numerous systems assisting our brains and organs of perception in order to guarantee high levels of flight safety. Still, one very basic problem remains. Once there were air traffic controllers, there was the chance of having two solutions to one problem at the same time based on the intent of the controller and the intent of the pilot. Both might be adequate ways of solving the problem as all roads lead to Rome but we need to decide which road to follow.

Being faced with a problem - say an airborne conflict - today, there may be several solutions presented to the actors. We have the basic reactions of pilots and controllers such as see and avoid, the mental picture or influences originating from experience, expectations or somewhere else. On top of this there are safety nets such as medium or short term conflict alerts as well as the airborne safety net called ACAS (airborne collision avoidance system). These systems all work independently from each other for good reasons. Still, if the solutions presented are contradictory, the consequence may be confusion.

Such a confusing situation happened to me on a short haul flight during climb out in low traffic density. We had been cleared to climb to flight level 190 on a northerly heading. All of a sudden, the

air traffic controller instructed us to immediately turn right onto heading 090 degrees. While we initiated our turn with the autopilot engaged, climbing through flight level 170, the air traffic controller instructed other traffic, cruising at flight level 180 on a southerly heading to immediately turn right onto a westerly heading. Almost immediately thereafter he asked us whether we could level off at flight level 170. So far this was the mental plan of the air traffic controller, probably assisted by a safety net.

We were already climbing through FL178 when we were asked to maintain flight level 170 by the controller. Therefore we asked the controller whether he wanted us to descend back flight level 170 or level off flight level 180. Just one second later, our TCAS (traffic alert and collision avoidance system) provided a "climb" resolution advisory. As we could not maintain the required climb rate of 1500 ft/min during the turn, we needed to stop the turn on a heading of around 045 degrees in order to comply with our TCAS RA.

The controller now saw us tracking in a direction we had not been instructed to and climbing instead of levelling off as being asked to. His whole mental picture had been invalidated and his approach to solve the problem might not work anymore. I do not remember what the other traffic did, but several seconds later we eventually got a 'Clear of Conflict' and continued the flight uneventfully to our destination.

Regrettably, such conflicts can lead to disastrous outcomes like the mid-air collision overhead Überlingen in the late evening hours of 1st July 2002[1]. The air traffic controller then had a different way in mind how to solve the conflict than TCAS had, as happened to me. The difference is that we followed the TCAS RA.

Trying to find solutions how to prevent this potentially deadly confusion, two ways have been researched: One is to harmonise and synchronise the different safety nets, the other is to increase situational awareness of all involved parties. The second way, the increase of awareness, led to extensive research about possible ways of displaying TCAS RAs to controller working positions. There are ATC centres where such a display is already available, but there is a lack of worldwide standardisation on this feature and no harmonised procedures on the use of such alerts.

A major problem of this so called TCAS RA downlink, besides the legal liability question, is how to deal with a situation where a TCAS RA alert is displayed to the controller but compliance to an RA is not apparent on the radar screen. What would you do as a controller? Intervene and possibly create confusion by giving potentially contradictory instructions, knowing that this kind of confusion can be very dangerous? Or would you keep quiet and trust the pilots of both aircraft to follow their TCAS, risking a mid-air collision destroying both the aircraft involved? An answer to this question has not been found yet.

Looking at the first way of solving this problem of contradictory advisories from different safety nets, it seems to be a good idea to connect all these safety nets with each other to get just one resolution.

Unfortunately the solution is not that simple. As often in life, we sometimes have to accept that nothing is perfect and this is also true for safety nets. Be it STCA (short term conflict alert), ACAS (airborne collision avoidance system), RIMCAS (Runway Incursion Monitoring and Collision Avoidance System), MSAW (Minimum Safe Altitude Warning) or whatever tool you like to examine, none of these safety nets is perfect. All these systems have in common that they have their minor, little bugs. Fortunately, the basic design and parameters of complementary systems is often very different. The chances are small that a conflict that is, for example, not detected by TCAS due to a little bug in the TCAS logic is also not detected by STCA.

1- http://www.skybrary.aero/index.php/T154_/_B752,_en-route,_Uberlingen_Germany,_2002_(LOS_HF)

The same works the other way round, if STCA does not detect a conflict due to a little bug, TCAS will probably do so.

If you connect these two systems and harmonise the alerts, the risk arises that an alert may be suppressed when one of the systems does not detect a conflict. The safety achieved through several levels of conflict detection[2] can only be maintained if the various safety nets work independently of each other.

What needs to be done is to create an order of priority for the different systems and their alerts. aircraft systems already have such priorities. For example, a terrain avoidance alert will always take priority over a traffic alert. This is supported by ICAO provisions that an ACAS resolution advisory should not be followed in preference to terrain avoidance manoeuvre, a wind shear escape or a stall recovery occurring at the same time.

This prioritisation is already in place for the case of a controller trying to resolve a conflict when the ACAS provides solutions at the same time.

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ICAO clearly says that controllers shall not try to alter an aircraft flight path in the event of a TCAS RA until that aircraft reports clear of conflict. But again we end up with the situational awareness-problem stated above, as the air traffic controller needs to be aware of the TCAS RA before ceasing his own efforts to resolve a conflict. As pilots need - and are trained - to fly their aircraft first before making radio calls, the chances are high that controller awareness of a TCAS RA will be delayed. Even if the task sharing on the flight deck is at its best, frequency congestion can make it impossible to notify ATC promptly.

Looking at ground-based safety nets and the possibility of instructing a rejection of a take off the situation can get even more complicated. An aircraft may not be able to safely reject its take off once the indicated speed exceeds V1 (the highest speed at which a take-off can be rejected with the aircraft still able to guarantee stopping on the runway). Neither the safety net nor the controller knows what the V1 of any particular aircraft on any particular day is given that it is dependent on the weight of the aircraft, environmental factors and actual runway conditions.

In the event of a runway incursion at the far end of the take off runway, two alternatives may be considered by a pilot. Continue the take-off, rotating ahead of the incursion and passing overhead of the vehicle or rejecting the take off and stopping ahead of the obstruction. As noted above, neither the controller nor the safety net can take this decision and even for pilots, it can sometimes be hard to judge which is best. An option that is definitely worse is to instruct contradictory to the judgement of each other (i.e. instruct an abort while the pilots judge the go-case to be better).

It is a pity but at the end of this article hardly any answer to the questions raised can be given. The best options still need to be researched; procedures need to be designed accordingly. The good news is that on the ICAO-level, within SESAR as well as within other regions and organisations, research and development is in progress which may lead to action plans for implementation and ultimately to appropriate manuals. However, we must not repeat the same mistakes again that we have already done, building single and additional safety nets without looking at the overall picture.

First of all, a safety net does not automatically mean additional safety. Why? Because more and more alerts can on one hand reduce the attention of operational staff to single alerts, on the other hand possible nuisance alerts can draw attention away from urgent and useful alerts. A safety analysis of the whole system before and after the implementation of the new safety net is required. Further, a decision must be made how to proceed. Do we want to build drones with all the safety nets included but without pilots and possibly even without controllers, or do we still want ATC and aircraft being operated by human beings? In the latter case, I think it is a bad idea to place thousands of "safety robots" around the operational staff telling the human what to do. The less advice is sometimes best as long as all the humans involved are properly trained.

This task of harmonising safety nets and properly training operational staff would be a long and winding but could lead to better flight safety in the future. Extensive consideration of human factors and of technical limitations is necessary; all future users of these systems need to be on board. Lastly, there needs to be good trust of the newly designed and harmonised safety nets so that operational users do not hesitate to accept them.

Certainly challenging, but the destination seems tempting.

2- The Swiss Cheese Model: http://www.skybrary.aero/index.php/James_Reason_HF_Model