THE NEW KID ON THE BLOCK

by Stanislaw Drozdowski

We all probably remember from our schooldays the tension in our group of friends when, at the beginning of a new school year, we saw a new face in the class. We all had well-defined roles in our "gang" and with the new arrival we did not quite know what to expect, whether the new one might be stronger or maybe a better football player and thereby threaten our well-established roles.

We are all familiar with TCAS II[1], in fact the only kid on the block in the world of airborne collision avoidance. TCAS II has been with us for over 20 years and we are all familiar with its functions and operations. As much as we may dislike TCAS II for its shortcomings (like nuisance Resolution Advisories in level off situations), its role in ensuring safety and preventing mid-air collisions is well known. But now the status of TCAS II as the only airborne collision avoidance system in use will change with the forthcoming arrival of the new kid – ACAS X[2] which we can expect in the skies above us in less than five years from now.

First of all, the new system is intended to generate optimised Resolution Advisories (e.g. reduce the number of unwanted or nuisance advisories). Secondly, the design of ACAS X logic will provide the flexibility not afforded by TCAS II to adapt relatively easily to any future modes of separation or operations as well as to new sources of surveillance data. Finally, ACAS X will be a family of collision avoidance systems (see the adjacent text box) which, through modification of the baseline system, will enable its extension to new classes of airspace users such as RPAS and general aviation as well as to specific types of operations such as closely-spaced parallel approaches, where TCAS II produces nuisance RAs too often.

ACAS X VARIANTS

ACAS Xa – The general purpose ACAS X that makes active interrogations to detect intruders. ACAS Xa is the baseline system, the successor to TCAS II. The Standards are expected to be ready by 2018.

ACAS Xo – ACAS Xa extensions designed for particular operations, like closely spaced parallel approaches, for which ACAS Xa is less suitable because it might generate a large number of nuisance alerts. The Standards are also expected to ready by 2018.

ACAS Xu – Designed for Remotely Piloted Aircraft Systems (RPAS), incorporating horizontal resolution manoeuvres. Work on Standards will start in 2016.

ACAS Xp – A variant that is expected to solely rely on passive ADS-B data rather than active interrogation to track intruders. It is intended particularly for light aircraft that are not currently required to fit TCAS II. No schedule for the development of Standards yet.

What is ACAS X?

The US Federal Aviation Administration has been driving the development program of ACAS X since 2008. A decision was made to develop a new collision avoidance system to take advantage of recent advances in dynamic programming and other computer science techniques, which were not available when TCAS II was initially conceived over three decades ago.

The key difference between TCAS II and ACAS X is in the design of collision avoidance logic. TCAS II issues alerts against a potential threat on the basis of the time to the closest approach using a set of hard-coded rules.

Instead of using a set of rules, ACAS X will use alerting logic that is based upon a lookup table. The current state of the own aircraft in relation to a threat aircraft is used to look up the best course of action in the table, whilst also taking into account predefined safety and operational objectives.

The best course of action is the one with the lowest 'cost'. This 'cost' increases in the order 'do nothing', 'generate a TA', 'generate a simple RA' and 'generate a complex RA'. An RA is complex rather than simple if it results in reversals or intruder's altitude crossings, as such RAs are generally considered operationally undesirable because they are sometimes not

1- TCAS II ("tee-cas two") – Traffic alert and Collision Avoidance System, also referred to as ACAS II – Airborne Collision Avoidance System.
2- ACAS X – Airborne Collision Avoidance System. Pronounced "Ay-cas eks" rather than "Ay-cas ten"

followed correctly. ACAS X will use the same hardware (antennas and displays) as the current TCAS II system and the same range of RAs as in TCAS II version 7.1. Although the timing of alerts may change, it is expected that pilots and controllers will not perceive any change with the transition to the new system. ACAS X will be fully backwards-compatible with current TCAS II systems (e.g. using the same coordination protocols between two units).

Previously, it was assumed that ACAS III (or TCAS III) would be the successor to TCAS II. ACAS III was foreseen as also generating horizontal RAs. However, the idea of ACAS III has been abandoned and it is now highly unlikely to ever materialise – although horizontal avoiding manoeuvres are expected to be used in ACAS Xu.

Putting the new kid through the stress test

So what did we do at school with new kids? We tested their strength, speed or resilience in their new environment. We did not always know what kind of tests the new kids needed to be subjected to and so we invented new tests whilst getting acquainted with them.

It is a bit easier with ACAS X given that we have several years to prepare for its arrival and conduct testing. Currently, ACAS X logic is undergoing a process of optimisation during which the lookup tables are fine-tuned to address any undesirable results found during testing.

The data used for testing comprise of recorded real-life encounters and radar data as well as millions of computer-generated encounters.

What do we look at specifically? First of all, we need to make sure that ACAS X will perform satisfactorily in critical conflict geometries, those where without an airborne collision avoidance system there would be a high probability of a midair collision. We also need to make sure that there is no degradation of existing safety standards when using the new system.

Secondly, through comparison of a large number of encounters, the types, timings and numbers of RAs generated are analysed. The goal is reduce the number of nuisance or other operationally undesirable RAs whilst also ensuring that RAs are issued correctly and timely when needed. Moreover, we would like to confirm (as much as it is possible in the simulation environment) that ACAS X will not create new problems, e.g. it will not generate nuisance alerts in situations in which even TCAS II is not generating any alerts. To the surprise of ACAS X developers, early testing has shown that within the airspace of one major European ANSP, the number of alerts generated by ACAS X compared to those generated by TCAS II has shown a significant increase. However, this mainly happened in encounters where there was adequate horizontal spacing between the aircraft involved and, therefore, a low risk of collision.

Finally, testing is looking at the interoperability of ACAS X with TCAS II to make sure that the new kid will fit into today's world of collision avoidance. ACAS X will have to co-exist with TCAS II for many years (if not decades) to come. But whilst it is expected that after 2020, most newly-manufactured aircraft will leave the assembly lines already fitted with ACAS X, many existing aircraft will largely remain TCAS II-equipped even if some operators upgrade to ACAS X to benefit from the new functionalities offered by ACAS Xo.

Sometimes, testing produces results which present the developers with difficult choices. For example, it may be possible to achieve a reduction in one type of nuisance RA but this may then result in an increase in another type of unwanted RAs. How do we balance which is better and which is worse? In these cases, the developers seek advice from the pilot and controller communities through specially-established working groups made up of representatives from major and regional airlines, ANSPs and the professional bodies representing pilots and controllers.

When the development of ACAS X is complete, the regulators will need to be satisfied that its design is sound and that the results of testing are acceptable. While testing and the data used for tests covers a wide array of situations and airspace environments, it is inevitable that some unusual cases will not be covered – a new kid can always cause surprises. ACAS X will be closely watched when it arrives. One always needs to keep a careful eye on the new kid.

Lastly, you are probably curious as to why the new version of ACAS got the suffix X, rather than sequential III or perhaps IV. I am not sure myself why the term X was coined and whether there is any relation to X Factor or X Files, as some people speculate. Most likely, ACAS X, like any new kid on the block, wants to come surrounded by a bit of mystery.

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