

derived pair probabilities conditioned on encounters involving at least one

cargo airplane as well as the relevant TCAS risk reduction factors.

RISK REDUCTION FOR CARGO AIRPLANES

	Cargo/cargo	Cargo/GA	Cargo/passenger	Cargo/unspecified
Conditional pair probability	0.324	0.174	0.503	1.000
Risk—when cargo is <i>not</i> TCAS-equipped	1.000	1.000	0.092	0.544
Risk—when cargo is TCAS-equipped	0.023	0.092	0.023	0.035

The current risk to cargo airplanes when they are not TCAS equipped and passenger airplanes are equipped with TCAS II is 0.544 (as compared to the pre-TCAS baseline situation when no airplane was TCAS-equipped). This risk reduction occurs because the equipage of passenger airplanes with TCAS II has already reduced the risk to cargo airplanes. Even though the cargo airplanes are not equipped with TCAS II, the passenger airplanes can see the cargo airplanes on their cockpit displays. This reduces the risk to both passenger and cargo airplanes.

If cargo airplanes were to be TCAS II equipped, this remaining relative risk would drop to 0.035 (as compared to the pre-TCAS baseline situation when no airplane was TCAS-equipped). This results in a comparative risk ratio of $0.035/0.544=0.064$, which roughly corresponds to a 94 percent reduction ($0.544 - 0.035 = .509$) compared to the present risk. In other words, cargo airplanes could experience a reduction in their NMAC risk by about 94 percent as compared to the current risk by installing TCAS II.

Risk Reduction—Passenger Airplane Perspective

For passenger airplanes that already have TCAS II, the perspective is considerably different because the cargo airplanes would represent only a small portion of their potential close encounter traffic. The following table (Table 4–12 in the MITRE study) shows the MITRE derived pair probabilities conditioned on encounters involving at least one passenger airplane as well as the relevant TCAS risk reduction factors.

RISK REDUCTION FOR PASSENGER AIRPLANES

	Passenger/c	Passenger/	Passenger/p	Passenger/u
Conditional pair probability	0.076	0.281	0.643	1.000
Risk—when cargo is not TCAS-equipped	0.092	0.092	0.023	0.070
Risk—when cargo is <i>not</i> TCAS-equipped	0.023	0.092	0.023	0.058

Combining these risks in a weighted manner according to the conditional pair probabilities shown in the first row of the above table, the risk to passenger airplanes when cargo airplanes are not TCAS-equipped is reduced by 93 percent to 0.070 (as compared to the pre-TCAS baseline situation when no airplane was TCAS-equipped). If cargo airplanes were to be TCAS-equipped this relative risk would drop to 0.058 (as compared to the pre-TCAS baseline situation when no airplane was TCAS-equipped). This corresponds to a Risk Ratio of $0.058/0.070=0.828$, which roughly corresponds to a 17 percent reduction ($0.070 - 0.058 = 0.012$) compared to the current risk to passenger airplanes.

The small proportion of encounters involving one passenger and one cargo airplane means that equipping cargo airplanes with TCAS would only reduce the risk to the passenger airplanes by another one percent (reducing the 0.070 risk by 17 percent) beyond the 93 percent already enjoyed through their TCAS equipage. Therefore, the total risk reduction for passenger airplanes from the installation of TCAS II on both passenger and cargo airplanes would be

approximately 94%. Coincidentally, this is the same reduction as the risk reduction to cargo aircraft going to TCAS from no TCAS protection. This should be kept in mind to avoid confusion in understanding the following analyses.

Post-TCAS II On Cargo Airplanes Accident Rates

Without TCAS II on all-cargo airplanes, the approximated MAC rate adopted in the previous section, for this analysis, was 0.5 MACs per 20-year period for all-cargo airplanes. The above analysis indicated that the installation of TCAS II on all-cargo airplanes will reduce the risk of all-cargo airplane NMACs by 94 percent. This will reduce the MAC rate for all-cargo airplanes to 0.06×0.5 or 0.03 per 20-year period.

If this rule were implemented, MITRE estimates that passenger airplanes will experience approximately a 17 percent risk reduction, or the risk factor for passenger airplanes will be reduced from 0.07 to 0.058.

One way to make these probabilities more meaningful is through the use of a Poisson probability distribution, a statistical tool often employed to describe rare events. If the factors for

cargo airplane midair collisions (0.5 for the cargo fleet without TCAS and 0.03 for the cargo fleet with TCAS) are assumed to be the mean values of the Poisson probability distribution, then those distributions imply that in the absence of this rule there will be a 40 percent chance that one or more midair collisions involving a cargo airplane will occur in the U.S. airspace within the next 20 years. On the other hand, this rule will reduce that likelihood of a midair collision involving cargo airplanes to a 1 percent chance.

If this rule were implemented, MITRE estimates that passenger airplanes will experience approximately a 17 percent risk reduction, or the risk factor for passenger airplanes will be reduced from 0.07 to 0.058. This small reduction in the risk of a passenger and cargo airplane colliding is a direct result of passenger airplanes already being equipped with collision avoidance systems (TCAS II) and because the cargo fleet is much smaller than the passenger fleet. None-the-less, a real reduction in the risk to passenger airplanes occurs when cargo airplanes are equipped with collision avoidance systems.