In a time of rapidly growing air traffic density, the interaction between man and technology grows increasingly complex. More and more information poses an increasing challenge to man, by making it more difficult to distinguish between important and unimportant information. This leads to a new requirement for information processing, the development of evaluation methods capable of weighing from situation to situation, whether a piece of information is of value or distracting.

Safety alert !

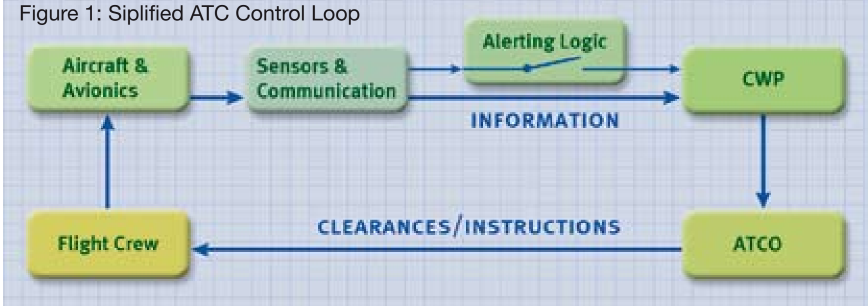


Figure 1: Siplified ATC Control Loop

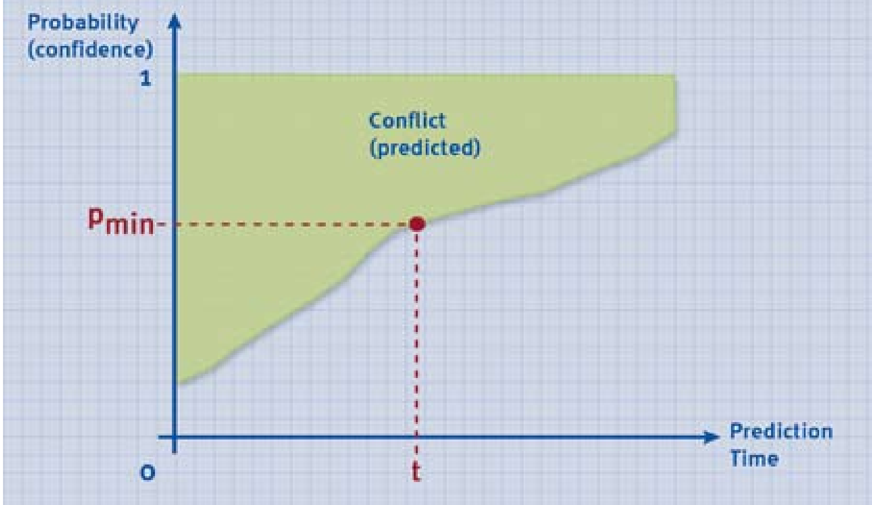


Figure 2: Probability Threshold vs. Prediction Time

Ground Based Safety Nets are the air traffic controller's attentive supporters, which mostly do their work unnoticeable in the background. Completely independent of the flight controllers, they assess the air situation in order to find or pre-anticipate potential infringements of safety thresholds. When such a situation is detected, the Safety Net function prompts a respective warning message to the air traffic controller, containing information about the aircraft involved, as well as additional data about the time and type of the threat.

Ground Based Safety Nets use real-time surveillance data as well as auxiliary flight plan information. Based on these data as well as underlying information about the air space under surveillance, the Ground Based Safety Nets perform predictions for aircraft movement and rate the resulting situation with respect to potential safety risks. Depending on an integrated decision logic, the Safety Net Functions notify the air traffic controller about such situations.

As automatic data processing system, Ground Based Safety Nets possess the required systematic and consequence to evaluate all aircraft movements, never neglecting a situation. Ground Based Safety Nets are not subject to human weakness, such as distraction, fatigue or misassumptions. Thus, the principal value of Ground Based Safety Nets is indisputable.

The Ground Based Safety Nets' greatest strength, the consistent processing and evaluation of flight situations based on measured values – however – is also their greatest weakness. They as a basic rule give a warning in all situations which, based on the factual data, result in the endangerment of flight safety, even if measures have already been implemented to eliminate

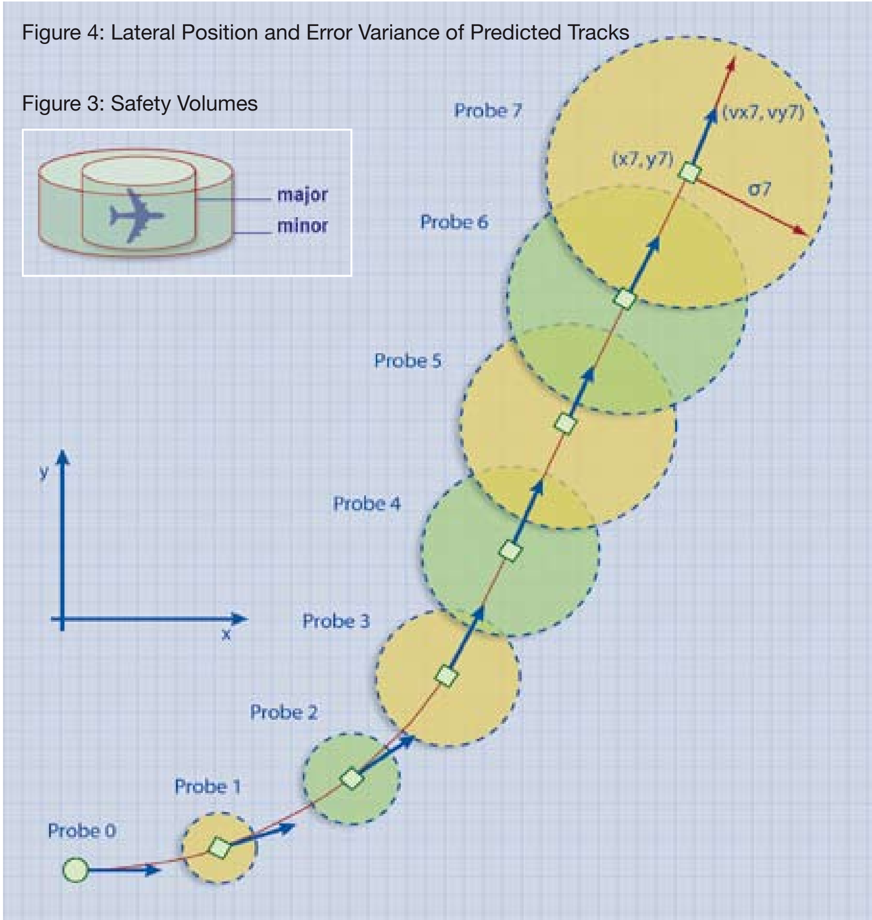


Figure 4: Lateral Position and Error Variance of Predicted Tracks

Figure 3: Safety Volumes

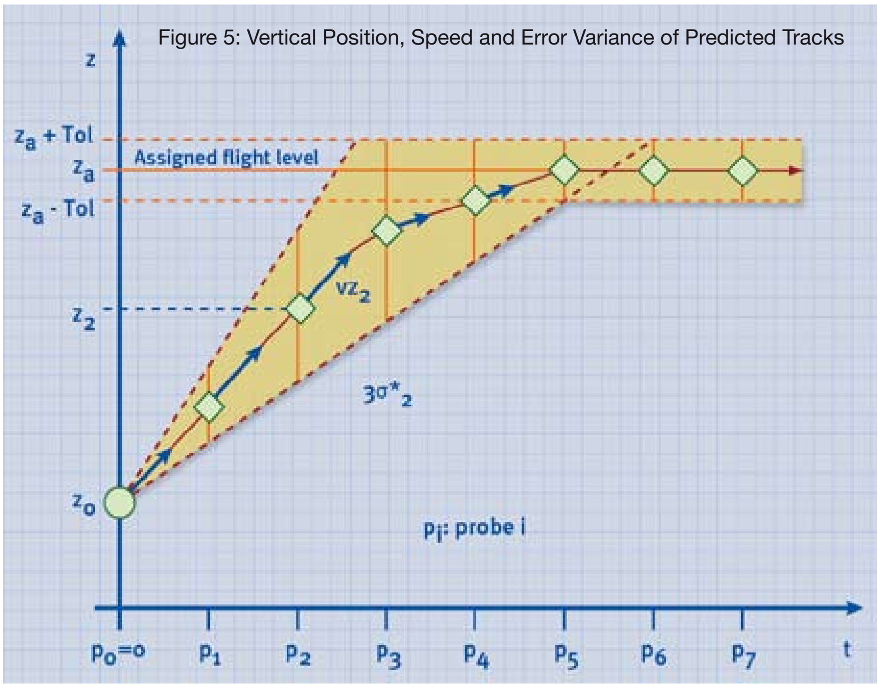
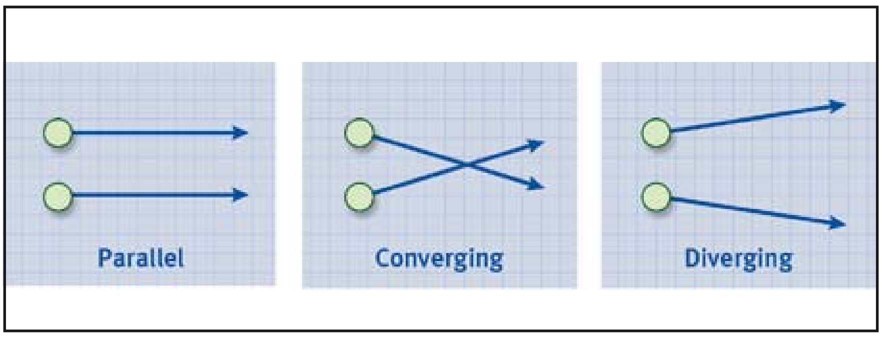


Figure 5: Vertical Position, Speed and Error Variance of Predicted Tracks



the potential risk. These types of warnings are often perceived as a nuisance by air traffic controllers, and can in a more serious case even lead to distractions. Frequent warnings of this type may, possibly, lead to the flight controller's desensitization, resulting in ignorance of or delayed registration of critical warnings. The ratio between desirable and nuisance warnings is thus of crucial relevance when it comes to the effective realisation of Ground Based Safety Nets . Recent projects involving Safety Nets have shown evidence of this problem in the realisation phase. As early as during the initial hazard assessment stage it became clear that the rate of nuisance alerts is perceived by users just as critically as when an alarm is actually triggered during a critical situation. The objective of achieving quantified safety according to ESARR, is often hampered by having to determine a quantified value as a requirement, due to the fact that what is considered a nuisance alert is oftentimes a subjective evaluation.

Almost all Ground based Safety Net realisations thus implement heuristics to optimise the “nuisance” warning rates, without suppressing desirable alarms. What is considered as optimal depends on a multitude of factors relative to the environment. Accuracy and update rate of sensors are taken into account as much as the performance of a Multi-Sensor Surveillance Data Processing System. Moreover, information about measures introduced (CFL, assigned heading, etc) can improve the quality perception of Ground Based Safety Nets.

In COMSOFT's implementation method, this is modellised using stochastic means. It is based on the conclusion that desirability and urgency of a warning are correlated, since a fundamental factor for a safety alert is the pre-warning time for a safety critical situation. There must be sufficient pre-warning time to allow the traffic controller to introduce measures ensuring flight safety and have these put into action by the pilots.

The advantage drawn from a stochastic modelling allows us to correlate the probability of the arrival of a safety critical situation with the corresponding urgency. The urgency is thus depicted as a function of the prediction time. The concept realised in this way can be verbalised as follows: The more probable a safety-critical situation, the sooner it is reported in form of a message. Contrariwise, this signifies that the higher the reversibility of a safety critical event, the more likely that a warning will be deferred.

This type of modelling makes it possible to integrate the uncertainty of a prediction directly into the decision process whether alerts are reported or not. Information from modern Surveillance Data Processing Systems about track quality and accuracy achieved can thus be taken into account as much as manoeuvre attributes. In principle, also here it must be considered that the prediction window is limited to a few minutes, as the uncertainty of the prediction increases as the projection range grows.

The modelling scheme using a stochastic approach can be applied to all predictive Safety Net Functions. The advantage herein lies in the fact, that safety of air traffic is achieved by the definition of spatial discrimination. This can be incorporated into a model by means of drawing a direct comparison from a positional prediction and probability of finding.

For Short Term Conflict Alerts, as an example, the separation between aircraft signifies a measure for security. Which distance values are chosen within the Safety Net Function defines the extent between a collision avoidance and separation assurance. To what extent the system is used operationally, is the subject of an operational assessment in this case.

The separation is now compared with the predicted position and its uncertainty. Although lateral and vertical predictions are considered independently, however, they result in a combined probability. The penetration of the protected volume defined by the separation as well as the volume of the probability of location constitutes thus a measure for the probability of the conflict event. Consequently the Safety Net functions assess the positional accuracy for lateral and vertical predictions taking into account available information.

In well-tuned Safety Nets, aside from the probability of appearance of a conflict, the geometry of a conflict also plays a decisive role in the classification of a potential conflict message. The Short Term Conflict Alert hereby distinguishes three distinct cases.

The respective classification is consulted during the generation of an alarm message and determines, together with the infringement of major and minor separation values, the criticality of an alarm. As a result, the air traffic controller can receive warnings with different severity levels.

An advantage of this type of modelling using probabilistic assessment methods for Ground Based Safety Nets is that by defining degenerated confidence levels for the prediction both, traditional modelling as well as heuristics can be integrated. Thus, the Ground based Safety Net is able to implement conventional prediction for the generation of safety alerts.

This applies particularly to proven heuristics that will prevent nuisance alerts in certain areas. Moreover, heuristics can be assessed as to their usability and integrated into the model with according weight. This allows a gradual migration of known processes and systems up to safety nets which can be adapted to various circumstances and operational requirements. ■