SCHOOL OF AVIATION
Lund University

Cleared to land?

- An overview of the problem Runway Incursions -

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A paper written by Mikael Gadenius and Nichlas Rudenäs

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ABSTRACT

"... Both aircraft broke up, skidded to the right of the active runway, and impacted an airport baggage hangar, which partially collapsed. ...".[1] Operating an aircraft on the ground may be a risky business. The most serious threat is when an unauthorized aircraft, vehicle, or pedestrian enters an active runway, which in the worst case results in a collision. These types of incidents/accidents are referred to as Runway Incursions.

The purpose of this study was to compile an overview of the subject Runway Incursions and to present and discuss the solutions utilized today and those that will be implemented in the future. We have gathered material (articles from electronic and paper sources) and also been in contact with representatives of the aviation community to get first hand information. Our key question has been:

- How can runway incursions accidents and incidents happen and what has been done to prevent and minimize future incidents/accidents?

All runway incursions can be linked to human error and the awareness about the problem has to be increased among all involved. Both technical and non-technical solutions are utilized to assist the human being in eliminating potential causes but much more can be done. Europe has been left behind in their efforts to prevent runway incursions in comparison with USA. A fundamental concern in both regions is the lack of proper reporting systems. The problem with runway incursions has definitely not gone unnoticed and during years to come the aviation community will have a reduction of incidents as a prioritized issue.

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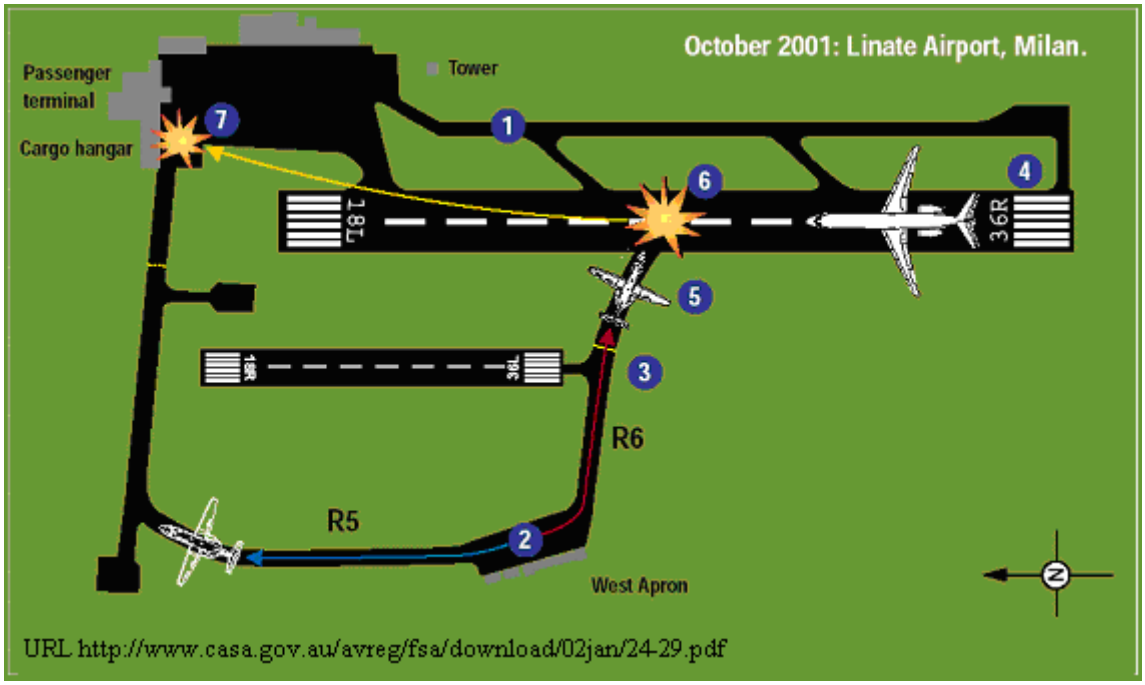
1 INTRODUCTION



"Scandinavian SK686, on a flight from Milan to Copenhagen, was cleared to taxi to Runway 36R for departure. At approximately the same time, a German Cessna Citation II business jet (D-IEVX), was cleared to taxi from the General Aviation ramp via taxiway Romeo 5. The Citation mistakenly entered taxiway Romeo 6, entered runway 36R, and at that point was impacted by SK686 which had been cleared for takeoff. Both aircraft broke up, skidded to the right of the active runway, and impacted an airport baggage hangar, which partially collapsed. Weather at the time of the accident was reported as "heavy fog" with a Runway 36R RVR (runway visual range) of 225 meters." [1]

With all respect to those who lost their lives at Linate.

Today the sophisticated systems which guides an airplane safely from point A to point B in the air, makes the airborne operation the easy part of the entire flight. Warning systems for track deviation and air proximity warns the pilot and can also present the correct actions to be taken. Operating an aircraft on the ground, especially in low visibility situations in combination with darkness and at an unfamiliar airport make every movement on the maneuvering area a risky business. No pilot interpreted warning system, solely for ground movement and surveillance, exists for the time being. The warnings during ground operation usually come from the controller in the tower, often with no other information at their hands than what their own eyes can see. Safety experts are concerned that the time an aircraft spends on the ground is becoming the most hazardous part of any flight.[2]

The most serious threat is when an aircraft, vehicle, or pedestrian enters an active runway, which results in a loss of separation, or even worse, a collision. These types of incidents/accidents are referred to as Runway Incursions and have become one of the most highlighted issues in civil aviation today. The situation at major airports today is highly complex and a taxiing ”road system” with confusing traffic lights and signs that sometimes are difficult to interpret.

Picture 1.1 - Busy day at an airport *(copyright Andrew Hunt, www.airliners.net)*

The traffic at an airport gets quite heavy at times, human errors are inevitable and the margin for those is close to zero. No single entity “owns” runway incursions and no single entity owns the cure. Incursions happen because a variety of people (pilots, controllers, and vehicle drivers) occasionally make mistakes. For this reason incursions are everyone’s problem and everyone, at every level the problem touches, must participate in forming the solution prologue.[3]

1.1 DEFINITIONS

Since this paper is intended mainly for persons with insight in the profession of flying it is recommended and foreseen that the reader has a basic knowledge of flight related terminology. However, dealing with the subject of and around runway incursions it is important to have an understanding of the terminology used for these types of incidents/accidents.

In this paper we will utilize the terminology used by the Federal Aviation Administration (FAA), the United States aviation authority. The FAA defines a Runway Incursion as: "Any occurrence at an airport involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in a loss of separation with an aircraft taking off, intending to take off, landing or intending to land."

In Europe the definition is almost similar, stated by the European organization for safety of air navigation (Eurocontrol): "Any unauthorized presence on a runway of an aircraft, vehicle, person or object that creates a collision hazard or results in a potential loss of separation."

The main difference between the FAA definition and the Eurocontrol definition is as follows: For the FAA definition, there is a loss of separation (or hazard) between an aircraft and another aircraft, vehicle, person or object, whereas for the Eurocontrol definition, there could be a situation classified as a runway incursion even if there is no loss of separation or no hazards; for example a vehicle on runway that did not have a clearance to enter that runway and there were no other aircraft around.[4]

1.2 OPERATIONAL CATEGORIES OF RUNWAY INCURSIONS

Runway incursions are divided into the following operational categories by both FAA and Eurocontrol:

- An Operational error is when an air traffic controller inappropriately clears an aircraft or vehicle into a situation that results in a collision hazard.
- A Pilot deviation is when a pilot moves an aircraft into a position, without air traffic control approval, that leads to a loss of separation.
- A Vehicle/pedestrian deviation is one where a vehicle or individual enters a runway without air traffic control approval that leads to a collision hazard.

1.3 SEVERITY CLASSIFICATION

An aircraft that stops with its nose wheel 0.5 meters (1,6 feet) over the runway hold-line is classed as committing an incursion, but so is an incident in which two aircraft narrowly miss each other in the middle third of a runway where their momentum is highest and the potential for a disastrous accident is greatest.[5] Therefore the FAA has classified the severity of runway incursions into four classes, A to D:[8]

- **Category A:** Separation decreases and participants take extreme action to narrowly avoid a collision, or the event results in a collision.

These runway incursions are typified by: the immediate need for corrective action by ATC and/or evasive action by a flight crew, or the lack of corrective/evasive action. The collision either occurs or is narrowly avoided by chance. These runway incursions are characterized by events, with at least one aircraft traveling at a high speed or speed sufficient to cause substantial damage with the potential for injury or fatalities.

- **Category B:** Separation decreases and there is a significant potential for a collision.

Level B events are characterized by the need for a time-critical corrective/evasive action that was, or could have been, taken by ATC or the flight crew. These situations are typified by critical errors, which under different circumstances or aircraft performance or the timing of ATC clearances or instructions, could have lead to a barely avoided collision.

- **Category C:** Separation decreases, but there is ample time and distance to avoid a potential collision.

In cases where no corrective action was taken, the collision risk is reduced by a significant level based on available time, distance margin, and aircraft performance. These situations are typified by critical errors, which under different circumstances of aircraft performance, or the timing of ATC clearances or instructions, could have lead to a higher potential for collision. Participants in these incidents usually do not come in close proximity at high speed.

- **Category D:** Little or no chance of collision, but meets the definition of a runway incursion.

2 PURPOSE

The serious and tragic accident described in the introduction took place on the 8th of October 2001; at Linate Airport, Milan, Italy and resulted in the loss of 118 souls. In the USA an increased amount of Runway Incursions has been reported between the years 1993 and 2000. This has raised many questions. How can accidents and incidents like this happen and what has been done in the world of aviation to prevent Runway Incursions incidents in the future? Is there a single solution to this type of problem or is it a chain of events that coincide? Can the problem be solved with technical inventions or is the key improved situational awareness among all involved parties?

Our purpose is to investigate and compile an overview about the problems surrounding the subject Runway Incursions and to discuss the solutions utilized today and those that will be implemented in the future. We will also review and assess these solutions.

3 METHOD

We will present a study mainly based on material found, and in articles published in elctronic and paper publications. The study will also contain a questionnaire (see section 4.7 and appendix 1), sent to organizations and companies (see appendix 2) which we considered to be important actors in European aviation. This will help us in getting first hand information on what measurements airlines, airports (ATC-units), and national authorities in Europe are taking to avert incursions but also to find out how cooperative these actors are regarding information sharing on this issue.

3.1 LIMITATIONS

The underlying work of this paper is limited to a study of articles and literature and a compilation of answers from our questionnaire. We decided on a send list limitation for our questionnaire to a total of twenty-five companies/organizations, ten to airlines well-known to us, ten to airports with high traffic capacity (e.g. crossing runways), and five to national aviation authorities in close proximity to Sweden. The main factor regulating the limitations and magnitude of this study is time available for this work.

4 RESULT

After an increasing trend of runway incursions during the last decade, according to FAA, the aviation authorities in the United States and Europe have started campaigns to prevent further incidents of this type.

4.1 FACTS

What are the main contributing factors causing runway incursions? In fact, there aren't even a handful of causes to target; there are a myriad of causes. From an analytical perspective, incursions can be considered to be almost random events – a product of a continuing interactions of numerous factors and thus essentially immune to single solutions. The only thing all incursions have in common is the fact that they are the end product of human error.[3]

This makes the effort to prevent incursions very complex. The multitude of possible causes is impossible to cover but they interact to create an ever-changing stage where the lowest common denominator is the human operator. Among contributing factors are radio phraseology, cryptic airport signs and markings; weather and visibility; language proficiency; and pilots, controllers, vehicle drivers all with differing levels of experience.

Controllers issue clearances, instructions, and advisories to pilots who operate their aircraft on the aprons, taxiways, and runways. Pilots navigate using paper charts of the airport layout; they look out of the cockpit window for surface taxiway/runway signs, markings, and lighting to provide orientation and situational awareness in order to follow the route issued by the controller.[3]

Controllers monitor surface traffic primarily by looking out of the tower window to determine the identity, location, and movement of aircraft on the taxiways and runways. For pilots and controllers, human vision provides the principle means of maintaining situational awareness and separation.[3]

4.2 USA

The FAA has taken strong measures against runway incursions. Reducing human error associated with runway incursions is an extensive task because so many people are involved. In the United States alone there are more than 600,000 certified pilots, 8,000 airport tower controllers and hundreds of thousands of airport personnel. Therefore it is an assignment that demands great resources to reach out with proper information to each and everyone concerned.

Between the years of 1993 and 2000, the number of runway incursions increased steadily from 186 to the peak value of 431 per year in 2000. That is an increase of 132 percent.[6]

One must take into consideration that during the peak year of 2000 there where over 67 million tower operations (take-offs and landings) at FAA tower controlled airports. This gives an incursion rate of about 155,000 operations per reported incident. Divided into the three types, described earlier, the statistic was as follows (presented in diagram 5.4.1, section 5.4):[6]

- Operational errors and vehicle/pedestrian deviations each represented 20 percent.
- Pilot deviations represented 60 percent.
- General aviation pilots committed 76 percent of the pilot deviations.
- The most hazardous incursions – category A and B – accounted for 16 percent of all incursions during the year 2000.

Since October 1999, the FAA has made a substantial effort to focus on runway incursion problems.[6] FAA established the Runway Safety Program Office (RSP) dedicated solely to reducing the number of incursions.

The RSP sought to expand the upgraded data-collection effort begun in 1997 to try to better understand causal chains that create incursions. Office of Runway Safety director Bill Davies says: "detailed data on incursion causal chains is needed so the FAA can take pre-emptive action to break each incursion-event chain before it can lead to an accident."[5]

The FAA has compiled the following statistics concerning runway incursions:[7]

- Weather is ***not*** a factor in 89 percent of runway incursions
- Pilots taxiing onto runways or taxiways without clearance accounted for 62 percent of cases
- Pilots landing or departing without clearance accounted for 23 percent of cases
- Pilots landing on wrong runway accounted for 10 percent of cases
- Pilot distractions accounted for 17 percent of cases
- Pilot disorientation or lost during 12 percent of cases
- Pilots not being familiar with ATC procedures or language accounted for 22 percent of cases
- Pilots not familiar with the airport accounted for 19 percent of cases
- General aviation aircraft are involved in 69 percent of all runway incursion cases
- Low time pilots (less than 100 hours) account for 32 percent of all runway incursions
- High time pilots (greater than 3000 hours) account for 10 percent of all cases
- The top five aircraft involved in runway incursions were all single engine general aviation airplanes

No information was found regarding what year or which years these statistics derive from but the statistics concludes that most of the incursions are caused by piloting error and that general aviation is a group to target with campaigns. A fact to consider is that weather does not play part in a majority of incursions. A description of the term "pilot distractions" is not to be found.

After numerous workshops and symposiums, which involved representatives from all segments of aviation, the RSP identified and outlined sixty potential initiatives grouped into seven major categories they chose to call thrusts. These thrusts are: Training; Technology; Communications; Procedures; Signs/Markings/Lighting; Data, Analysis, and Metrics; and Local Solutions.[3] The seven thrusts are published in a document called the Runway Safety Blueprint. It defines the strategy and prioritizes the efforts from the FAA to reduce runway incursions.

Eight goals have been established for the improvement of airport surface safety:[8]

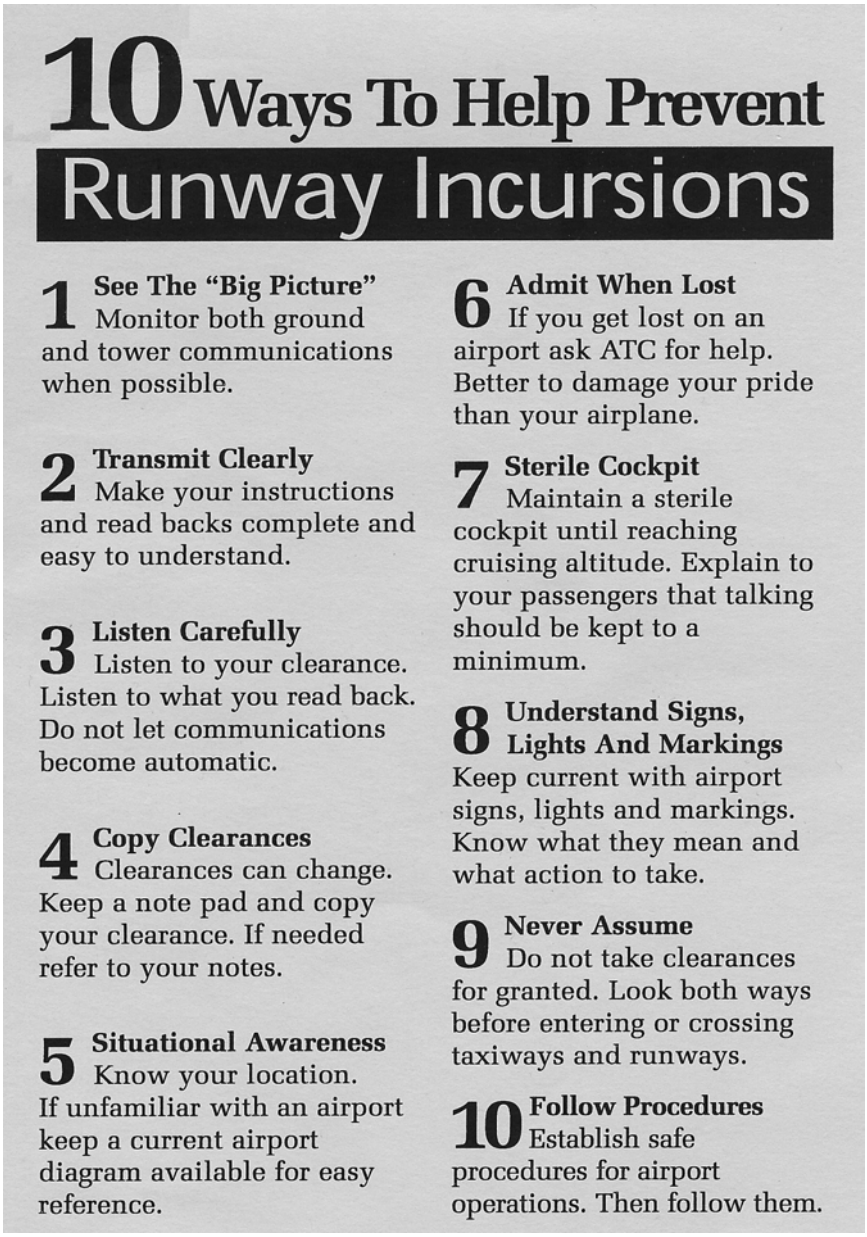
1. Develop and distribute runway safety education and training materials to controllers, pilots and all other airport users.
2. Increase surface safety awareness throughout the aviation community.
3. Assess and modify procedures to enhance runway safety.
4. Improve runway safety data-collection, analysis, and dissemination.
5. Identify and implement enhancements to improve surface communications.
6. Increase situational awareness on the airport surface.
7. Support and deploy new technologies that reduce the potential for collision.
8. Implement site-specific runway safety solutions in coordination with local aviation communities.

During the last years a lot of work has been done in striving towards these goals. During 2002 the Runway Safety Program Office distributed 250,000 items of program materials. These included memory-aids cards on runway and taxiway signage and markings, folders with helpful hints (se picture 4.2.1), training videotapes in English and Spanish, and posters – the last two items featuring film star Harrison Ford, an experienced pilot and the FAA's celebrity advocate for the runway safety program.[5] Furthermore, the RSP made accomplishments in for example:[8]

- The Runway Safety Program web site (http://www.faa.gov/runwaysafety) where more than 1.4 million hits were recorded that represent over 91,000 unique visits.
- Enhanced operational tower controller training.
- Conducted pilot/controller communications phraseology reviews.
- Establishing revised airport markings for hold short lines.
- Published human factors and runway safety booklet "Runway Safety: It's Everybody's Business" (http://www.faarsp.org/humanelement/handbook.pdf).
- Conducted runway incursion prevention seminaries for pilots and aircraft mechanics – conducted 1,467 safety meetings with a total attendance of 104,160.

Finally the efforts were making a change in the statistics. During year 2001 over 65 million tower operations were conducted. Even though that is a 3.3 percent reduction from 2000 there was an even bigger decrease in number of incursions to 383 (equivalent to ~12 percent). This is a decrease to one incursion per 170,000 operations, during 2001. More importantly, the number of the category A and B runway incursions decreased to 14 percent compared to 16 percent of all incursions in year 2000. This was an important step in the right direction.

During the first five months of 2002 the numbers were decreasing even more, showing every sign of a slowdown. Only 119 incursions until June suggested that 2002 could emerge with fewer than 350 incursions.[5] Unfortunately no complete statistic for 2002 was available when this paper was written.



10 Ways To Help Prevent Runway Incursions

1 See The "Big Picture" Monitor both ground and tower communications when possible.

2 Transmit Clearly Make your instructions and read backs complete and easy to understand.

3 Listen Carefully Listen to your clearance. Listen to what you read back. Do not let communications become automatic.

4 Copy Clearances Clearances can change. Keep a note pad and copy your clearance. If needed refer to your notes.

5 Situational Awareness Know your location. If unfamiliar with an airport keep a current airport diagram available for easy reference.

6 Admit When Lost If you get lost on an airport ask ATC for help. Better to damage your pride than your airplane.

7 Sterile Cockpit Maintain a sterile cockpit until reaching cruising altitude. Explain to your passengers that talking should be kept to a minimum.

8 Understand Signs, Lights And Markings Keep current with airport signs, lights and markings. Know what they mean and what action to take.

9 Never Assume Do not take clearances for granted. Look both ways before entering or crossing taxiways and runways.

10 Follow Procedures Establish safe procedures for airport operations. Then follow them.

Picture 4.2.1 - An example of the items distributed by the Runway Safety Program Office. Collected at Shannon Airport, Fredericksburg, Va, USA.

4.3 EUROPE

It is a fact that Europe has been left behind in the struggle against runway incursions in comparison with USA, but on the other hand the issue has not been that evident in Europe. During 1999 the Eurocontrol member states collectively reported just 48 runway incursions[9] but the number of operations did not appear in the statistics. It is evidently almost impossible to gather current and trustworthy statistics from the European aviation authorities.

In July 2001, ironically three months before the tragic accident at Linate Airport, Eurocontrol set up a Task Force drawn from the Joint Aviation Authorities (JAA), International Civil Aviation Organization (ICAO), Group of Aerodrome Safety Regulators (GASR), numerous of other professional organizations, air navigation service providers and airlines.[10]

The problem with runway incursions has now clearly been given a lot of attention. It is now included as a major safety issue along with air proximity and altitude penetration. However, even given raised awareness now, issues remain:

- The potential lack of data and reluctance to share safety information;
- The absence of a harmonized and consistent approach for analyzing the data;
- The difficulty to understand causal and contributory factors;

Safety Regulation Unit head Peter Stastny says: *"States treat safety data very much as a national issue. They might have a reporting system, but be reluctant to let the summaries go."* Therefore there is little data available on runway incursion incidents, but available evidence suggests that the threat is just as great as in the USA.[9] The only statistics found were from Eurocontrol and briefly presented types and classification of runway incursions committed (see diagram 5.4.1, section 5.4):[10]

- Operational errors accounted for 1 percent
- Vehicle/pedestrian errors accounted for 38 percent
- Pilot deviation accounted for 61 percent
- Category A and B represented 35 percent of the reported incursions
- Twenty percent involved General Aviation

No information available regarding what year or which years these statistics derive from.

To create a picture of the situation, Eurocontrol carried out a survey involving over 2000 inquiries. Nearly 95 percent of them were aimed for pilots. One-quarter of respondents claimed to have seen or been involved in a runway incursion in the previous two years – and 46 percent of those considered the potential for collision to have been big. The most prevalent contributory factors, they reported, where problems in radio phraseology and language proficiency, airport layout and guidance, and air traffic control procedures. Other factors mentioned were weather and visibility and the pilots' own experience. More than half did not know whether their primary airport had a specific runway safety-reporting scheme. Of the remainder, one-third stated that no such scheme existed.[9] (How many European airports that actually have this scheme has not been found). This survey and conclusions from Task Force workshops reconfirmed that runway safety is an issue in Europe and that improvements in this field are absolutely necessary and that European airports shall establish a runway safety program. The airports are to be supported with the following:[11]

- Develop Awareness Material,
    - General awareness for the aviation community (leaflet and poster).
    - Dedicated awareness for controllers, pilots and drivers.
- Recommendations for specific local awareness actions
    - Initial guidance: improvement to the material initially developed for the survey purpose (based on FAA process).
    - Additional guidance: Supporting its implementation and supporting the identification of causal factors.
    - Means for data exchange: Allowing safety data exchange and lesson dissemination. Improve both the quality of runway occurrence data, and the collection and exchange process.

Some major airports throughout Europe, such as Amsterdam Schiphol and Paris Charles De Gaulle, are already implementing procedures and technologies to create a safer ground operation.[12,13] Actions taken are improved guidance and markings, advanced ground surveillance e.g. ASDE-3 (will be described in section 4.6.1), and specific taxi instructions.

4.4 DIFFERENCES BETWEEN USA AND EUROPE

As noticed, there are differences on how both regions (FAA and Eurocontrol) handle the runway incursion issue. Avoiding collisions between airliners is the issue in Europe, rather than between an airliner and small aircraft as in the USA.[9] In USA, with the large quantity of general aviation, the FAA has decided to make this everyone's problem. Eurocontrol on the other hand tend to keeps this at a much more administrative level and do not reach out to the involved parties as powerful as the FAA. Earlier the focus has been on airprox and altitude penetration probably because runway incursions have not been a highlighted issue until recent years. One explanation could be that general aviation is not as widespread in Europe as it is in USA. General aviation does not commit all runway incursions, but facts show that they are involved in the majority of reported incidents according to FAA statistics. The number of incidents reported to Eurocontrol has been few, despite that Eurocontrol's definition is stricter than the FAA's, and thus probably causing the organization to believe the problem was not that imminent. It is obvious that the traffic volume in Europe is smaller than in the USA. Of the fifty airports in either region which have over 300,000 yearly aircraft movements, only about 20 percent are European.[9]

4.5 NON-TECHNICAL SOLUTIONS

As stated in section 4.1 Facts, the only thing all incursions have in common is that they are the end product of human error. Improvements to prevent future incursions are to work with solutions directly addressed to the operator without any technical interface. Not only preventive actions must be taken. It is also important to design and utilize a proper reporting system in order to identify which preventive actions to be taken. Efforts must be made with respects to different problems at different airports. Strategic measures suitable for one location might make little difference at another.[9]

4.5.1 SITUATIONAL AWARENESS

Aviation authorities are working on increasing the situational awareness among involved parties. Situational awareness seems to be one of the major keys to create a safer ground operation. One way of improvement is for everyone to have a humble attitude towards the problem and to understand the importance of a correct behavior. This may be achieved by regular training and education.

4.5.2 SIGNS & MARKINGS

A uniform system for airport signs and markings is of great importance to ease the ground operation. Is the sign before or after the taxiway? Especially direction signs (yellow with black figures) must be standardized and have their location either before or after an intersection to show which taxiway it is directing to. This is not the case today with different standards at different airports.

4.5.3 COMMUNICATION

Radio phraseology and language proficiency is mentioned as one of the most common causes for runway incursions. Misunderstandings are common. In many situations there is a possibility to interpret messages on the basis of the receivers own values and experiences. A standardized language is already utilized but all ambiguities must be minimized. In USA, the Runway Safety Office is conducting reviews of pilot and controller phraseology to try to generate a standard set of instructions and wording to prevent misunderstandings, particularly where foreign pilots and non-professional general aviation pilots are concerned.[5]

4.5.4 REPORTING SYSTEM

Diligent and complete reporting of minor and major runway incursions, and the consistent collection of critical runway safety parameters, is vital for identifying underlying causes and contributing factors. The FAA has placed a greater emphasis on reporting runway incursions in recent years. By implementing initiatives as education and training programs, a heightened awareness of runway safety has most likely translated into more frequent reports of runway incursions that were minor in severity and may have previously gone unreported. In USA the need is for better information, not necessarily more of it. In Europe on the other hand more information is needed. To improve matters Eurocontrol has been gathering information on Air Traffic Management (ATM) related incidents, including runway incursions since 1999 under a

project linked with the development of a harmonized incident-reporting database – a project known as the Tool Kit for ATM Occurrence Investigation (TOKAI).[9] Steps that should be taken to improve the quality of runway incursion information involve:[14]

- Revamping data collection forms to systematically capture more detailed information regarding human performance, procedural, technical, and environmental factors that may have interacted to contribute to runway incursions.
- Improving the mechanism for sharing runway safety data among members of the aviation community.
- Providing a more user-friendly system for analysing runway incursion data according to specific parameters.
- Enlisting the participation of aviation human factors experts in the data analysis process.

4.6 TECHNICAL SOLUTIONS

A vast amount of effort and money is put into developing different kinds of surveillance systems. No system can solve these problems alone without the close interaction with the human being. These systems are developed for surveillance and can assist in the preventive work of runway incursions.

4.6.1 ASDE-3

Airport Surface Detection Equipment – Model 3 (ASDE-3) is an airport surface movement detection radar which helps air traffic controllers manage the ground operation especially during low or no visibility. Although the system effectively supplements the controller's vision, the radar does not provide any identification tags on aircrafts and vehicles nor conflict prediction or alerting logic. ASDE-3 is installed at forty major US airports.[6]

4.6.2 AMASS

Airport Movement Area Safety System (AMASS) is a software package that takes data from the ASDE-3 system and processes it to provide controllers with aural and visual warnings that a runway incursion is about to, or has, occurred. The system evaluates airborne aircrafts'; as well as ground-based objects'; position, velocity, and acceleration to determine a potential collision risk. Unfortunately the system has failed to accomplish the tasks it was originally designed for. Due to problems with too many nuisance alerts the FAA had to turn off AMASS' warning capability for "side-impact" collisions. The system cannot predict actions taken by a pilot or driver of a vehicle. The intention may well be to stop at the "hold short" but AMASS can only see the momentary inputs and therefore warn even if there was no cause for alarm. Another problem is the insufficient time the controller has to first identify what's causing the alarm (which units that are involved and their present position), secondly decide what action to take and thereafter transmit instructions to the involved units on the right frequency/frequencies. AMASS is now operational at twelve major US airports and the FAA plans to provide the thirty-four busiest US commercial airports with AMASS systems. They expect to have the system in operation at all of them except security-sensitive Washington National airport by July 2003.[5]

4.6.3 ASDE-X

Airport Surface Detection Equipment – Model X (ASDE-X) is known as the next generation of ASDE-3. It combines data from three sources: surface movement radar; multiple airport-based transmitters and receivers that work together with the moving units' transponders; and ADS-B (see 4.6.4 for description). The information is presented on the controllers display with current position of each transponder-equipped unit, all labeled with call sign tag. This system will improve the controllers' situational awareness but despite the advantages of the system it is believed to suffer from the same limitations as AMASS (se 4.6.2) regarding its predictability. It is also a very expensive system (~$13 million per unit) contrary to what it was supposed to be from the beginning. The FAA has contracted to purchase ASDE-X to equip twenty-five US commercial airports where traffic levels are not as high as the ASDE-3/AMASS-equipped airports – but high enough to create significant risks of incursions. All of them shall be equipped by 2007.[6]

4.6.4 ADS-B

Automatic Dependant Surveillance-Broadcast (ADS-B) is a traffic advisory system which is partly intended as an anti-collision system. The system transmits its position to other systems both in airplanes and ground stations in the vicinity. The position transmitted is collected from an appropriate source, i.e. a GNSS-receiver, and is distributed via data link. In airplanes with the system installed the information will be presented on a "Cockpit Display of Traffic Information" (CDTI) with information about position, speed, altitude, heading and identification. This gives a very detailed picture about the traffic situation in the vicinity of the aircraft. One of the great advantages is that the system works almost as good on the ground as in the air which means that it will be of great assistance while taxiing. Chart information can be presented in the display along with the information where other users are, but to get information about aircraft/vehicles it is required that they also have the system installed. There are many political decisions to be taken before a universal standard can be applied and today the system is not yet operational. Though, it is clear that many problems will be solved with this system.[15]

4.6.5 RWSL

Runway Status Lights (RWSL) will illuminate (red lights) when a runway is unsafe to enter, cross or to begin take-off roll. The system is automatically controlled through the use of airport ground and terminal area radar data. These lights directly inform pilots and ground vehicle operators about a runways' status. The system was introduced in 1995 and showed great promise, but was later cancelled due to obsolete light controlling. This system seems to be on the verge of a reintroduction, this time with technology based on the ASDE-X.[6]

4.6.6 ANTI-BLOCKING RADIOS

Anti-Blocking Radios will prevent two simultaneously transmitting stations to block the frequency. Without this technology the third parties in the area hear a distinctive squeal so they are aware that blocked transmissions have occurred but they do not know the content of the transmissions. Secondly, the transmitting stations will not be aware that a "double-transmission" has occurred. With anti-blocking radios the disturbance will be excluded and both transmissions will be audible. It is a fairly simple technology that has been available for years but for some reason not implemented but will be tested by FAA in a near future. It is widely considered to be a safety improvement, particularly in preventing runway incursions.[6]

4.6.7 OTHER SYSTEMS

A multitude of other systems are under development and scrutiny such as "virtual tripwires"; infrared signature detectors; moving maps; programmable runway and taxiway light-diode signs; and to use Bluetooth™ wireless communication datalink. These inventions will not be described any further.

4.7 QUESTIONNAIRE

We decided to send a questionnaire to ten airlines, ten airports and five national aviation authorities in Europe to get first hand information about actions taken to reduce the risk of incursions. The questionnaire contained a presentation of the school, Trafikflyghögskolan (TFHS), a brief presentation of us, the students, and finally an introduction of the subject Runway Incursions and our questions. A total of twenty-five letters gave us six letters in response, three airlines, two airports (ATC), and one national aviation authority.

The few answers we received did not give us enough material to create a basis for a discussion and to draw any major conclusions. We will therefore only make a short introduction of the questions and answers:

- What specific routines and preventive measures does your organization have/take?
    - This question obviously was too generally put and we didn't get any stringent answers. The only conclusion we can draw is that runway incursions are taken seriously and that the issue is handled thoroughly by all parts. Adequate training is important for all involved, and improvements of SOPs are constantly being done.

- The use of Ground Surveillance Radar (GSR). Compulsory or not for Low Visibility Procedures (LVP)?
    - The airlines generally don't demand the use of GSR during LVP. This rule seems to be on a national basis. On an airport without GSR one movement at the time on the maneuvering area during LVP is often applied. The use of GSR may allow more than one movement at the time. At some airports the use of GSR during LVP is compulsory. For an example, Copenhagen Kastrup Airport in Denmark divides the airport into areas during CAT III operations, and only one aircraft at the time is allowed in an area. This presumes a working GSR.

- How many incidents/accidents per year ('99/'00/'01) is your organization subjected to and how thorough investigations are made of each incident/accident?
    - This question was apparently difficult to define. It is evident that no standard definition of runway incursion is utilized despite both FAA's and Eurocontrol's own definitions. One organization handled this as confidential data. It was also pointed out that the definitions for incident and accident vary from airline to airline.

- Does your organization provide internal training specifically to prevent runway incursions?
    - Regular training is applied at airlines. Subjects like runway incursions are an integrated part of flight crew training e.g. during an approach a car suddenly appears on the runway and a go-around is initiated.

- Any specific rules and regulations from national authorities?
    - All organizations are complying with respective national regulations. Not able to draw any conclusions from the answers if there are any distinguishing rules. (Badly formulated question.)

- Any operational limits with LVP in force, e.g. only one movement at the time in the maneuvering area?
    - Partially answered in question number two. Basically it is the airport authority/ATC that shall be approved for LVP. The responsibility then lies on the airport to decide when the procedures shall be in force. The airlines always have the planning and operational minimums to consider when operating at an airport.

- Do your organization have any role in development or testing of future systems e.g. ADS-B and AMASS?
    - Experiments are being performed at both Copenhagen Kastrup Airport and at Swedish CAA. Scandinavian Airlines System performs tests with technical solutions in both aircraft and simulators.

- Is a landing clearance at an airport with crossing runways acceptable when it only extends to the crossing point?
    - Conditional clearances like “Runway XX, cleared to land, to hold short of runway YY” are allowed according to international rules and regulations (ICAO). This kind of clearance is called “Landing And Hold Short Of” (LAHSO) and is not applied in Europe. In USA clearances like that can be issued but neither SAS nor Swiss will accept it.

5 DISCUSSION

5.1 COMPLACENCY

We can ascribe all runway incursions to human error but why is not an error like complacency mentioned in any of the articles we have read? For us it seems to be a possible cause for runway incursions. We will continue with the example given earlier; the tragic accident at Linate airport. This accident is an example of a causal chain that leads to an accident. Deteriorating weather, an inoperative Ground Surveillance Radar, a pilot on the Cessna not used to neither plane nor airport and the MD-87 taking off at precisely the worst moment were all factors interacting. If one of those links could have been broken the accident most likely would not have occurred. The pilot of the Cessna receives an initial taxi clearance which is read back omitting certain keywords which were vital for a complete understanding of the clearance. The controller accepted the read back and the Cessna commenced taxiing. When reaching the holding position at R6 apparently no effort was made to acknowledge present position. The controller assumed that the plane was heading the correct and cleared way and did not pay any attention to the fact that the Cessna was on its way onto an active runway. What makes a controller assume that everything is in order? Probably because he issued a taxi clearance that was correct in all senses. The pilot on the other hand received the clearance and started taxiing and then arrived at the wrong holding position and received "continue your taxi on the main apron". Try to imagine yourself as the pilot in this situation. Would you continue or stop when the clearance you asked for was issued even if you suspected you were lost? This chain of events could in many ways be derived to complacency.

The pilot's lack of situational awareness in combination with both the controller's and the pilot's complacency lead to the worst runway incursion accident in Europe since 1977 (two Boeing 747s collided on Tenerife Airport in the Spanish Canary Islands resulting in the loss of 583 lives).

5.2 INFORMATION

The effort to reduce human errors like complacency and lack of situational awareness is solved only by reaching the aviation community with information and advisories. In USA, the FAA has started a fierce campaign to reach everyone involved at all levels. It is important to get a solid foundation to stand on and manifest the fundamental principles to avoid runway incursions. FAA's methods to spread information are aggressive, powerful, and are meant to create a consciousness among involved parties.

Eurocontrol, on the other hand, has treated this issue quite differently. Even though the Runway Safety Task Force was formed three months before the accident at Linate in Italy it seems like this accident was a wake-up call for Eurocontrol. Tragically all work that is being done seems to stay at an administrative level and do not reach the pilots, controllers, and airport workers that need it. Posters, flyers and ads that informs about how to minimize runway incursions should be spread to briefing offices, flying clubs, aviation publications/magazines, and aviation schools. The work with development of awareness material (see section 4.3) seems to be a slow process and nothing has yet been found about such items. Despite the lack of awareness material so far, the process of supporting individual runway safety programs is a proof of determination on behalf of Eurocontrol.

5.3 POSSIBLE IMPROVEMENTS

The system ADS-B (described in section 4.6.4) will in many ways be revolutionary to the navigation in both the air and on the ground. The technology is available today but the issue has turned political. A world standard is probably not to be decided upon in a near future. USA has already decided on a standard that will promote own industries. Europe on the other hand can not decide on a uniform system. Each country wants to affect the decision and to be a part of developing the new standard. The problem of runway incursions as it is today will probably not persist when ADS-B is fully operational. The situational awareness of both pilots and controllers will increase when all involved will be able to "see" each other. There will most probably still be incidents and the weak link as we see it is the internal communication between controllers administrating different frequencies (for example ground and tower frequency). By handing over an aircraft to another controller there is always a risk that important and information specific for the situation will be lost. The use of different controllers and frequencies must be minimized, especially during LVP. A pilot receives a lot of important information (situational awareness) by just monitor a specific frequency. By changing frequencies the pilot's mental image of the traffic situation has to be reconstructed.

5.4 STATISTICS VS. REPORTING SYSTEMS

Statistics should always be reviewed critically. It is a fact (from the FAA) that runway incursions in the USA have increased from 186 to 431 in eight years but what is the reason for this increase? Could it be due to increased incursions or is it just an increase in filed reports that have caused the increase to become conspicuously high? Unfortunately it is impossible for us to answer with the material we have had access to.

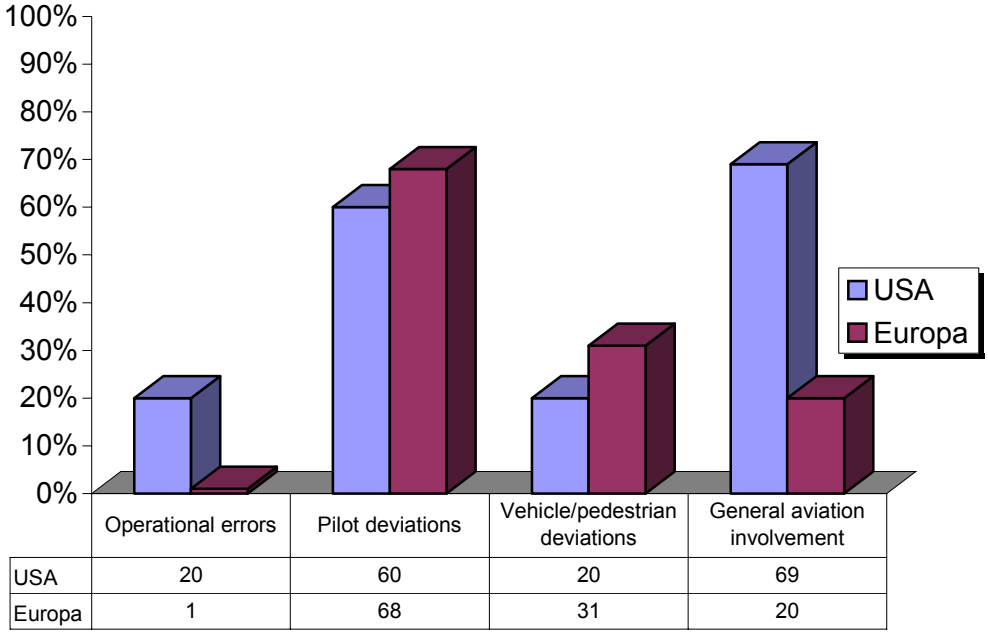


Diagram 5.4.1: Breakdown of incursions in percent according to FAA and Eurocontrol.[6, 10]

According to diagram 1, the European controllers were accounted for one percent of reported incursions unlike US controllers who were accounted for twenty percent of the incursions. Since we cannot assure the reliability of the statistics we therefore question the numbers. Is it possible that there are glitches in the reporting system? We would consider that there are glitches. Some of the participants in our questionnaire were not aware, or unable to answer, if they have had any runway incursion or not due to difficulties regarding definitions and the lack a common reporting system. The interesting facts about an incursion are not that it has occurred but how and why it occurred. It is thus of utmost importance that all incursions/incidents are reported on a standard template. This is to get an objective picture of the course of events and also to get an adequate follow up to find eventual actions to be taken. A reporting system must encourage the involved to report incidents. Each and everyone would benefit from a non-punishing system. Incidents that will cause a legal enforcement action (certificate action or civil penalty action) will most likely not be reported. To offer certain assurances to airmen and controllers regarding enforcement action that typically would be taken for an alleged violation resulting from a runway incursion could be one way of improvement.

5.5 QUESTIONNAIRE

Our questionnaire could have been perfected in many ways before we sent it. One easy step would have been to have the questions numbered on a separate page with space for answers. Another step would have been to enclose a stamped envelope. The importance of being accurate in formulations can not be overemphasized. Our questions were not specific enough and that is the main reason why we got so diverging answers. We spent a lot of time trying to find addresses were to send our questionnaire. This search was mainly performed via the Internet to try to find contact persons. When proper contacts were found we first sent an e-mail to ask if it was okay to contact them further. It was surprisingly hard to find information about personnel responsible for safety issues. Nevertheless this first contact gave many positive responses and the answers we received to our questionnaire contained valuable information.

5.6 SUMMARY

Runway incursions is a pressing issue in the aviation world today. The awareness about the problem exists but there is still no universal formula to put a definite end to it. Runway accidents will become the biggest killer in aviation during the next twenty years, according to a study commissioned by the FAA.[16] Too many incidents have been "near misses" where only the skill and alertness of pilots and controllers – plus a good measure of luck – have averted major tragedies. A lot of work has to be done and money has to be invested into the research and development of future systems and awareness material. Money is a key factor in many aspects but as a long time FAA observer of the scene stated*: "No matter how much money you throw at it, the runway incursion situation will never be entirely resolved as long as you have human beings in the loop. In the end, education and strict discipline are the only ways to truly bring things back under control."*[17]

5.7 SEQUEL WORK REGARDING RUNWAY INCURSIONS

A continued research of this subject could be performed but more up-to-date statistics from both FAA and Eurocontrol must be obtained. To do this, focus must be laid on finding suitable persons in these organizations to have regular contact with. Possible researches in connection with this subject would be:

- Development of reporting systems. What should a standard template contain and what actions could be done to encourage involved parties to report incidents?
- How to develop effective awareness material. What should material designed for the aviation community contain (e.g. posters showing signs and markings, terminology etc. with the text: "Do you remember" or "Do you know what they mean")? Which different kind of actions would be the most effective?
- Review up-to-date statistics to see if FAA's and Eurocontrol's efforts are making further progress.

We would like to thank the following persons for taking their valuable time to answer our questionnaire:

Brix, Thorkil; Copenhagen Airport
Carlsson, Staffan; Scandinavian Airlines, STOOS
Johansson, Bo; Ljungbyhed ATC
Lindmon, Percy; Luftfartsinspektionen
Schmid, Jürg; Swiss International Air Lines Ltd.
Westin, Johan; Malmö Aviation AB

SOURCE MATERIAL

1 Author unknown. [www document] URL http://www.airdisaster.com/photos/sk686/photo.shtml

2 Author unknown. (15th Mar 2000) *Danger Zone: Airport Runways* [www document] URL http://www.airsafetyonline.com /news/2000/03/15/1.shtml

3 FAA Office of Runway Safety (2000). National Blueprint for Runway Safety. Washington D.C: The author.

4 Johnsen, Hans-Petter. "Runway Incursions", *Scandinavian Air Safety* no 1, (2002): 3-5

5 Kjelgaard, Chris. "Holding the Line", *Flight International* no 4834 volume 161, (2002): 28-30

6 United States House of Representatives, Subcommittee on Aviation. (26th June 2001) Hearing on Runway Incursions, Focusing on the Technology to Prevent Collisions. Washington D.C: The author.

7 Author unknown. *Preventing Runway Incursions* [www document] URL www1.faa.gov/fsdo/cle/RI.htm

8 FAA Office of Runway Safety (July 2002). Runway Safety Blueprint 2002-2004. Washington D.C: The author.

9 Kaminski-Morrow, David. "Holding the Line", *Flight International* no 4834 volume 161, (2002): 32-33

10 Author unknown. (2002) *Runway Safety Workshop in Eurocontrol* [www document] URL http://www.eurocontrol.int/safety/RunwaySafety_RunwayIncursion.htm

11 Paulson, George. (2002) *The Way Forward* [www document]. URL http://www.eurocontrol.int/safety/downloads/PRE_RwyWkshpWayForward_020909_SNT01.ppt

12 Van Zuijlen, E. (15th Nov 2001) *Runway Incursion Prevention at Amsterdam Airport Schiphol.* Presentation for the 4th Meeting of the Ad-Hoc Task-Force, Brussels, Belgium.

13 Author unknown. (15th Nov 2001) *Special Information on CDG Runway Incursion Prevention.* Presentation for the 4th Meeting of the Ad-Hoc Task-Force, Brussels, Belgium.

14 FAA Office of Runway Safety (June 2001). FAA Runway Safety Report. Washington D.C: The author.

15 Saxholm, Philip. (2003). ADS-B – Automatic Dependant Surveillance-Broadcast. (Paper from Trafikflyghögskolan). Lund University, Trafikflyghögskolan, 260 70 Ljungbyhed.

16 Author unknown. (23rd Oct 2000) *Working to avert runway disaster* [www document] URL http://www.airsafetyonline.com/news/2000/10/23/2.shtml

17 Gerold, Adrian. (April 2001). *Runway Incursions: The Threat on the Ground* [www document] URL http://www.aviationtoday.com/reports/avionics/previous/0401/0401coverstory.htm

Questionnaire about

Runway incursions

Runway incursions are a growing problem in a, for each year, more and more intensifying traffic environment. The purpose of this inquiry is to get a fundamental knowledge of how companies, organisations and authorities are striving for a common goal – to gradually reduce and eventually eliminate the incidents/accidents to zero!

Please send an e-mail to one of the e-mail addresses on page three as a notice of delivery.

Project by Mikael Gadenius and Nichlas Rudenäs

APPENDIX 1

The School
TFHS (Trafikflyghögskolan) is a school of aviation within Lund University (Sweden). TFHS is an independent unit that is led by its own board of directors. TFHS was established in 1984 by the Swedish Air Force with a main task to train pilots for the civil aviation carriers, however since 1st of January 1998 we belong to Lund University. The school is operated on government funds. The Ab-initio ATPL course is the main program and currently 24 students graduate every year with Commercial Pilot License, CPL + IR/ME/SP + MCC + ATPL-theory. Every student receives approximately 200 flying hours.

The Students
Mikael Gadenius and Nichlas Rudenäs, two students writing a paper about the subject mentioned above. Mikael is a former Naval Officer and worked at Berga Naval base in Stockholm. Nichlas is a former Flight Engineer-student from Mälardalens Högskola in Västerås. We are both students of course 01:2. Graduation is due in late February 2003. In order to receive a full commercial pilot degree every student is required to present an examination paper. The paper is mandatory and the subject shall be flight related often dealing with a safety matter.

Runway Incursion
A pressing issue which we think demands great attention is Runway Incursion (RI). What we are trying to do is to gather material for our paper to get a picture of what measurements airlines, airports and national authorities are taking in order to prevent future incursions. Our goal is NOT to give any organisation or company bad publicity but ONLY to find out policies and prevention taken from an objective point of view. This letter is sent to a number of, in our opinion, interesting actors on the market. We therefore ask You kindly to take Your time and answer the following questions.

- What specific routines and preventive measures does Your organisation have/take?
- The use of Ground Surveillance Radar. Compulsory or not for Low Visibility Procedures (LVP)?
- How many incidents/accidents per year ('99/'00/'01) is Your organisation subjected to and how thorough investigations are made of each incident/accident?
- Does Your organisation provide internal training specifically to prevent RIs?
- Any specific rules and regulations from national authorities?
- Any operational limits with LVP in force e.g. only one movement at the time on the movement area?
- Does Your organisation have any role in development or testing of future systems e.g. ADS-B and AMASS?
- Is a landing clearance at an airport with crossing runways acceptable when it only extends to the crossing point?
- And of course any other aspects about this subject that is relevant but not mentioned here.

The answers to our questions and any other questions can be sent to the following addresses:

Mikael Gadenius
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+46-704-610000

Nichlas Rudenäs
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Sweden

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+46-435-440360, +46-708-130533

The final paper will be sent to all participating parts and they will be mentioned with kudos.
Thank you in advance for your valuable help by participating in this project.

Best regards:

Mikael Gadenius

Nichlas Rudenäs

SEND LIST

AIRLINES:

- BRITTISH AIRWAYS
- BRITTISH MIDLAND
- LUFTHANSA
- MALMÖ AVIATION
- RYAN AIR
- SCANDINAVIAN AIRLINES (SAS)
- SKYWAYS
- STERLING AIRWAYS
- SWISS
- VIRGIN ATLANTIC

AIRPORTS:

- AMSTERDAM AIRPORT SCHIPHOL
- ARLANDA AIRPORT
- BRUSSELS AIRPORT
- COLOGNE/BONN AIRPORT
- DUBLIN AIRPORT
- FRANKFURT AIRPORT
- HEATHROW AIRPORT
- HELSINKI – VANTAA AIRPORT
- KASTRUP AIRPORT
- LJUNGBYHED AIRPORT

CIVIL AVIATION AUTHORITIES:

- DENMARK
- GERMNAY
- NORWAY
- SWEDEN
- UNITED KINGDOM