DUTCH
SAFETY BOARD

Pitch-up Upsets due to ILS False Glide Slope

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Pitch-up Upsets due to ILS False Glide Slope

The Hague, June 2014

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Dutch Safety Board

The aim in the Netherlands is to limit the risk of accidents and incidents as much as possible. If accidents or near accidents nevertheless occur, a thorough investigation into the causes, irrespective of who are to blame, may help to prevent similar problems from occurring in the future. It is important to ensure that the investigation is carried out independently from the parties involved. This is why the Dutch Safety Board itself selects the issues it wishes to investigate, mindful of citizens' position of independence with respect to authorities and businesses. In some cases the Dutch Safety Board is required by law to conduct an investigation.

	Dutch Safety Board		
Chairman:	T.H.J. Joustra E.R. Muller P.L. Meurs		
General Secretary:	M. Visser		
Visiting address:	Anna van Saksenlaan 50 2593 HT The Hague The Netherlands	Postal address:	PO Box 95404 2509 CK The Hague The Netherlands
Telephone:	+31 (0)70 333 7000	Fax:	+31 (0)70 333 7077
Website:	www.safetyboard.nl		

NB: This report is published in the Dutch and English languages. If there is a difference in interpretation between the Dutch and English versions, the English text will prevail.

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The Eindhoven incident

On 31 May 2013, upon approaching Eindhoven Airport a Boeing 737-800 was radar vectored to runway 21 for a landing using the instrument landing system (ILS). During the approach, clouds obstructed the view of the runway in instrument meteorological conditions. The ILS is a ground-based radio wave system used by airports providing both horizontal and vertical guidance to aircraft, under all weather conditions, guiding them to the runway along the 3 degree glide slope.

The aircraft was flying above the normal altitude that is customary for this type of approach, and the autopilot[1] and autothrottle[2] were engaged. Within two kilometres' distance from the runway, at an altitude of approximately 1,060 feet (330 metres), a 'false glide slope' was captured. To ensure a stable approach and safe landing, regulations prescribe the 3 degree glide slope; in aviation the term 'false glide slope' is used to denote the 6 and 9 degree glide slopes that aircraft are not supposed to follow. The moment the aircraft crossed the false 9 degree glide slope, a pitch-up upset occurred, causing the airspeed of the aircraft to drop despite the autothrottle selecting increased engine thrust. This drop in speed triggered a brief stick shaker warning,[3] after which the flight crew decided to initiate a go-around. During the crew's subsequent recovery procedure the stick shaker was briefly activated a second time. Eventually the crew managed to regain control over the aircraft and, after a successful go-around, to land safely at Eindhoven Airport.

The incident revealed a characteristic of the ILS that had previously been unknown. The ILS is a navigation aid that is used all over the world to facilitate the approach and landing of aircraft. Approximately 1500 to 2000 runways all over the world, including runways at all the major airports, are equipped with an ILS.

Against the backdrop of these findings, the Dutch Safety Board launched an investigation into the Eindhoven incident, whose gravity and significance were not initially recognised by all the parties involved. Indeed, the Dutch Safety Board itself initially failed to appreciate the potential hazards of incidents of this type. A similar incident had occurred at Amsterdam Airport Schiphol two years before. Although the Dutch Safety Board was aware of the internal investigation conducted by the airline concerned, it saw no reason to launch an investigation at the time into the use of the ILS. Only when it emerged from

1 The automatic flight system of a Boeing 737-800 consists of the autopilot and the autothrottle.
2 The autothrottle is used to change the position of the thrust lever in order to achieve the selected thrust or air speed.
3 A stick shaker is a warning that is triggered before an aircraft actually 'stalls' and the wings provide insufficient lift. The warning offers the crew the time they need to take action and regain control of the situation. In a Boeing 737, this stick shaker warning consists of a strong vibration of the stick combined with a loud rattling noise (shaker).

the investigation of the Eindhoven incident that the event was inconsistent with the existing theories did the Safety Board decide to further examine the ILS.

The investigation into ILS glide slope signals

The incident at Eindhoven Airport was not an isolated event. Four similar incidents occurred: two in 2011, one in 2012 and another one in 2013, after the Eindhoven incident. These incidents involved different types of aircraft operated by different airlines during the approach of several different European airports.

The investigation into the Eindhoven incident revealed characteristics of the ILS signal in the area above the 3 degree glide slope that were previously not generally known. According to the existing theory, false glide slopes appear in fixed intervals above the normal 3 degree glide slope; the general view is that a false glide slope, like the 3 degree glide slope, also guides the aircraft to the runway albeit at a higher descent rate. In addition, the assumption is that an automatic warning is given in the cockpit before the aircraft crosses a false glide slope. However, these incidents and the Dutch Safety Board's investigation have proved both views to be incorrect.

The Dutch Safety Board conducted various measurements, in the Netherlands and the United States, of ILS glide slope signals of an antenna system commonly used all over the world. Those measurements have shown that signal reversal with the ILS sometimes occurs at the 6 degree glide slope and always occurs at the 9 degree glide slope. As a result, when the aircraft crosses a reversed signal, instead of the required 'fly down' command to the runway, the aircraft systems actually do the opposite and give a 'fly up' command that causes the aircraft to suddenly pitch up. This may cause the aircraft to (an approach to) stall, which is a dangerous situation during the landing phase. Flight crews are assuming they are aware of the characteristics of false glide slopes by which they are surprised by the effects of signal reversal. During the measurements in the area of the false glide slopes, the instruments in the cockpit gave no warnings. This, too, is contrary to the general view in the sector.

On the basis of these findings, the Dutch Safety Board concluded that unknown ILS signal characteristics in the area above the 3 degree glide slope constitute a significant threat to aviation safety. This is because those characteristics may cause unexpected autopilot behaviour, thus potentially compromising the safety of passengers and crew members. In view of the frequency of this phenomenon combined with its potentially serious consequences, the Dutch Safety Board issued a worldwide aviation Safety Alert on 18 November 2013, which was taken over by various regulatory aviation authorities and other stakeholders in several different countries.

Supplementary to the Safety Alert, the Board issued a recommendation to stakeholders including the European Aviation Safety Agency (EASA) and the U.S. Federal Aviation Administration (FAA). In it, the Dutch Safety Board recommends that the information about the characteristics of false glide slopes and their potential consequences for aircraft be modified and widely distributed, and published in manuals and training programmes within the aviation sector.

The investigation also revealed that ILS calibration or flight inspections are not carried out in the area above the 5.25 degree glide slope. The purpose of those inspections is to ensure the quality of the ILS signals. The flight inspections for the ILS are focused around the 3 degree glide slope. No glide slope field inspections are carried out at a glide slope angle of 5.25 degrees and higher, nor are such inspections required under international regulations. This means that an aircraft that is flying above the 5.25 degree glide path is beyond the reliability envelope which is certified and regularly checked by flight inspection. The Dutch Safety Board's investigation has identified the risks for aircraft flying in the area above the 5.25 degree glide path.

Safety management systems in aviation

In order to enhance aviation safety, information about incidents is being gathered and shared on a global basis. This takes place at the level of operators (including airline operators and air navigation service providers), at the national level in national databases and at the international level in, for example, the European database. Analysis of this data enables researchers to establish connections between incidents and identify risks at an early stage. However, for this approach to work reported incidents must be interpreted and registered correctly. In many cases this requires in-depth knowledge of or further investigation into the incident concerned. As a rule, it will be necessary to ask for supplementary information from the parties involved in order to register the incident on the basis of the right search terms or key words so that it can be easily retrieved later on. In practice however it turns out that either no supplementary information is gathered prior to registration, resulting in a lack of specific detail for the incidents once registered in the databases, or the information does not actually expand or update the incident data in the database, which hinders data analysis for trend studies.

Strikingly, the series of incidents did not come to light until after specific information had been requested from the airlines involved and from various national databases in Europe, and that the regular analyses had failed to unearth them. Although the EU Member States have already used this 'incident report analysis' methodology for several years, the approach did not become compulsory until 2012. An analysis of the NASA database for voluntarily submitted incident reports showed that similar incidents have also occurred in the United States.

Flight path management in relation to automation and basic flying skills

The use of modern technology has improved aviation safety in recent years. Complex on-board systems have been introduced that warn flight crews of risks, support them in the decision-making process and actually take over part of their tasks. Many of those automated systems are designed to accommodate standard procedures. It goes without saying that pilots are also trained in the use of those systems. Evidently, these innovations have brought considerable progress in terms of safety. But they also have a downside. Flight crews risk becoming too reliant on the automated systems. This could cause them to gradually lose certain basic skills through a lack of routine in actions which they practised during their training but which in real life tend to be performed using automated systems. This constitutes a risk when flight crews are called upon to respond to unexpected situations.

One thing that the five comparable incidents had in common was that they all involved reliable and highly automated aircraft. In all cases, moreover, the flight crews were aware that they were flying above the normal 3 degree glide slope. They were also aware of the need to increase the descent rate of the aircraft in order to capture the 3 degree glide slope. However, their predictions (flight path management) as to where the 3 degree glide slope would be captured were inaccurate or at least unrealistic. While supplementary aids or procedures may help avoid crews capturing a false glide slope, they should not substitute the regular distance versus altitude crosschecks that are part of the basic flying skills. In that respect the Dutch Safety Board is concerned that the use of advanced automation can result in situations where the flight crew's flight path management degrades. Flight crews should be made more aware of this, and their training should keep pace with the development of automated systems in aircraft.

Based on the findings and conclusions the Dutch Safety Board made the following recommendations.

The Dutch Safety Board made the following recommendations to the regulators involved with the manufacturing of transport category aircraft; European Aviation Safety Agency (Europe), Federal Aviation Administration (USA), Agência Nacional de Aviação Civil (Brasil), Civil Aviation Administration of China, Federal Air Transport Agency (Russian Federation), Japan Civil Aviation Bureau, and Transport Canada.

1. **Information and awareness**
   Ensure that the established False Glide Slope characteristics and the possible associated consequences for aircraft are made widely known and are modified accordingly in the published manuals and training material used in the aviation sector. This specifically refers to:

   a. the area above and below the published or nominated ILS Glide Path;
   b. the absence of warnings in the cockpit when flying with the automatic systems engaged in the area above the published or nominal ILS Glide Path.

2. **Short term measures**
   Ensure with oversight that aviation operators, manufacturers, and Air Navigation Service Providers take mitigating actions to prevent pitch-up upsets due to aircraft exposure to False Glide Slope Reversal as a result of flying in the area above the published or nominated ILS Glide Path with automatic flight systems engaged. This can be achieved by means of:

   a. operational measures;
   – raising the interception of the ILS Glide Slope from below to a Standard, or in the event of an interception from above,
   – developing additional operating procedures.

b. technical measures;
   automated on-board systems when in use should not cause a pitch-up upset, at least not without a preceding clearly recognizable warning and with ample time for flight crew intervention.

3. **Long term measures**
   Stimulate that aircraft manufacturers in the long term develop new landing systems to accommodate new approaches for aircraft with automatic flight systems engaged and ensure that airports are equipped with these landing systems.

4. **Occurrence reporting and analyses**
   Assess the aviation Safety Management System occurrence reporting and analyses methodology, including the use of the existing ECCAIRS databases on the levels (operator, Air Navigation Service Provider, manufacturer, national-international level) whether measures are required to achieve the goal of the system to identify potential safety deficiencies in a timely manner. The review should also take into account: (a) the possibility to add internal investigation results into the ECCAIRS databases (feedback-loop), (b) the necessity to exchange investigation information with the manufacturer.

5. **Training regulations**
   Review the applicable regulations on initial and recurrent flight crew training to assess whether they adequately address the potential degradation of situational awareness (basic pilot skills) and flight path management due to increased reliance on aircraft automation by flight crews.

The Dutch Safety Board made the following recommendation to the International Civil Aviation Organization.

6. **International regulations**
   Raise the recommended procedure in paragraph 8.9.3.6 (*ICAO Document 4444 PANS - ATM*) to intercept the published or nominated ILS Glide Path from below to a Standard.

   In the event that interception of the Glide Path from below is not adopted as a Standard, horizontal and vertical operating landing gate limits need to be added to prevent aircraft exposure to pitch-up upsets due to False Glide Slope Reversal.

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The Dutch Safety Board made the following recommendation to the Flight Safety Foundation.

7. Update of stabilised approach criteria
Update the Approach and Landing Accident Reduction (ALAR) toolkit stabilised approach criteria to include guidance to prevent pitch-up upsets due to aircraft exposure to False Glide Slope Reversal in the area above the published or nominal Glide Path.

T.H.J. Joustra
Chairman, Dutch Safety Board

M. Visser
General Secretary

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ABBREVIATIONS

ABL	Analysebureau Luchtvaartvoorvallen (Occurrence Analysis Bureau)
AFDS	Autopilot Flight Director System
AIC	Aeronautical Information Circular
AFE	Above Field Elevation
ANAC	Agência Nacional de Aviação Civil (Brasil)
ANU	Aircraft Nose Up
ANSP	Air Navigation Service Provider
ANSV	Agenzia Nazionale per la Sicurezza del Volo (Italy)
AOA	Angle of attack
APP	Approach
ASRS	Aviation Safety Reporting System database
AT	Autothrottle
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
B737NG	Boeing 737 Next Generation
BEA	Bureau d’Enquêtes et d’Analyses pour la sécurité de l’aviation civile (France)
CAAC	Civil Aviation Administration of China
CIAIAC	Comisión de Investigación de Accidentes e Incidentes de Aviación Civil (Spain)
CSB	Carrier and Sideband
DALPA	Dutch Airline Pilots Association
DDM	Difference in Depth Modulation
DME	Distance Measuring Equipment
DSB	Dutch Safety Board
EASA	European Aviation Safety Agency
EFIS	Electronic Flight Instrumentation System
EU	European Union
FAA	Federal Aviation Authority (United States of America)
FAF	Final Approach Fix
FATA	Federal Air Transport Agency (Russian Federation)
FCC	Flight Control Computer
FCTM	Flight Crew Training Manual
FCOM	Flight Crew Operating Manual
F/D	Flight Director
FIS	Flight Inspection System
FL	Flight Level
FMA	Flight Mode Annunciation
FMC	Flight Management Computer
FMS	Flight Management System

ft	feet
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
G/S	Glide Slope
Hz	Hertz
IAA	Irish Aviation Authority
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
ILS/DME	Combined ILS and DME system
IMC	Instrument Meteorological Conditions
JCAB	Japan Civil Aviation Bureau
LOC-I	Loss of Control In-flight
MCP	Mode Control Panel
NASA	National Aeronautics and Space Administration
NLR	National Aerospace Laboratory
NM	Nautical Mile(s)
NTSB	National Transportation Safety Board (United States of America)
PFD	Primary Flight Display
RWY	Runway
RFI	Radio Frequency Interference
SA	Situational Awareness
SARP	Standards and Recommended Practices
SAIR	Safety Alert Initial Report
SBO	Side Band Only
SMS	Safety Management System
SRGC	Safety Recommendation of Global Concern
SSP	State Safety Program
TOGA	Take-off / Go-around
TUDelft	Delft University of Technology
V/S	Vertical Speed
VOR/LOC	VHF Omnidirectional Radio Range Localizer
VMC	Visual Meteorological Conditions
VNAV	Vertical Navigation
VSD	Vertical Situation Display
WX	Weather

DEFINITIONS

The terms Glide Slope and Glide Path are used interchangeably in the aviation community. ICAO only uses the term Glide Path in ICAO Annex 10 Volume 1. In this report the term Glide Slope and Glide Path are used interchangeably.

Definitions:

ILS Glide Path	That locus of points in the vertical plane containing the runway centre line at which the DDM is zero, which, of all such loci, is the closest to the horizontal plane.[4]
ILS Glide Path angle	The angle between a straight line which represents the mean of the ILS Glide Path and the horizontal.[5]
False Glide Slope	That locus of points in the vertical plane containing the runway centre line at which the DDM is zero, which is not the closest to the horizontal plane.

The term 'False Glide Slope' is used in the aviation community to describe a Glide Path which is not the normal Glide Path which an aircraft follows to the runway for landing. In some cases the report uses the term Glide Path with a Glide Path angle for clarity. In that case the 3 degree Glide Path is the 'normal' Glide Path and in other cases it's the 'False Glide Slope'.

4 ICAO Annex 10 Volume 1.
5 ICAO Annex 10 Volume 1.

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1 INTRODUCTION

1.1 Reasons for the investigation

1.1.1 Initial investigation

During the approach to Eindhoven Airport (The Netherlands) on 31 May 2013, a Ryanair Boeing 737-800 was radar vectored towards runway 21 for a landing with the aid of the Instrument Landing System[6] (ILS). The aircraft was flying under Instrument Meteorological Conditions (IMC). During the latter stage of the approach, the aircraft was above the intended 3 degree Glide Path. After the Localizer was captured, a Glide Slope intercept from above was executed. The Autopilot Flight Director System[7] (AFDS) and the Auto Throttle[8] (AT) were engaged. The Approach mode was armed and the aircraft was configured for landing.

At short final, approximately 0.85 NM from the threshold at 1060 feet altitude, the Glide Slope was captured. Upon Glide Slope capture, a pitch increase of 24.5 degrees aircraft nose up (ANU) occurred in about 8 seconds. The crew pressed the 'take off/go around' (TOGA) button for a go around, almost simultaneously followed by the activation of the stick shaker warning. During the following approach to stall recovery manoeuvre there was a second stick shaker activation. The crew made a successful go around and landed at Eindhoven Airport.

The activation of the aircraft's stick shaker during an autopilot coupled ILS approach in close proximity to the runway was a factor of interest that prompted the Dutch Safety Board to start an investigation. The occurrence (henceforth: the Eindhoven incident) has been categorized by the Safety Board as a serious incident.

1.1.2 Significance of the Eindhoven incident

Eindhoven investigation revealed characteristics of the ILS signal which was not fully understood and appreciated. Also, it became clear during the investigation that the Eindhoven incident was not unique. Four[9] other occurrences with autopilot commanded pitch-up upset during ILS approach from above the 3 degree Glide Slope were identified. These incidents took place with different types of aircraft, operated by different airlines, on approach to different airports.

6 See chapter 3 for the description of the instrument landing system.
7 The automatic flight system of the Boeing 737-800 consists of the autopilot flight director system and the autothrottle..
8 The autothrottle (automatic throttle) moves the thrust levers to control thrust or airspeed.
9 Two of the four incidents were known before the Safety Alert was published.

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The general belief is that False Glide Slopes invariably occur at regular intervals from the normal 3 degree angle. In addition, the general view is that a warning is given in the cockpit before the aircraft crosses a False Glide Slope. The identified incidents with different aircraft types seem to indicate differently.

These findings led the Dutch Safety Board to conclude that little known ILS signal characteristics pose a significant threat to aviation safety, as they may result in unexpected aircraft behaviour and may thus endanger the safety of passengers and flight crews. Because identified occurrences, combined with the potential severity of this hazard, the Dutch Safety Board decided to address this issue separately.

The fact that similar incidents in the past did not lead to mitigating measures also raises the question of the effectiveness of the aviation Safety Management System (SMS) framework.

This report represents the investigation into the ILS signal characteristics and the SMS framework. The other findings from the Eindhoven investigation are presented in a separate report, issued contemporaneously.

1.2 Investigation questions and scope

This report seeks to answer three questions:

1. What are the signal characteristics of the ILS, especially in the area above the standard 3 degree Glide Slope?
2. What are the effects of very reliable automated aircraft on flight crew decisions when the aircraft is flying significantly above the vertical profile during ILS approaches?
3. Why did aviation safety management systems and previous Safety Investigation Authorities investigation not identify the ILS characteristic as a serious safety deficiency?

The investigation does not include the technical investigation of the aircraft navigation receiver and automation systems nor was the investigation exhaustive in the number of similar occurrences worldwide.

The frame of reference including the relevant (international) legislation, regulations, guidelines, operating and training manuals for this investigation are described in Appendix C.

1.3 Objectives

The investigation has two objectives. First, the Dutch Safety Board intends to draw lessons from the incidents related to the ILS characteristic to prevent repetition, and to

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limit the consequences of similar occurrences in the future. Second, the purpose of this investigation is to inform all concerned parties - pilots, airline operators, Air Navigation Service Providers, aircraft manufacturers and regulators - of the potential severity of the hazard.

In accordance with Annex 13 to the Convention on International Civil Aviation, it is not the purpose of the investigation to apportion blame or liability. The sole objective of the investigation and the Final Report is the prevention of accidents and incidents.

1.4 Intermediate notifications

During the first stage of the Eindhoven incident investigation, in particular when it was known that two similar incidents had occurred previously, the Dutch Safety Board notified all parties concerned in the Netherlands of its preliminary findings by formal letter.[10] In the letter the risks associated with ILS Glide Slope intercept from above the standard 3 degree Glide Path were addressed. The Dutch Safety Board also pointed to the ICAO guidelines that crews shall be given the opportunity to fly level on the ILS approach track at a good distance from the runway in order to intercept the Glide Path from below. The letter is contained in Appendix D.

After ILS Glide Slope signal flight test measurements had been verified, the Dutch Safety Board decided to issue an industry-wide Safety Alert on 18 November 2013. The purpose of the Safety Alert (Appendix E) was to inform stakeholders that M-array Glide Slope antennas have signal characteristics above the standard 3 degree Glide Path which may induce unexpected aircraft behaviour, resulting in (approach to) stall conditions.

1.5 Reader's guide

Chapter 2 contains the relevant facts of the five occurrences (in total) and the results of database search for similar occurrences. Chapter 3 describes the ILS Glide Slope system, the theory and received wisdom.[11] This chapter deals with the results of the flight test measurements and the analysis of the ILS Glide Slope signal characteristics. Next, the procedures to intercept the Glide Slope from above are described. Thereafter, the relationship between reported incidents and the use of aircraft automation and flight path management is analysed. Chapters 3 concludes with a summary of actions taken by the parties concerned. Chapter 4 describes the framework of Safety Management Systems in general, the reporting of the false Glide Slope incidents and how they were analysed. The final conclusions are presented in Chapter 5. Chapter 6 contains recommendations based on this investigation.

10 This letter was sent to the Dutch civil and military Air Navigation Service Providers, the Dutch Civil and Military Aviation Authorities, all major Dutch airline operators, and the Dutch Airline Pilots Association.
11 Knowledge or information that people generally believe is true, although in fact it is often false.

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2 SIMILAR OCCURRENCES

This chapter gives an overview of similar pitch-up upset occurrences that were found during the investigation. The chapter begins with the principal pitch-up upset investigation - 'the Eindhoven incident' which was investigated by the Dutch Safety Board. Next a summary of the relevant facts of the four other incidents, which were investigated by different entities, is given. The last paragraph describes the outcome of a database search for similar occurrences.

2.1 Principal Pitch-up Upset incident

In addition to the description of the incident in paragraph 1.1.1, the following results of 'the Eindhoven incident' investigation are relevant.[12]

The flight was uneventful until the Boeing 737-800 received radar vectors for the arrival and approach to the landing runway at Eindhoven Airport. During vectoring the aircraft's speed was high and its vertical position remained approximately 1,000 feet above the descent profile up to the moment of pitch-up upset. During the approach a 30 knots crosswind at 2,000 - 3,000 feet on base leg and a tailwind on final approach contributed to the aircraft being closer and higher to the runway than normal. The influence of the crosswind and tailwind on the flight path remained unnoticed by both the air traffic controller and the flight crew. At approximately 1,300 feet the captain informed the FO that it was very unlikely a successful landing would be possible and they should prepare to make a go-around.

At approximately 1,060 feet and 0.85 NM from the runway threshold the aircraft captured the 9 degree False Glide Slope. The aircraft pitched up rapidly and the engine N1 increased from 30% to 90% on both engines in order to maintain the selected airspeed. Finding this behaviour unexpected, the Captain called for a go-around. The pitch further increased to approximately 24.5 degrees nose up and the stick shaker warning activated. Almost at the same time the TOGA button was pushed once by the First Officer and the autopilot was deactivated.

2.2 Similar Pitch-up Upset incidents

During the investigation the Dutch Safety Board became aware of four similar pitch-up upset incidents. The similarities between these incidents are described in the box.

12 Final Report '*Stick Shaker warning on ILS final*', Eindhoven Airport, 31 May 2013. Issued [date], www.safetyboard.nl.

Similarities between the incidents

- Three out of four incidents occurred in IMC; the runway was not visible to the flight crews.
- The aircraft were vectored to the runway by Air Traffic Control (ATC.
- The aircraft altitude-distance position was such that it would be difficult or impossible to make a normal automatic landing.
- Glide slope capture occurred above 1,000 feet. This is the normal altitude at which an approaching aircraft should be stabilised under IMC conditions.
- The approach flown using automatic systems (autopilot and autothrottle engaged).
- The incident aircraft involved were equipped with modern and reliable automatic systems which were being used by the flight crews.
- The flight crews were unaware of the effects False Glide Slope had on the aircraft automatic flight system.

2.2.1 Amsterdam Airport Schiphol, The Netherlands, 2011

The incident with a KLM Cityhopper Embraer 190 took place on 12 February 2011 during an ILS approach to runway 06 Amsterdam Airport Schiphol. After the incident the flight crew filed an Air Safety Report. Subsequently the operator reviewed the flight data. The operator assessed the occurrence as an incident and started an internal investigation. A mandatory occurrence report was filed with the Occurrence Analysis Bureau, part of the Civil Aviation Authority of the Netherlands (ABL - Analysebureau Luchtvaartvoorvallen). The operator also reported this event to the aircraft manufacturer.

The occurrence was not reported to the Dutch Safety Board. The incident only came to the attention of the Safety Board when it received a courtesy copy of the operator's internal investigation report end of 2012.[13] The internal investigation did not lead to an additional (in-depth) ILS investigation by the Safety Board. However, it was only following the Eindhoven incident that the seriousness of the Schiphol incident became clear to the Board.

The KLM Cityhopper flight was uneventful until the start of the approach. The approach was flown in IMC using the aircraft auto flight systems.[14] The flight crew was cleared for the ILS approach after ATC had asked if the crew was in a position to execute the approach, this was confirmed by the flight crew. The crew was aware that the aircraft's position was high. At 2,380 feet the Glide Slope indicator became visible on the Primary Flight Display (PFD) which showed the Glide Slope had to be captured from above. At 2,100 feet and 1.8 NM from the runway the false (9 degree) Glide Slope was captured. Due to the Glide Slope capture the autopilot followed the 'Fly Up' Glide Slope indication which resulted in a sudden pitch-up and associated speed loss. The aircraft rapidly reached the stick shaker speed. The crew responded to the stick shaker by executing the

13 Operator internal report: Flight Safety Investigation Report 2011-01, December 2011.
14 With both autopilot and autothrottle engaged.

stall recovery procedure and subsequently performed a go-around. Due to the unexpected nature of the events, neither procedure was performed according to the standard operating procedures.

2.2.2 Murcia Airport, Spain, 2011

The incident with the Ryanair Boeing 737-800 took place on 23 March 2011 during an ILS approach to runway 05 at Murcia Airport (Spain). This occurrence was investigated by the operator and the internal report was made available to the Dutch Safety Board.[15]

The aircraft was cleared for the ILS approach to runway 05. During the base turn the flight crew noticed that the ILS was not identing (sending out signal). The crew asked ATC if the ILS was operating, which was confirmed. The aircraft was now on finals in Visual Meteorological Conditions (VMC), the Approach Mode was armed. The aircraft was at 2,400 feet and 2.5 NM from the runway when the autopilot engaged the Glide Slope Mode and pitched the aircraft up to 19 degrees in an attempt to capture a Glide Slope full 'Fly Up' indication. Time required to spool the engine up to the required thrust to maintain the selected speed at the commanded pitch caused the speed to decrease and trigger an aural airspeed low warning. The crew responded to the airspeed low warning and performed a go-around, the minimum speed was 147 knots.

2.2.3 Paris Charles de Gaulle Airport, France, 2012

The incident with the Air France Airbus A340 took place on 13 March 2012 during an ILS approach to runway 08R Paris Charles de Gaulle Airport (France). The occurrence was investigated by the French Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA).[16]

While receiving radar vectors, the flight crew was cleared for the ILS approach in IMC. The crew was unable to descend at a rate that would allow the aircraft to capture the ILS Glide Slope at 2 NM from the runway. When still at 2,500 feet, the ILS Glide Slope mode engaged, resulting in a rapid pitch-up (1 degree to 26 degrees) and speed reduction (163 knots to 130 knots)and a loss of control over the aircraft. After a period of confusion the flight crew initiated a go-around. The following factors contributed to the incident:

- The inadequate monitoring of the aircraft's flight path by ATC and the flight crew.
- The absence of visual reference points on the air traffic controller's radar monitor for Glide Path interception at altitudes lower than 5,000 feet.
- The crew's use of an unsuitable method to intercept the Glide Path from above.
- The autopilot's capture of a false ILS signal, which generated an excessive increase in pitch attitude.
- Flight crew and controller fatigue may have contributed to the occurrence of this serious incident.

15 Operator internal report: SAIR Base Investigation - Final Report 27_101_DUB_11.
16 Final Report on www.bea.aero - report 'Approach above Glide Path, interception of ILS sidelobe signal, increase in AOA angle commanded by autopilot', September 2013.

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BEA formulated five recommendations, three to EASA and two to the French DGAC. Two recommendations to EASA are relevant:

- *'EASA ensure that aircraft ILS modes are not engaged on an ILS signal other than the one corresponding to the published descent path; that failing this, a system enabling the crew to be alerted be put in place.*
- *EASA ensure that the activation of aircraft ILS modes in autopilot does not lead to inappropriate attitudes during approach.'*

2.2.4 Treviso Airport, Italia, 2013

The incident with the Ryanair Boeing 737-800 took place on 29 October 2013 during an ILS approach to runway 07 Treviso Airport (Italy). This occurrence was investigated by the operator and the internal report was made available to the Dutch Safety Board.[17] This incident is under investigation by the Italian Agenzia Nazionale per la Sicurezza del Volo (ANSV).

Before the approach to runway 07, the aircraft was in a high energy state as a result of a late descent and shortened routing. The aircraft received radar vectors to stay clear of numerous thunderstorms in the vicinity. When clear of the weather the aircraft was cleared for the approach. The Approach mode was armed when the aircraft was approximately 2,500 feet above the descent profile and within 10 NM of the runway. The wind then increased from the west, which resulted in a 20 knot tailwind. To compensate for the tailwind the Pilot Flying set the speed to 155 knots. The Captain realised that the approach was probably not going to work and started to discuss the possibility of a go-around with the First Officer. The crew noticed the Glide Slope indicator rapidly moved from full 'Fly Down' to full 'Fly Up'. Glide Slope capture occurred and the aircraft pitched up following the Glide Slope 'Fly Up' indication and as the engines were still at flight idle airspeed decreased. The Captain immediately disconnected the autopilot and autothrottle and recovered the aircraft. Glide Slope capture occurred at approximately 2,000 feet above the 3 degree Glide Slope at 7.9 NM from the runway.

2.3 Database reports False Glide Slope events

2.3.1 Introduction

The fact that four more ILS False Glide Slope-induced pitch-up occurrences were identified during the investigation prompted the Dutch Safety Board to perform a detailed database search for these types of incidents. A database search of the Occurrence Analysis Bureau in the Netherlands revealed only one case which is described in the paragraph 2.2.1. Furthermore it is known that the Occurrence Analysis Bureau over the years performed mainly quantitative analyses on the occurrences and not qualitative.

There was one reported case in France, which was investigated by the French BEA and is described in paragraph 2.2.3. In the final stages of this investigation the Dutch Safety Board was informed by the French BEA that a similar pitch-up upset occurrence had

17 Operator internal report: SAIR Base Investigation - Final Report 45920_BRE_13.

been reported by an operator to Airbus. The occurrence pre-dated the A340 pitch-up upset. Both the Dutch Safety Board and BEA were unsuccessful in obtaining information from Airbus because of a confidentiality agreement between Airbus and the operator.

After the Draft Final Report consultation the BEA informed the Dutch Safety Board of similar pitch-up upset occurrences with another French aircraft manufacturer. According to information provided events data back to 2008 but no further details were given as it is an ongoing investigation.[18]

A database search in the United States of America performed by both the National Transportation Safety Board and the manufacturer Boeing did not find similar events. By contrast, a search and analysis of the Aviation Safety Reporting System database (ASRS) revealed that 57 occurrences were reported between 1998 and 2013 where a 'False Glide Slope' was mentioned in the narrative. These occurrences were analysed in more detail. An overview of the occurrence reports can be found in Appendix F.

2.3.2 Results of ASRS database research

The National Aeronautics and Space Administration (NASA) operates ASRS. This system receives, processes and analyses voluntarily submitted incident reports from pilots, air traffic controllers, aircraft dispatchers, cabin crew, maintenance technicians and others. Reports submitted to ASRS may describe both unsafe occurrences and hazardous situations. Information is gathered from these reports and disseminated to stakeholders.

A narrative search was performed on the ASRS database with the key words: 'False Glide Slope', 'False Glideslope' and 'False GS'. The result was 57 occurrences related to False Glide slopes. These occurrences were analysed further.

Example ASRS report number 1054754
Boeing 737-300, 20 December 2012, altitude 3,000 feet

This event occurred during approach to Runway 28L. The ceiling was approximately 1,500 ft MSL, requiring ATC vectors to the approach. There was other traffic in the area and we were vectored to final behind them. ATC had slowed us to 150 KIAS, which, in our type of aircraft, requires landing gear down, and flaps 15. This is a high amount of drag to have, especially in level flight. I was the pilot flying. I was given an intercept heading to join the localizer, and cleared for the approach. The autopilot was engaged, and I armed the VOR/LOC mode. It was clear that the localizer was going to capture at about the same time as the Glide Slope was intercepted. As soon as the FMA changed VOR/LOC to green (captured), I selected the approach function, and the Glide Slope indication went to green (captured) almost immediately. The Glide Slope indicator then trended downward, showing that we were getting high on the desired path. The autopilot, instead of pitching down to follow the Glide

18 The Dutch Safety Board has offered assistance to the BEA.

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Slope, began to pitch up. The airspeed then began to decrease below the minimum for the configuration. I had to add thrust significantly, disconnect the autopilot and manually push the nose over to increase the airspeed and try to regain the proper Glide Slope. I regained it successfully, and flew the remainder of the approach in a stabilised fashion, but the aircraft did not perform as it should have. Performing in the opposite of what it's supposed to do, in a low airspeed, high drag situation is very dangerous. This is not the first time that I have witnessed this kind of behaviour in this type of aircraft. This is the third or fourth time that I have seen this, at different airports, but all on ILS frequencies. I have discussed this error with the Captains at the time, and I always get a response such as, 'Well, it's a -300.' This is completely unacceptable, and counter to safety. I can't understand how this equipment can be certified for use in IFR when it behaves in this fashion. Perhaps it's just in a series of autopilots, or series of aircraft, but it seems that a tracking by Maintenance or investigation of some sort is warranted. As we move more and more to a higher level of safety and automation, attitudes like, 'Well, it's a -300,' don't seem to have any place in our system. I have also seen these airplanes nose over suddenly to capture the Glide Slope if you happen to be above it. The pitch over moment is quite severe, and causes alarm to passengers and crew members alike. That may be a separate issue, but it seems like there is a regular deficiency with the autopilot system in this type of aircraft. I believe that this needs to be investigated by the Maintenance Department. Request that when crews witness this behaviour, note the time, approach, configuration, frequency, etc. to see if there is a pattern. Have the autopilot system in the affected/reported aircraft checked for proper function. Consult with Boeing to see if there are other reports of this type of behaviour.

The data showed that in 66% of the cases the False Glide Slope event was characterised as occurring 'Below' the Glide Path. The 'Below' Glide Slope events are characterised as descents prior to the 'published' Final Approach Fix. In general from the reported occurrences the crew noticed either a high descent rate, a low altitude alert by ATC or a combination of the two. In approximately 50% of the cases the event was detected by the flight crew and 25% by ATC (automatically – low altitude warning or in person).

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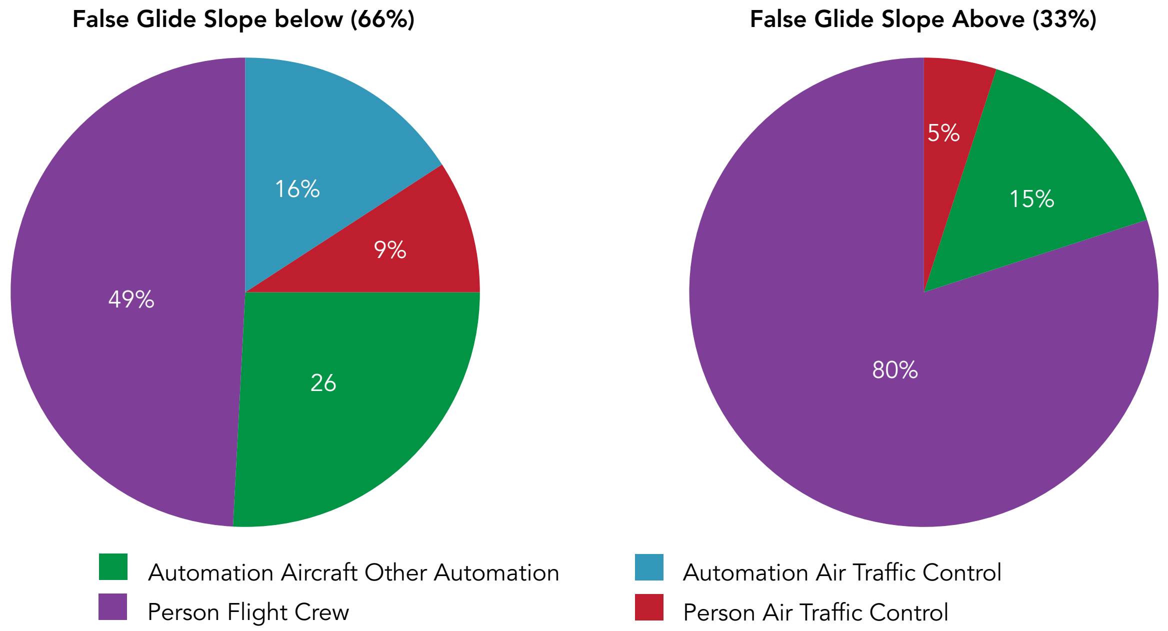

Figures 1 and 2: Division of False Glide Slope below and above Glide Path events.

In 33% of the cases the False Glide Slope event was characterised as occurring 'Above' the Glide Path with a pitch-up to a varying pitch attitude. These 'Above' events were detected by the crew in 80% of the cases and in 15% by the automation (loss of signal).

The classification labels for the anomaly focus on deviations in 'procedural published material', 'assigned altitude' and 'procedural clearance'. With respect to aircraft equipment the False Glide Slope anomaly is classified in 11 instances (9 Below and 2 Above) as Aircraft Equipment Problem Critical. In 7 instances the problem is classified as Aircraft Equipment Problem Less Severe (2 Below and 5 Above). Furthermore in 6 instances the event was classified as an In-flight Event / Encounter Loss of Aircraft Control (1 Below and 5 Above).

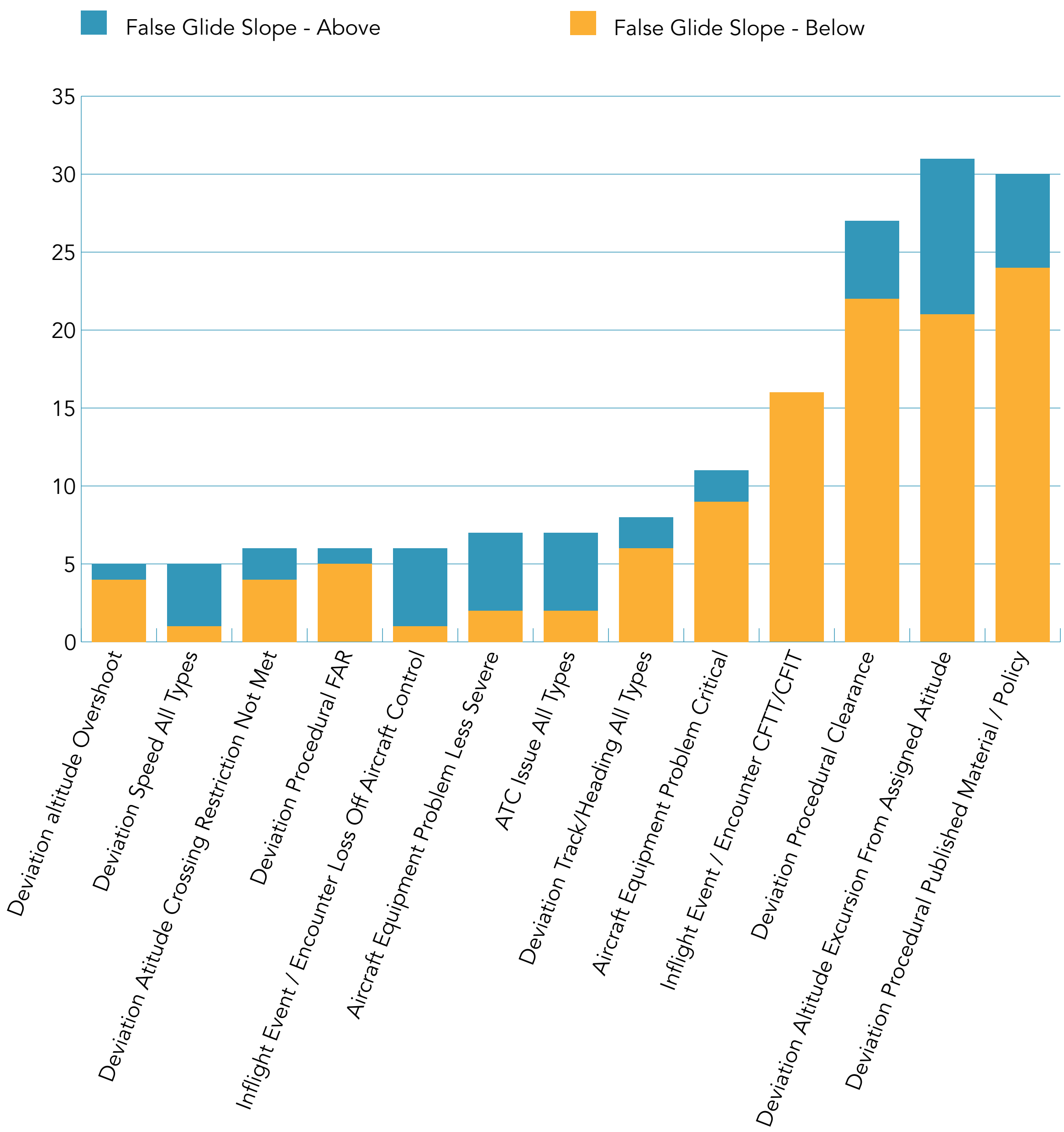

Figure 3: Overview of False Glide Slope event anomalies.

The assessment of the primary problem adjusted for percentages shows that Human Factors (45% Below and 27% Above) have a large contribution. Additionally, ATC equipment is assessed as the primary problem for 30% of False Glide Slope events.

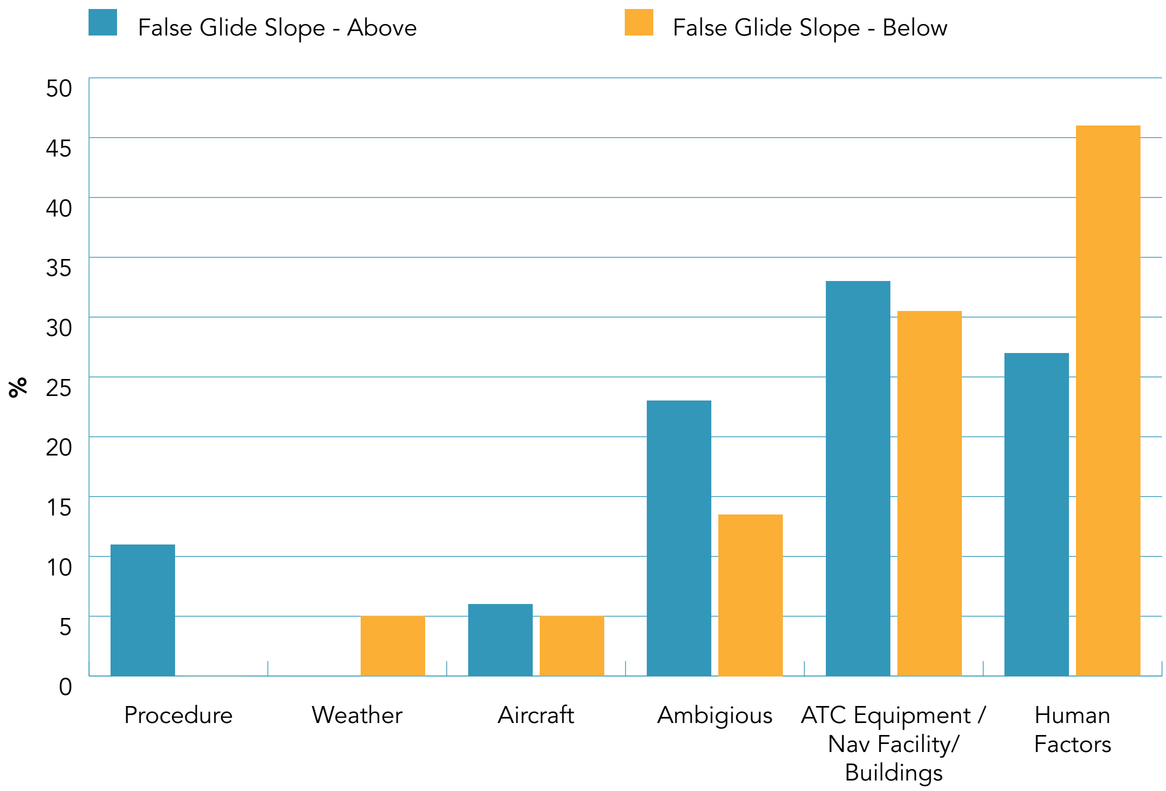

Figure 4: Overview of False Glide Slope assessments as primary problem.

In 25 cases a component problem was inserted into the database as a contributing factor. The three descriptions in the database for the component problem were: Design, Improperly operated or Malfunction. For the Glide Slope 'Above' events the contribution is spread equally. The data show a larger percentage is attributed to Malfunction for Glide Slope 'Below' events, but due to the smaller number of events this is is not considered significant.

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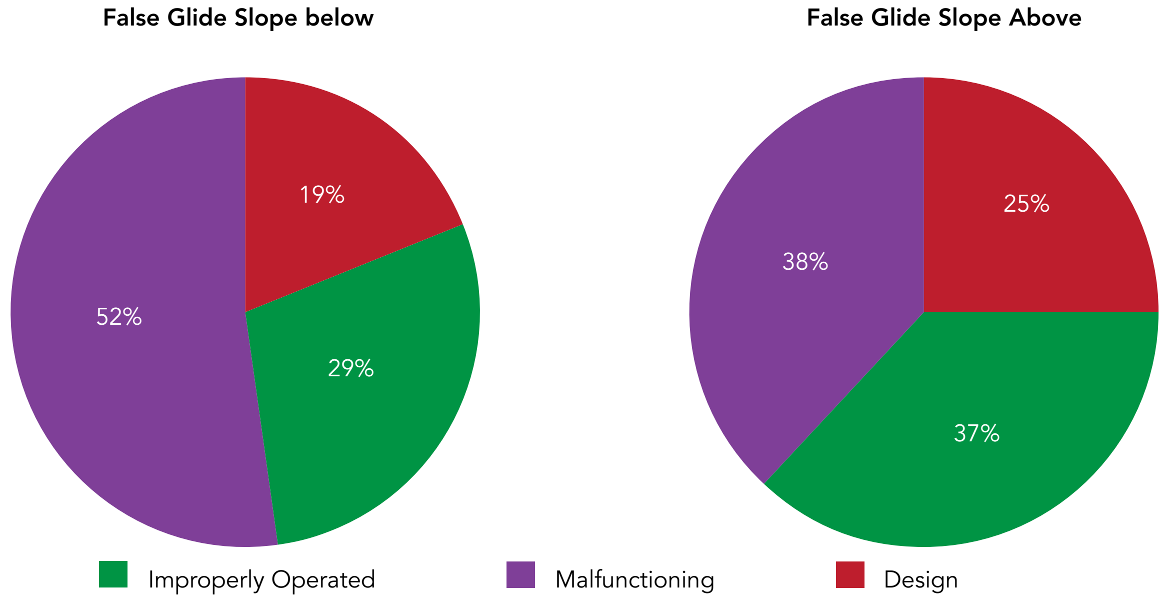

Figures 5 and 6: Division of False Glide Slope below and above Glide Path as component problem.

The pitch-up upsets for the above Glide Path analyses showed that aircraft of different manufacturers were involved in these reports. This is supported by the occurrences reported in the previous paragraphs.

The investigation of the 'Eindhoven incident' revealed that four other events occurred in Europe. Similar occurrences have been reported in the past and were inserted in the voluntary reporting system in the United States of America. The analysis of the ASRS shows that a distinction can be made between Glide Slope events from 'Above' and 'Below'. The 19 pitch-up upset events above the Glide Slope attributed to the main cause to a False Glide Slope. The ASRS assessment of the problem is not definitive but the database suggests that human factors and navigation facility equipment plays a major part.

Conclusion
Pitch-up upsets were reported to European national occurrence databases and the voluntary NASA ASRS database.

Analysis of similar events and database analyses suggests that aircraft pitch-up upsets have occurred with a variety of aircraft model types and manufacturers.

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3 ILS – FALSE GLIDE SLOPES

This chapter describes the ILS Glide Slope system in general terms and Glide Slope antenna systems in particular. Also, the prevailing theory regarding False Glide Slopes and the information in handbooks and manuals are described. Furthermore, the results of Glide Slope signal measurements made during the Eindhoven investigation are presented and the signal characteristics are analysed. The Glide Slope intercepting methods in Airbus and Boeing aircraft manuals are described, as are methods of verifying altitude in relation to the distance to the runway during the approach. The next paragraphs deals with an analysis of the relationship between aircraft automation and flight path management with regard to the investigated incidents. The chapter ends with an overiew of the actions taken by different parties.

3.1 Instrument Landing System Theory

3.1.1 General information

ILS is a navigation aid used worldwide to facilitate the approach and landing of aircraft. ILS is a ground-based radio wave system providing both lateral and vertical guidance to aircraft at airports under all weather conditions.[19]

An aircraft follows a Standard Published Instrument Approach or is given directions (i.e. radar vectors) from ATC to the ILS coverage area where the aircraft systems can receive the Localizer and Glide Slope signals to make a landing on automatic systems. An ILS can consist of the following ground based components:

- Localizer transmitter which transmits the lateral guidance signal
- Glide Slope transmitter which transmits the vertical guidance signal
- Marker Beacons which transmit vertical signals

Distance Measuring Equipment (DME) which transmits a signal for distance away from a fixed point, usually the runway threshold. The ILS contains Localizer and Glide Slope transmitters. ILS equipment can be supplemented with Marker Beacons and/or DME. The relevant components are described in the following paragraphs.

3.1.2 Localizer – lateral guidance

A Localizer antenna is normally located beyond the departure end of the runway. It generally consists of several pairs of co-located directional antennas, which transmit two signals. One signal is modulated at 90 Hertz (Hz), the other at 150 Hz. Each antenna transmits a narrow beam, one slightly to the left of the runway centre line, the other slightly to the right.

19 There are three instrument landing system categories (I, II and III) each with different decision height (DH) and minimum runway visual range (RVR). The decision altitude is different for each ILS category and depends on the aircraft onboard receiving equipment, flight crew qualification and certification standard ILS antenna system.

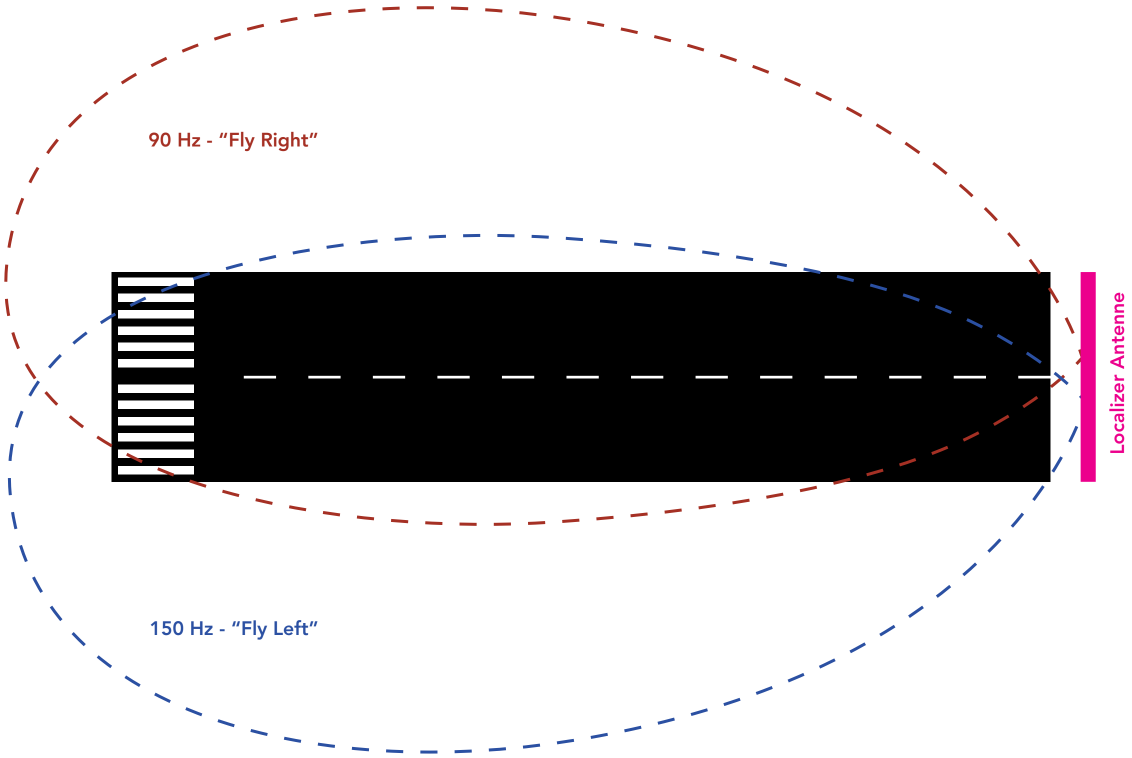

Figure 7: Lateral guidance by the Localizer antenna.

The Localizer receiver on the aircraft measures the Difference in the Depth of Modulation (DDM) of the 90 Hz and 150 Hz signals. The difference between the two signals varies depending on the deviation of the approaching aircraft from the runway centreline. If there is a predominance of either 90 Hz or 150 Hz modulation, the aircraft is off the centreline. If the DDM is zero, the aircraft is on the runway centreline.

3.1.3 Glide Slope – vertical guidance

Vertical guidance is provided using the same method of DDM measuring as with the Localizer. The Glide Slope antenna is situated to one side of the runway touchdown zone. The centre of the Glide Slope signal is arranged to define a Glide Path of approximately 3 degrees above touchdown ground level. The Glide Slope receiver on the aircraft measures the DDM of the 90 Hz and 150 Hz signals similarly to that of the Localizer (Figure 8). For a standard 3 degree Glide Path the relative signal strength of the 'Fly Up' (150 Hz) command and the 'Fly Down' (90 Hz) command is equal (Null).

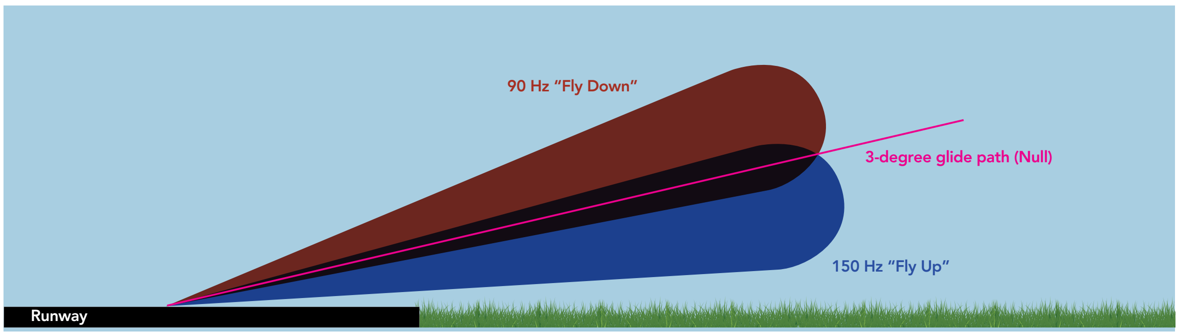

Figure 8: Vertical guidance Glide Slope signal with 150 Hz 'Fly Up' and 90 Hz 'Fly Down'.

Five types of Glide Slope antenna systems are used worldwide, three of which are Imaging Type antennas. These three types are referred to as Null Reference, Sideband Reference, and Capture Effect or M-array (Figure 9). The two non-imaging type antennas are the Endfire and Waveguide. The non-imaging type ILS Glide Slope antenna systems were excluded from the investigation because they are infrequently used.

System	Type	Antennas
Sideband	Image	2
Null Reference	Image	2
Capture effect or M-Array	Image	3
Endfire	Non-image	Multiple
Waveguide	Non-image	Multiple

Table 1: Overview of Glide Slope antenna types.

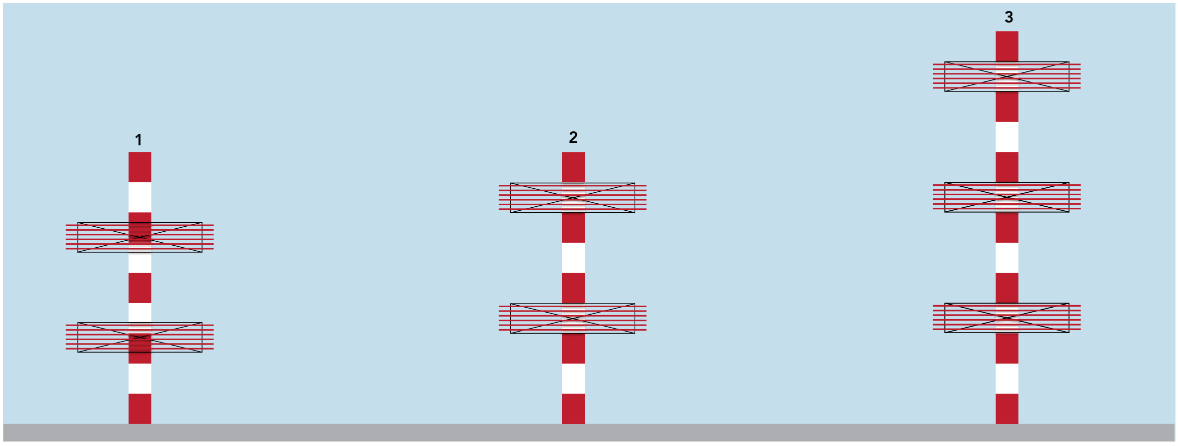

Figure 9: Example ILS Glide Slope antenna types: Sideband (1), Null Reference (2) and Capture effect (M-array) antenna (3).

Null reference system

The Null reference system employs two antennas, one top and one bottom. The lower antenna has the carrier wave modulated by two tones (90 and 150 Hz) in equal strength (CSB). The top antenna carries the sideband (90 and 150 Hz) with the carrier suppressed (SBO), and the two tones are out of phase to each other. This antenna setup results in a signal field characteristic whereby the 150 Hz signal is enhanced and the 90 Hz signal reduced below the Null. Above the Null the 90 Hz signal is enhanced and 150 Hz signal reduced. This combination of antenna signals will create a Glide Slope field as shown in Figure 10.

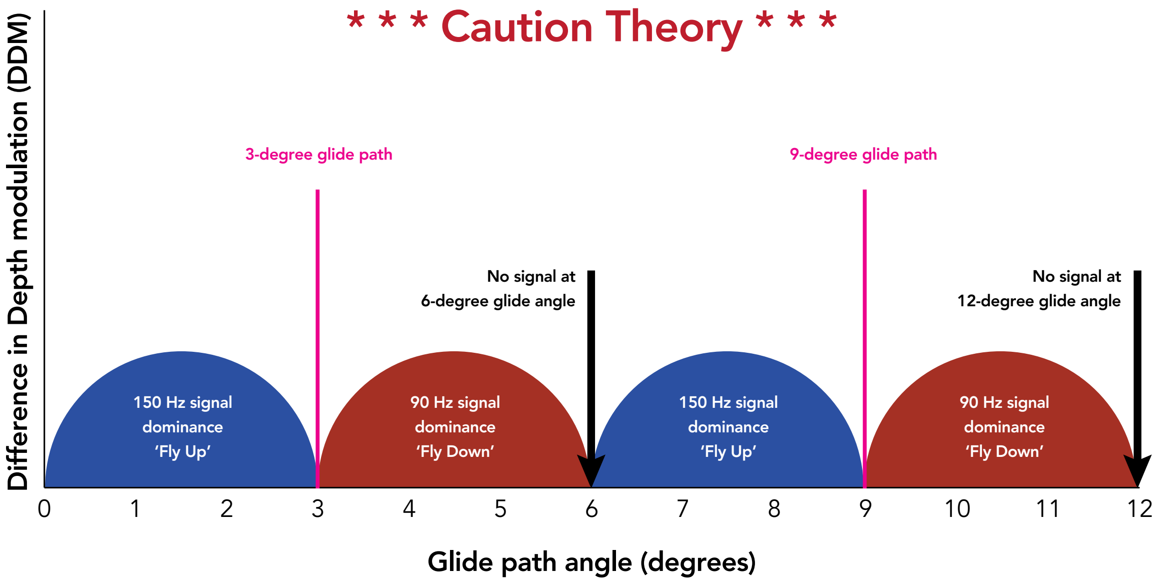

Figure 10: Theoretical plot for the Null Reference antenna system type radiation pattern (90 Hz and 150 Hz) resulting in a 'Fly Up' and 'Fly Down' with the Glide Path angle on the X-axis.

Sideband reference system

The sideband reference system has been used to provide Glide Path guidance since 1960. It also employs two antenna elements, one located above the other. The upper element transmits one signal (Side Band Only - SBO) and the lower element two signals (Carrier and sideband + Side Band Only – CSB and SBO). The SBO signal radiated by the lower element is 180 degrees phase displaced with respect to the SBO signal from the upper element. This combination of antenna signal will create a Glide Slope field as shown in Figure 11.

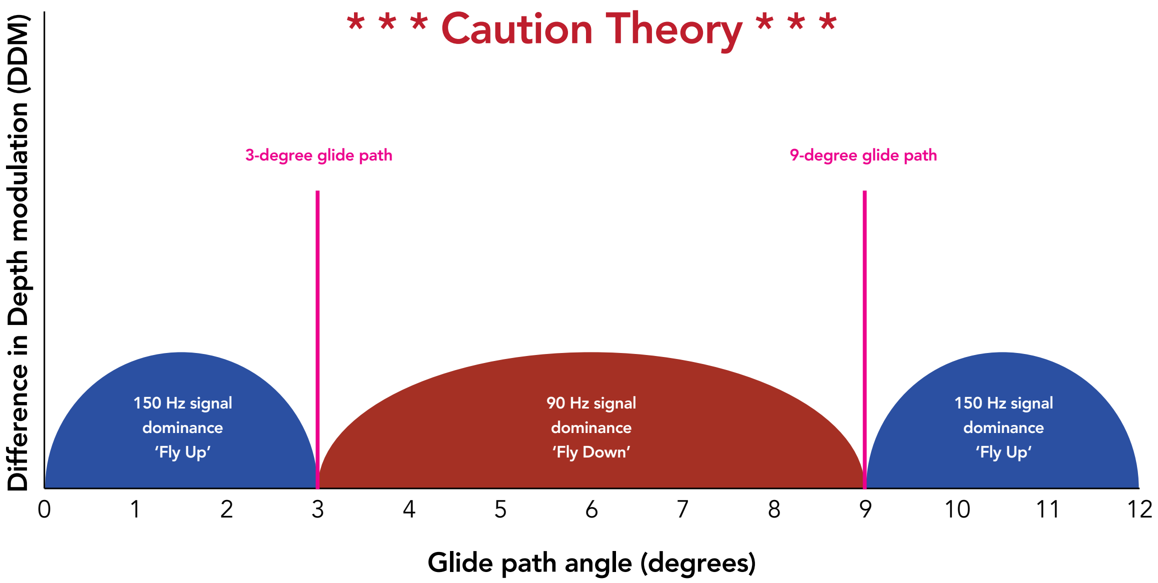

Figure 11: Theoretical plot of the Sideband Reference antenna type radiation pattern (90 Hz and 150 Hz) resulting in a 'Fly Up' and 'Fly Down' with the Glide Path angle depicted on the x-axis.

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The sideband reference system is just as susceptible to above-ground interference as the Null Reference system, but it has the merit of requiring an image plane of only 700 meters for a 3 degree Glide Path angle.

M-array system
The M-array system has also been widely used since 1960 and is often referred to as the Capture Effect array. The M-array system uses a three-element array with the upper, middle and lower elements being driven with SBO signals, and the middle and lower elements both being driven with CSB signals. The upper and lower element SBO driving signals have the same amplitude and are out of phase, whilst the middle element SBO signal has twice the amplitude. The middle element CSB drive signal has amplitude and is in phase and the lower element CSB signal has twice the amplitude and is out of phase. The M-array Glide Slope field is a complex addition and subtraction of 90 Hz and 150 Hz signals, the result is shown in Figure 12.

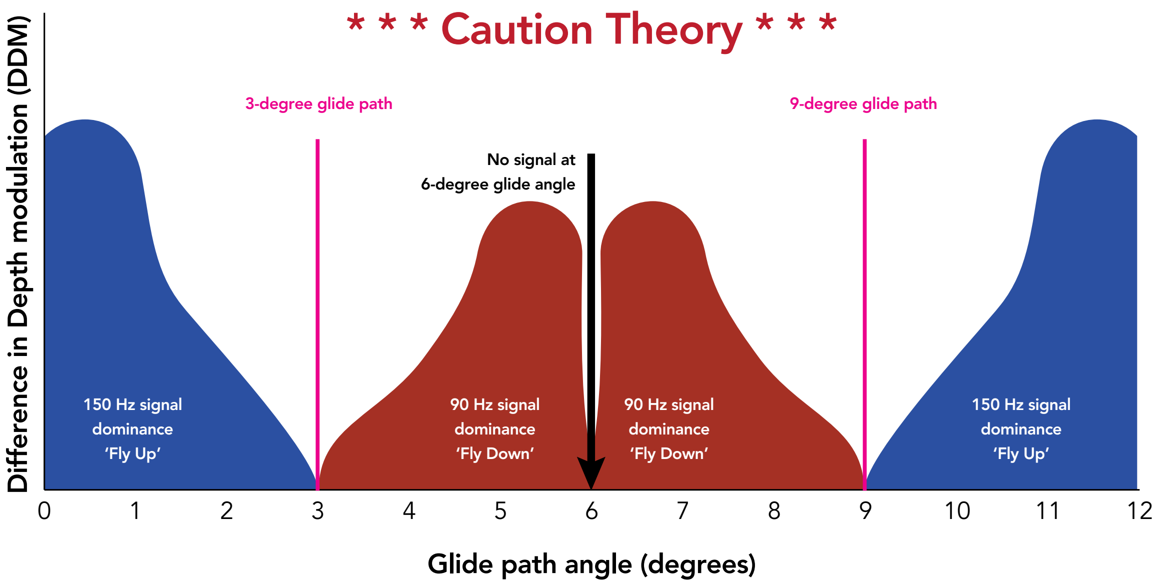

Figure 12: Theoretical plot of the M-array type radiation pattern (90 Hz and 150 Hz) resulting in a 'Fly Up' and 'Fly Down' with the Glide Path angle depicted on the x-axis [0-12 degrees].

3.1.4 Numbers and locations of ILS Image Type Glide Slope antennas

It is estimated that worldwide there are approximately 1,500 - 2,000 runways equipped with an ILS.[20] In the Netherlands only M-array antenna systems are used at ILS equipped airports. Following inquiries the CIAIAC confirmed that the incident at Murcia Airport involved a M-array ILS antenna. The BEA confirmed that the incident at Paris Charles de Gaulle Airport involved a M-array ILS antenna. And the ANSV confirmed that the incident at Treviso Airport involved a M-array ILS antenna too.

20 In the first quarter of 2014 Jeppesen published 4399 ILS procedures worldwide, the 1,500-2,000 runways equipped with an ILS is an estimate.

Thales, one of the manufacturers constructing M-array antenna systems provided information that approximately 430 M-array (LS420 type) ILS systems have been installed in 80 countries worldwide. No information is available to flight crews on which type of ILS antenna is installed at an ILS equipped runway.

3.1.5 ILS errors

An ILS is commonly perceived as transmitting a focused Localizer and Glide Slope beam that form a narrow electronic 'funnel' leading to the runway. In reality ILS antennas transmit a complex radiation field. Due to the complexity of this field two different types of errors can be distinguished.

- Erroneous Localizer or Glide Slope signal.
- False Localizer or Glide Slope signal.

An erroneous signal is a deviation of the signal due to an anomaly. The anomaly can be of a static nature, e.g. the signal is reflected by fixed objects such as aircraft hangars or airport fencing. A second type of erroneous signal is dynamic in nature. The erroneous signal is reflected by moveable objects such as aircraft taxiing in the runway environment. ILS critical and sensitive areas around Localizer and Glide Slope facilities are therefore defined in order to protect aircraft on approach from dynamic multipath effects that could cause the ILS signal-in-space to exceed allowable alignment and tolerances. Another example of an erroneous signal is when the ILS Glide Slope antenna transmitter is left in test mode.[21]

A second error type of the ILS signal is the False Glide Slope. This error differs from the previous type as it is an artefact of the Glide Slope antenna itself. According to various manuals a pilot can recognize this False Glide Slope by the steeper-than-normal rate of descent. Pilots can avoid encountering a False Glide Slope by following published instrument approach procedures (More information in paragraph 3.2).

All aircraft ILS receivers are required to implement the ICAO-specified warning to alert the pilot when the Localizer or Glide Slope ground station has developed flaws such as low modulation or reduced signal strength.[22] When a viable signal is not being received from the ground equipment, or when a receiver is malfunctioning to such an extent that the output is not reliable, a 'warning flag' (OFF) will appear on the appropriate place on the PFD.

3.1.6 ILS status inspection and certification

Electronically Monitoring

The status of the ILS is monitored in different ways. The operation of the ILS is permanently monitored electronically. In case of equipment malfunctioning, the

21 The erroneous signal anomaly became apparent during the investigation of the Air New Zealand Boeing 767 approach to Apia (Controlled Flight Towards Terrain) http://flightsafety.org/fsd/fsd_jul02.pdf.

22 ICAO Annex 10, paragraph 2.7.1 states: 'Radio Navigation aids of the types covered by the specifications in Chapter 3 and available for use by aircraft engaged in international navigation shall be the subject of periodic ground and flight checks.'

electronic monitor system switches the equipment off in less than one second (LS420). In the airport control tower indicator lights show the status of the system and which ILS/DME system is in use (active runway).

Airborne Flight Inspection
ICAO mandates that Radio Navigation aids of all types which are available for use by aircraft engaged in international navigation shall be the subject of periodic ground and flight checks.[23] Ground measurements cannot completely assure the quality of the signal in space due to the environmental effects of terrain, man-made obstructions, Radio Frequency Interference (RFI), and reflective surfaces such as snow, water and other aircraft. The use of specially equipped aircraft, precisely positioned (laterally and vertically), is the only effective method of evaluating a signal-in-space or instrument flight procedure. Flight inspection certifies instrument approaches and ensures that an aircraft at the lowest authorized altitude is guaranteed to be safe from ground obstacles.

Flight inspection is traditionally based on in-flight measurement of the signal in space produced by air navigation systems on board a calibration aircraft. During flight inspections the 3 degree ILS Glide Slope signal is inspected in different ways, including at a prescribed flight offset, to verify a valid 3 degree Glide Slope signal.

The inspection is based on the ICAO prescribed performance standard.[24] The Glide Path equipment must provide signals sufficient to allow satisfactory operation of a typical aircraft installation in sectors of 8 degrees in left and right (azimuth) on each side of the centreline of the ILS Glide Path, to a distance of at least 18.5 km (10 NM) up to 5.25 degrees (1.75*θ and θ=3 degrees) and down to 1.35 degrees (0.45*θ). According ICAO SARPs, there are no regulations requiring that the signal of the system should be checked above 5.25 degrees. Therefore, the use of ILS above a 5.25 degree Glide Path is not part of the ILS ICAO certified volume of operation.

The inspected area is normally situated between 0 and 10 NM from the runway threshold and approximately 35 degrees left and right of the runway heading (Localizer). The ILS antenna system is checked and if required adjusted at least once a year.

3.2 Generally available False Glide Slope information

This paragraph gives a summary of information regarding the subject False Glide Slope that is available to aviation stakeholders such as flight crews and aircraft operators. The information presented is general and serves as reference only.

Information that is available to Boeing 737NG flight crew is the Flight Crew Training Manual (FCTM). In the 737NG FCTM, the description of the False Glide Slope signal is focused on detection (altitude - range relationship). When a False Glide Slope is suspected a missed approach should be initiated.

23 ICAO Annex 10 Volume I, Chapter 2, 2.7 [ICAO Standard].
24 ICAO Annex 10 par. 3.1.5.1.1 [ICAO Standard] and 3.1.5.3.1. [ICAO Standard].

Boeing FCTM 737NG June 2013 (excerpt from page 5.16)
There have been incidents where airplanes have captured False Glide Slope signal and maintained continuous on Glide Slope indication as a result of an ILS ground transmitter erroneously left in the test mode. False Glide Slope signals can be detected by crosschecking the Final Approach Fix crossing altitude and VNAV path information before Glide Slope capture. A normal pitch attitude and descent rate should also be indicated on final approach after Glide Slope capture. Further, if a Glide Slope anomaly is suspected, an abnormal altitude range-distance relationship may exist. This can be identified by crosschecking distance to the runway with altitude or crosschecking the airplane position with waypoints indicated on the navigation display. The altitude should be approximately 300 feet HAT per NM of distance to the runway for a 3 degree Glide Slope.

If a False Glide Slope capture is suspected, perform a missed approach if visual conditions cannot be maintained.

For some additional theoretical background the Federal Aviation Administration (FAA) Instrument Handbook gives additional information on ILS errors. According to the FAA Instrument Flying Handbook, Glide Slope needle gyration and a warning flag will be presented before various False Glide Paths are passed. The lowest of the False Glide Paths occurs at approximately 9-12 degrees. The False Glide Path is described as a signal that produces a higher vertical angle.

Instrument Flying Handbook FAA-H-8083-15B
U.S. Department of Transportation Federal Aviation Administration 2012

ILS Errors (page 9-40)
The ILS and its components are subject to certain errors, which are listed below. Localizer and Glide Slope signals are subject to the same type of bounce from hard objects as space waves.

1. Reflection. Surface vehicles and even other aircraft flying below 5,000 feet Above Ground Level may disturb the signal for aircraft on the approach.
2. False courses. In addition to the desired course, Glide Slope facilities inherently produce additional courses at higher vertical angles. The angle of the lowest of these false courses occurs at approximately 9°–12°. An aircraft flying the Localizer/Glide Slope course at a constant altitude would observe gyrations of both the Glide Slope needle and Glide Slope warning flag as the aircraft passed through the various false courses. Getting established on one of these false courses results in either confusion (reversed Glide Slope needle indications) or in the need for a very high descent rate. However, if the approach is conducted at the altitudes specified on the appropriate approach chart, these false courses are not encountered.

To get quick access to information related to a False Glide Slope, an internet search will show Figure 13. This picture shows that at a 6 degree Glide Slope a (warning) Flag will appear and at 9 degrees a False Glide Slope is present. This is a Glide Path with a higher than normal descent rate.

*** * Caution: Incorrect representation glide slope signals * ***

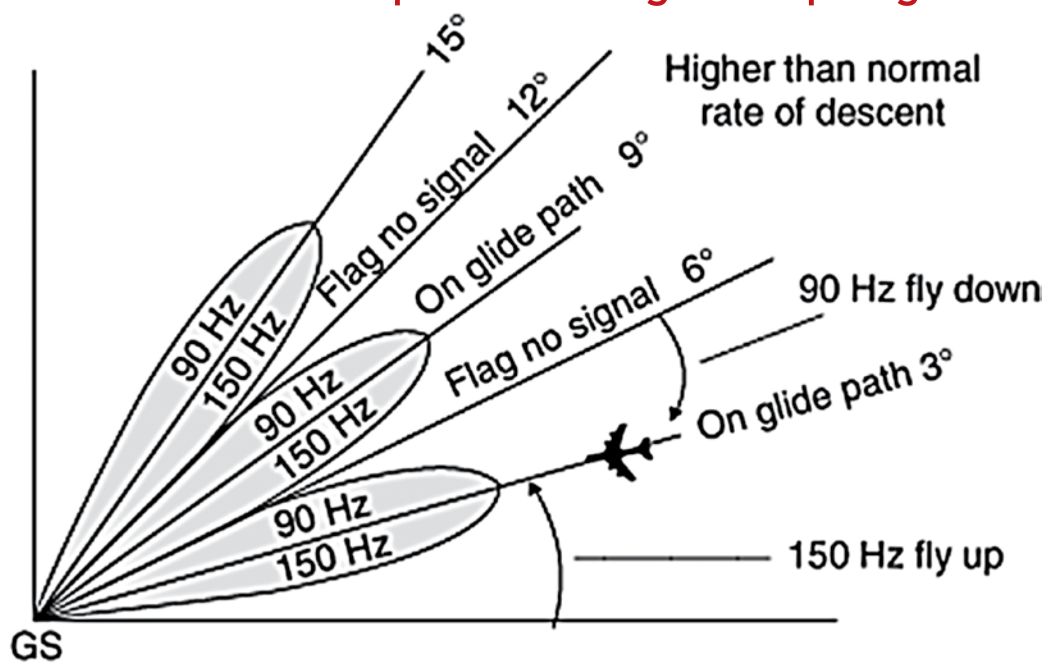

Figure 13: Depiction of the False Glide Slope as can be commonly found on the internet [source: http://www.answers.com/topic/false-glide-slope (McGraw-Hill Dictionary of Aviation: False Glide Slope)].

3.3 Instrument Landing System Glide Slope measurements

As part of this investigation, measurements were conducted to determine the Glide Slope fields of the three different Image Type array antenna systems. The primary goal of the measurement was to determine the Glide Slope field (direction and strength), specifically above the 3 degree Glide Path. In order to conduct this type of field measurement an aircraft equipped with a Flight Inspection System (FIS) is required. The FIS records various parameters and is normally used to verify and calibrate ILS as described in paragraph 3.1.6.

Because no Sideband or Null Reference ILS antennas are present in the Netherlands these two antenna types were measured at the request of the National Transportation Safety Board (NTSB) by the FAA in the United States of America. The results of these measurements are presented in the subsequent paragraphs.

3.3.1 Measurements of M-array antenna systems – The Netherlands

Three measurements of M-array antenna systems with a laboratory aircraft were performed at two different airports in the Netherlands: at Woensdrecht Air Base and at Eindhoven Airport, runways 03 and 21. As part of the measurements the Glide Slope logic and the reaction of the automatic flight system were also considered.

Figure 14: Cessna Citation II on the ground at Woensdrecht Air Base with the M-array ILS Glide Slope antenna in the background.

The approach flight profiles at Amsterdam Airport Schiphol (2011), Paris Charles de Gaulle (2012) and Eindhoven Airport (2013),where false Glide Slopes were captured and pitch-up upsets occurred were also flown during the measurement flights. The goal of these measurements was to verify and understand the occurrences and to test the capture logic of the automatic flight system of the laboratory aircraft. For detailed information on the flight tests procedure and results, see Appendix G.

Summary of the horizontal measurements at Woensdrecht Air Base (figure 15)
The measurements at Woensdrecht Air Base showed that a 'Fly Down' indication was measured between the 3 and 6 degree Glide Path. Around the 6 degree Glide Path a small 'Fly Up' indication area was present. This area triggered the Glide Slope capture logic in the aircraft instruments and the aircraft subsequently followed the 'Fly Up' command. Between approximately the 6 and 9 degree Glide Path a 'Fly Down' was measured. Hereafter a 'Fly Up' signal was measured. See Figure 15 for the results.

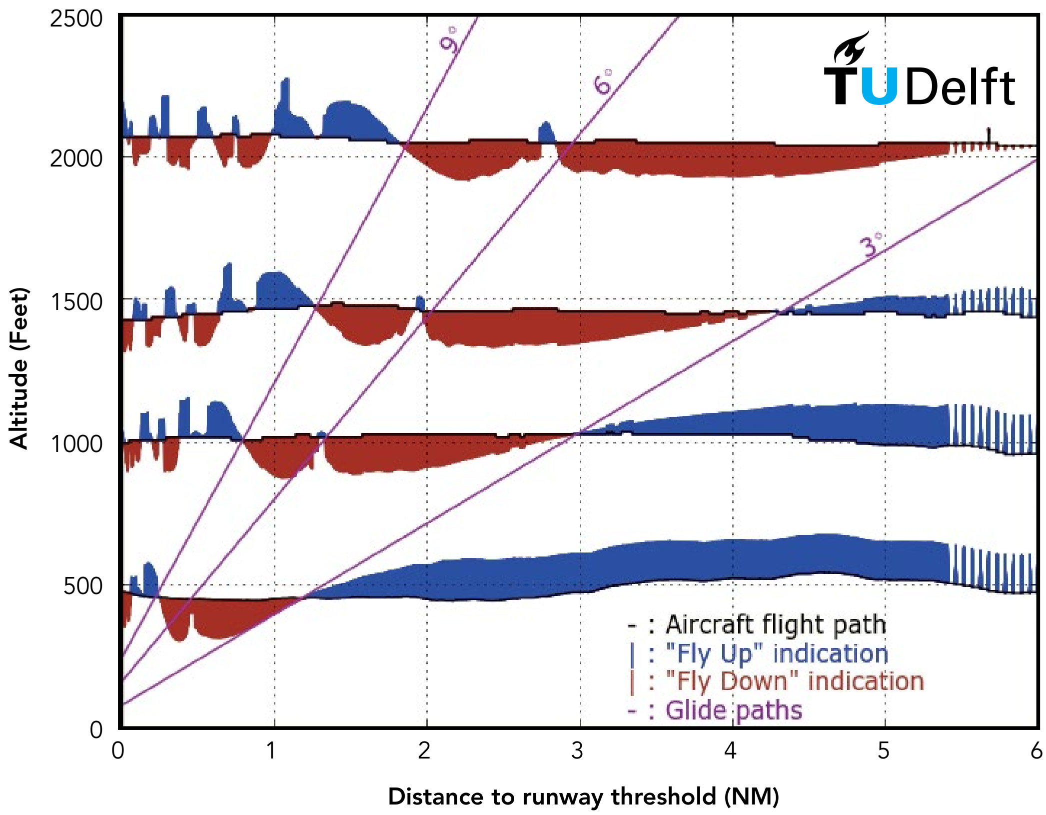

Figure 15: Different level flight measurements at Woensdrecht Air Base.

Summary of measurement flights Eindhoven Airport Runway 21 (Figure 16)
The horizontal measurements at Eindhoven Airport showed that a 'Fly Down' indication was measured between the 3 and 9 degree Glide Path. Between the 9 and 15 degree Glide Path a 'Fly Up' indication was present.

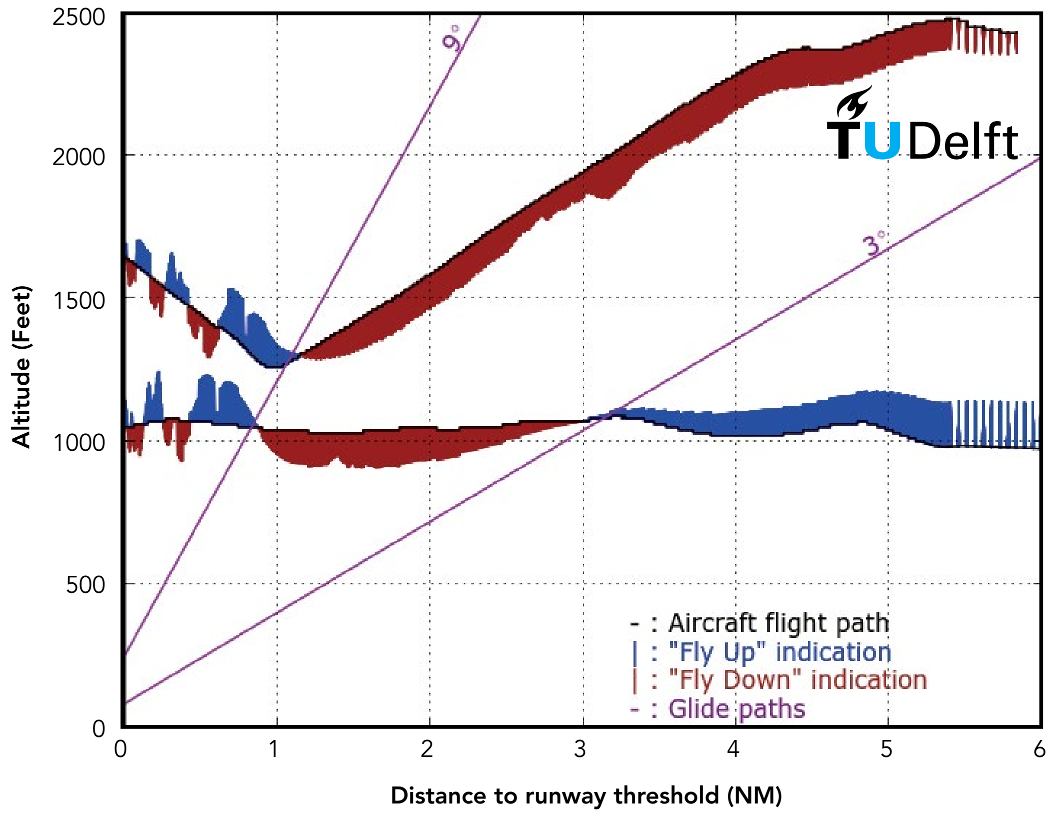

Figure 16: 1,000 feet level and diagonal run measurement flight at Eindhoven Airport Runway 21.

The diagonal measurement depicts the flight path of the Eindhoven incident (paragraph 1.1.1 and 2.1). This measurement was performed with the Glide Slope mode armed. The result was that around the 9 degree Glide Path, where a 'Fly Up' signal is present, the Glide Slope capture logic was triggered and the aircraft pitched-up rapidly. This test was identical to the Eindhoven incident and immediate flight crew intervention was required.

Summary of measurement flights Eindhoven Airport Runway 03 (Figure 17)
A second series of test flights were performed with a Swearingen Sa-226TC Metro II operated by the National Aerospace Laboratory (NLR) to measure the Glide Slope field at Eindhoven Airport Runway 03.

A measurement was performed at 2,000 feet in level flight and a descending run was performed with the autopilot not engaged. The measurement at Eindhoven Airport Runway 03 showed that a 'Fly Down' indication was measured between a 3 and 6 degree Glide Path. Around the 6 degree Glide Path a small 'Fly Up' indication area was present. Between approximately the 6 and 9 degree Glide Path a 'Fly Down' indication was measured. Hereafter a 'Fly Up' indication was measured between 9 and 15 degrees with a small area of 'Fly Down around 12 degrees. See Figure 17 for the results.

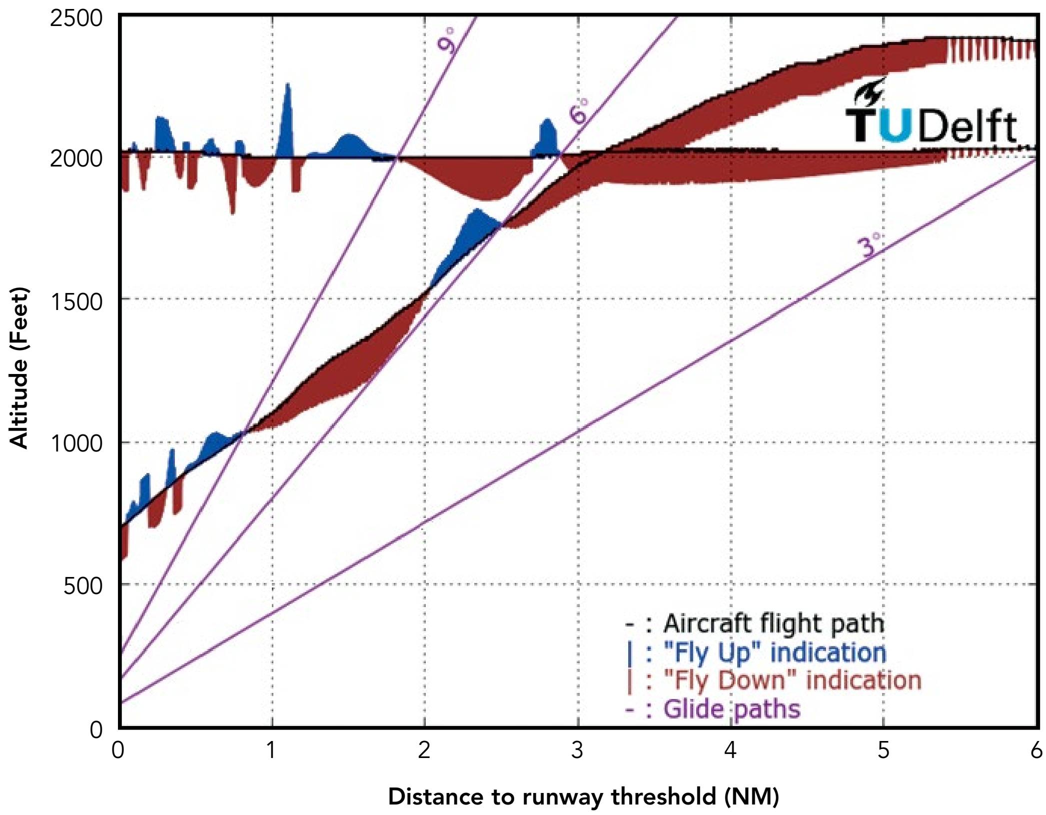

Figure 17: 2,000 feet level and diagonal run measurement flight at Eindhoven Airport Runway 03.

Summary of measurement results

The measurements in the Netherlands of three M-array antennas identified two different Glide Slope fields. These Glide Slope fields are different around the 6 degree Glide Path ('M-array 1 in table below'). The Glide Slope fields at Eindhoven Airport Runway 03 and 21 are different ('M-array 2 in table below').

ILS Glide Slope antanna system type	Glide path angle (degrees)				
	0 - 3	3 - 6	6	6 - 9	9 - 12
M-array field 1	↑	↓	↑	↓	↑
M-array field 2	↑	↓	↓	↓	↑

Legend: ↑ = GS signal "Fly Up" ↓ = GS signal "Fly Down"

Table 2: Generalised overview of the Glide Slope signal direction for the ILS M-array antennas that display two different Glide Slope fields.

3.3.2 FAA measurements ILS Glide Slope antenna systems

Sideband and Null Reference ILS are not available in the Netherlands; these antenna types were measured by the FAA, at the request of the NTSB, in the United States of America.

The FAA has a fleet of approximately 32 aircraft of 5 different types to execute its flight inspection program.[25] All aircraft are equipped with Flight Inspection equipment capable of performing the necessary measurements for this investigation. Following the measurement request, an additional level run was performed at 1,500 feet and field measurements were recorded until the runway threshold. Normally such a measurement is not part of the FAA flight inspection program.

A Beechcraft BE-300 performed the requested measurements during a normal Flight Inspection. The recorded data of a Null Reference and Sideband Reference Glide Slope antenna system was graphed and sent to the Dutch Safety Board for analysis. The results of the analyses are presented below.

Null Reference Glide Slope antenna system (Figure 18)
The measurement of the Null Reference Glide Slope antenna systems showed that below the 3 degree Glide Path a 'Fly Up' indication is present. Above the 3 and until the 6 degree Glide Path a 'Fly Down' indication is present. Hereafter signal reversal occurs around 6 degrees and a 'Fly Down' indication is present until approximately the 9 degree Glide Path. Above 9 degree Glide Path a 'Fly Up' indication is present.

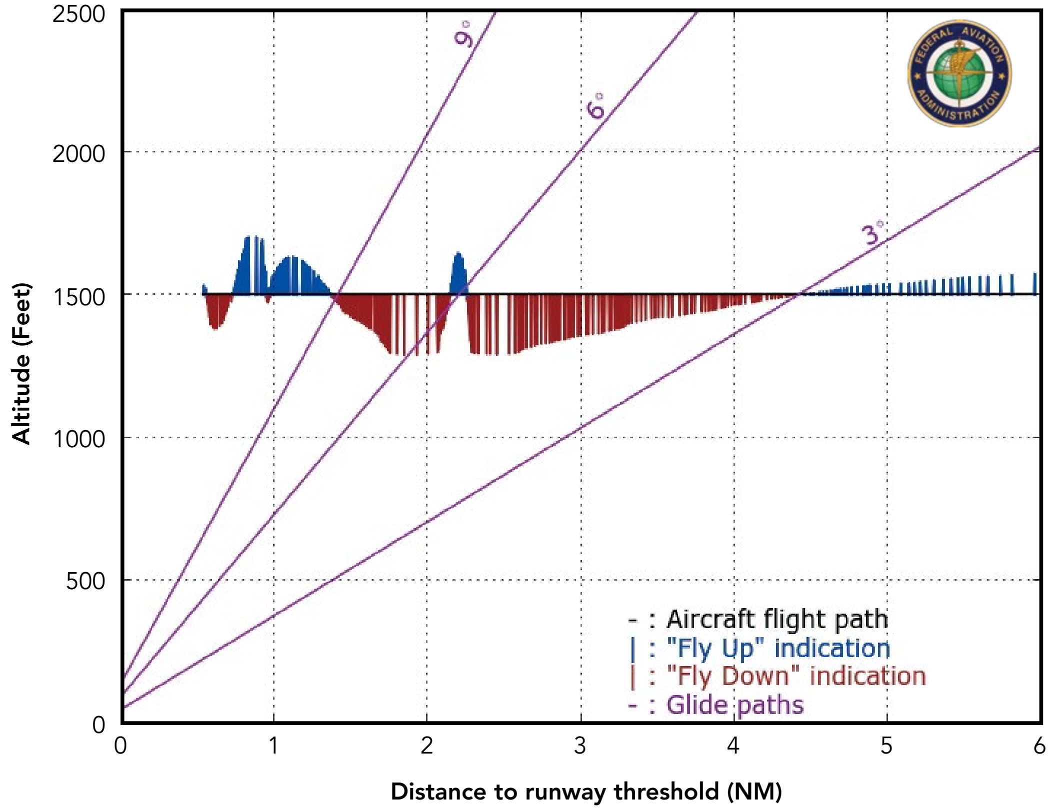

Figure 18: 1,500 feet level flight measurement of the Null Reference Glide Slope antenna system [source data FAA – adapted by the DSB].

25 These aircraft are: Challenger 601, Challenger 604, Challenger 605, Lear 60, and Beechcraft BE-300.

Sideband Glide Slope antenna system (Figure 19)
Measurement of the Sideband Glide Slope antenna systems showed that below the 3 degree Glide Path a 'Fly Up' indication is present. Above the 3 and until the 9 degree Glide Path a 'Fly Down' indication is present. Hereafter signal reversal occurs at approximately 12 degrees with a 'Fly Down' and then a 'Fly Up' indication.

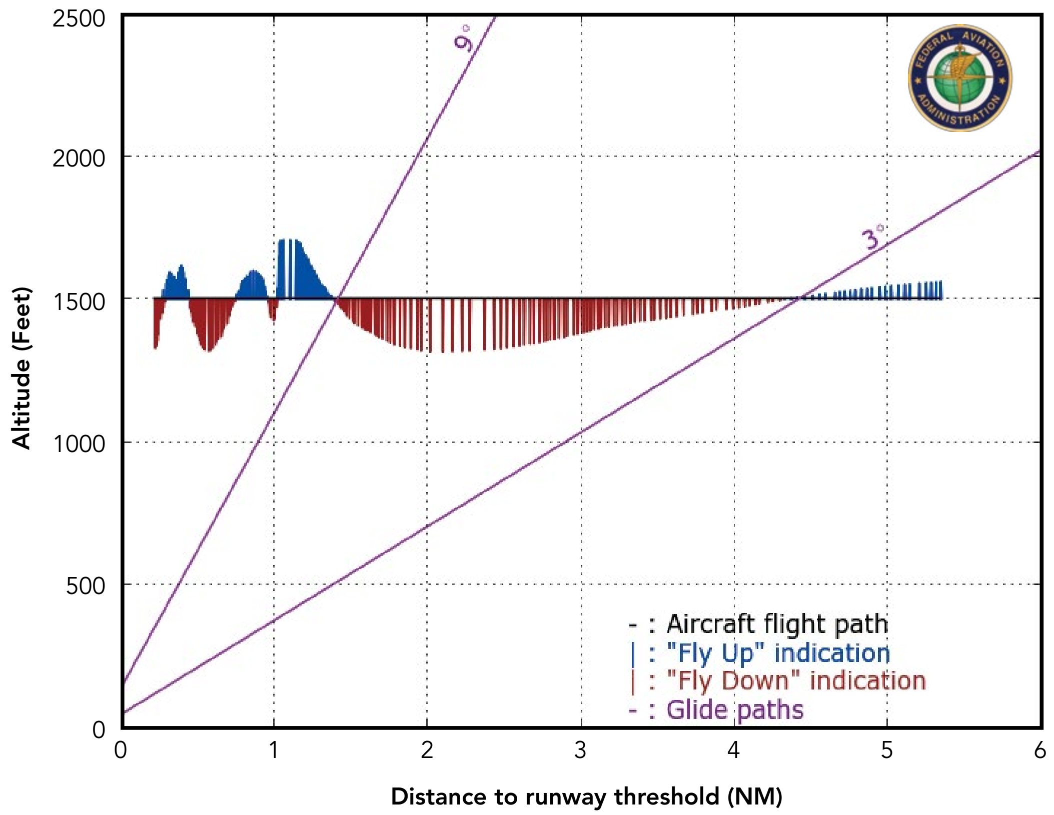

Figure 19: 1,500 feet level flight measurement of Sideband Glide Slope antenna system [source data FAA – adapted by the DSB].

Summary of measurement results
The measurements in the United States of America of the Null Reference and the Sideband antennas identified two different Glide Slope fields. These Glide Slope fields are different around the 6 degree Glide Path; the Null Reference has a signal reversal around 6 degrees.

ILS Glide Slope antanna system type	Glide path angle (degrees)				
	0 - 3	3 - 6	6	6 - 9	9 - 12
Null Reference	↑	↓	↑	↓	↑
Sideband Reference	↑	↓	↓	↓	↑

Legend: ↑ = GS signal "Fly Up" ↓ = GS signal "Fly Down"

Table 3: Generalised overview of signal direction for the Null Reference and the Sideband ILS Glide Slope system types, measured by the FAA.

3.4 Identified Glide Slope Characteristics

3.4.1 False Glide Slope Types

Two types of ILS errors were described in paragraph 3.2.5: an erroneous signal and a False Glide Slope. An erroneous signal was defined as a deviation (multipath effect) of the Glide Slope antenna signal due to an anomaly. Although this is an ILS error that can occur, it was not examined further because it has no relevance to this investigation. A second error type that was defined concerned False Glide Slopes, which are artefacts (characteristics) of the ILS Image Type antenna system. The analysis of this report focuses on these artefacts.

When a False Glide Slope is examined more closely two different types can be distinguished. The first type of False Glide Slope is the False Null. This type resembles a normal 3 degree Glide Slope to the ground but in fact it is not. For a normal 3 degree Glide Path the signal strengths of the 'Fly Up' (150 Hz) command and the 'Fly Down' (90 Hz) command are equal (Null). A False Null resembles the normal 3 degree Glide Slope signal (Null) but is actually either at the wrong location in space or has a steeper angle. Following a False Null signal will result in an aircraft having a higher than normal descent rate.

The second type of False Glide Slope that can be distinguished is the Signal Reversal. This Signal Reversal is 'unstable' as the ILS signal changes from 'Fly Down' to 'Fly Up'. When the autopilot is engaged in the appropriate mode, the 'Fly Up' signal will result in a command to pitch-up the aircraft.[26]

Type False Glide Slope	Effect False Glide Slope with automatic system engaged
False Null	The aircraft will follow a Glide Path with a higher than the normal descent rate.
Signal Reversal	The aircraft may pitch-up depending on aircraft type and Glide Slope logic.

Table 4: Overview of the False Glide Slope type and characteristics.

Accessible information and received wisdom makes no distinction between the two types of False Glide Slope. The distinction between the False Null and the Signal Reversal will be used for the remainder of the report to show the different False Glide Slope phenomena.

3.4.2 Identified Glide Slope field characteristics

Glide Slope signal measurements have been conducted for this investigation for all three Image Type antenna systems (Sideband Reference, Null Reference, M-array). These measurements focused on the area above the 3 degree Glide Path and the results are described in paragraph 3.3. Two different Glide Slope field characteristics could be distinguished from the flight test measurements.

26 The effect of Glide Slope capture depends on aircraft type and Glide Slope logic used in that particular aircraft. Some aircraft autopilots, including for example the Boeing 747-400, 777 and 787, use logic that does not permit capture of the Signal Reversal False Glide Slope beam above the 3 degree Glide Path.

The first type of field is depicted schematically in Figure 20. Below the 3 degree Glide Path a 150 Hz signal dominance ('Fly Up') is present. Following a 90 Hz signal dominance ('Fly Down') between the 3 degree and 9 degree Glide Path angle. Between 9 and 12 degree Glide Path angle a 150 Hz signal dominance is presents (Fly Up').

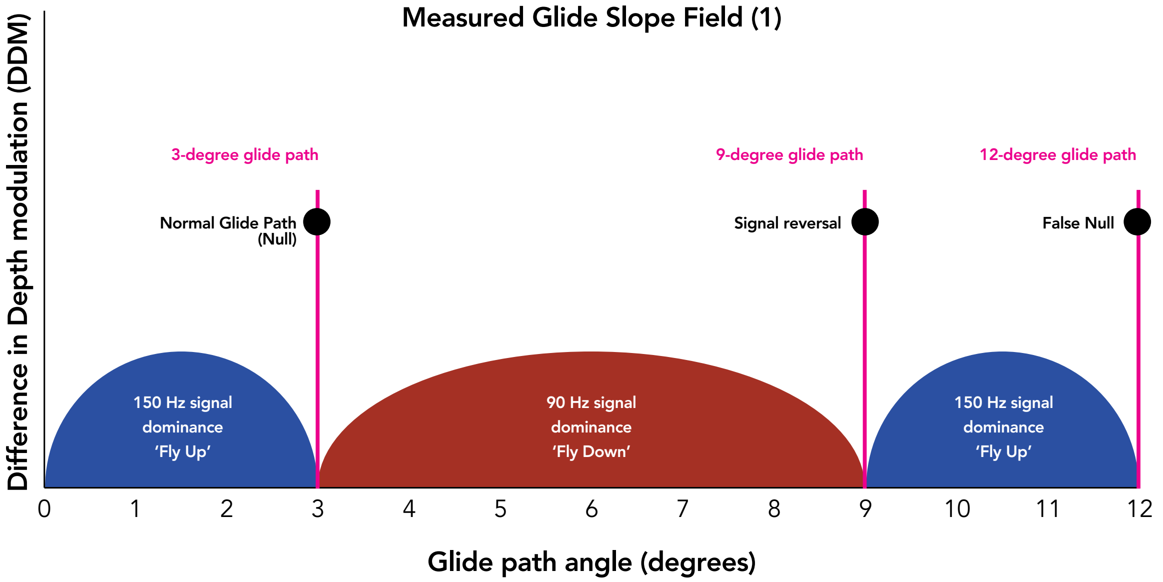

Figure 20: DDM versus Glide Path angle first Glide Slope field characteristic; signal reversal at 9 degree Glide Path (Sideband and M-array).

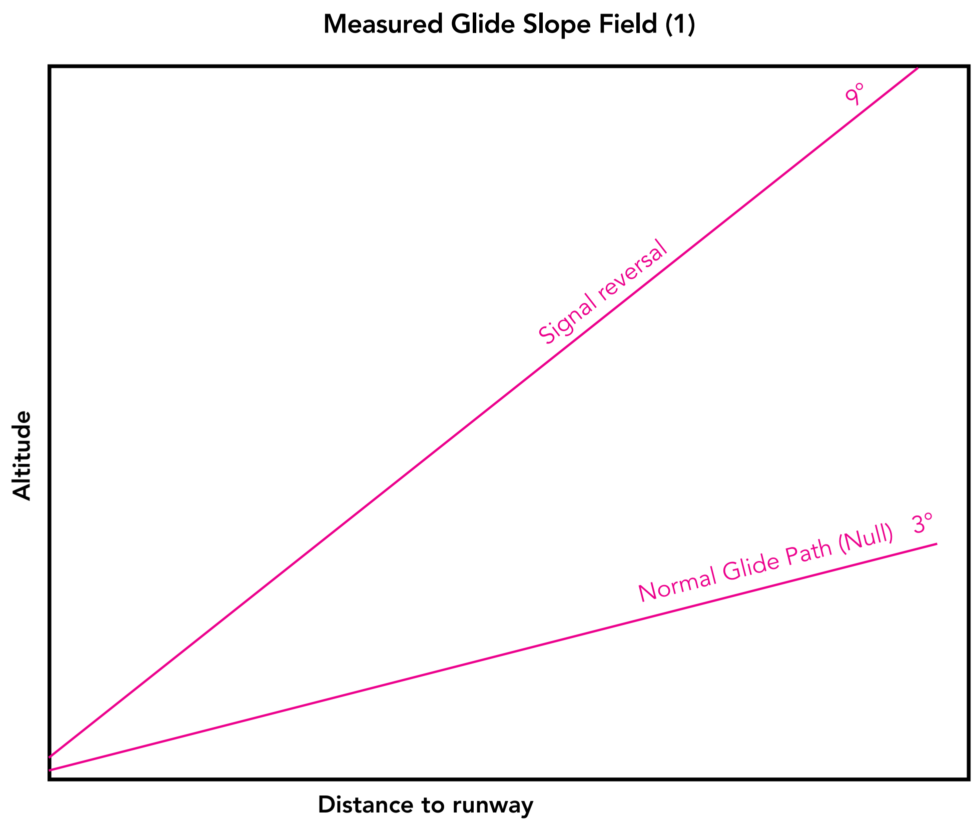

Figure 21: Cross section first Glide Slope field characteristic; signal reversal at 9 degree Glide Path (Sideband and M-array).

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The characteristic of this first Glide Slope field pattern type is that a Normal Glide Path (Null) is present at the 3 degree Glide Path angle, which was to be expected. At an angle of approximately 9 degrees a Signal Reversal occurs. At 12 degrees the a False Null appears, this will result in an aircraft following the Glide Path with a higher than normal descent rate. See Figure 21.

The second type of field is presented schematically in Figure 22. Below the 3 degree Glide Path a 150 Hz signal dominance ('Fly Up') is present. Following a 90 Hz signal dominance ('Fly Down') between the 3 degree and 6 degree Glide Path angle. Around the 6 degree angle a small area with 150 Hz signal dominance ('Fly Up') is present. Thereafter, until the 9 degree Glide Path angle a 90 Hz signal dominance is present ('Fly Down'). Finally, between the 9 and 12 degree Glide Path angle a 150 Hz signal dominance is presents ('Fly Up').

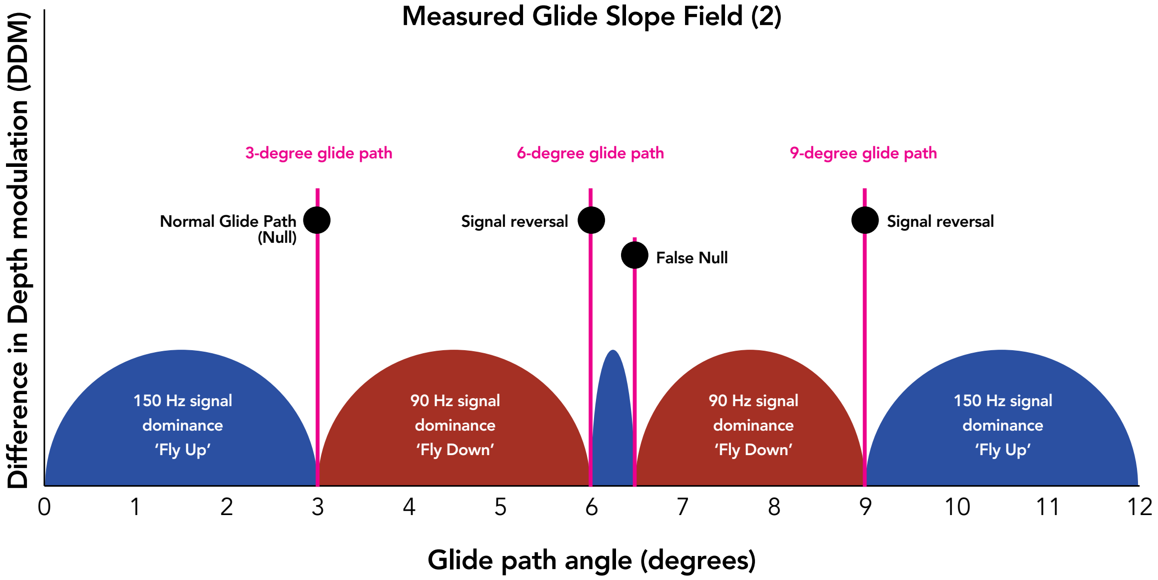

Figure 22: DDM versus Glide Path angle second Glide Slope field characteristic; first signal reversal at 6 degree Glide Path (Null reference and M-array).

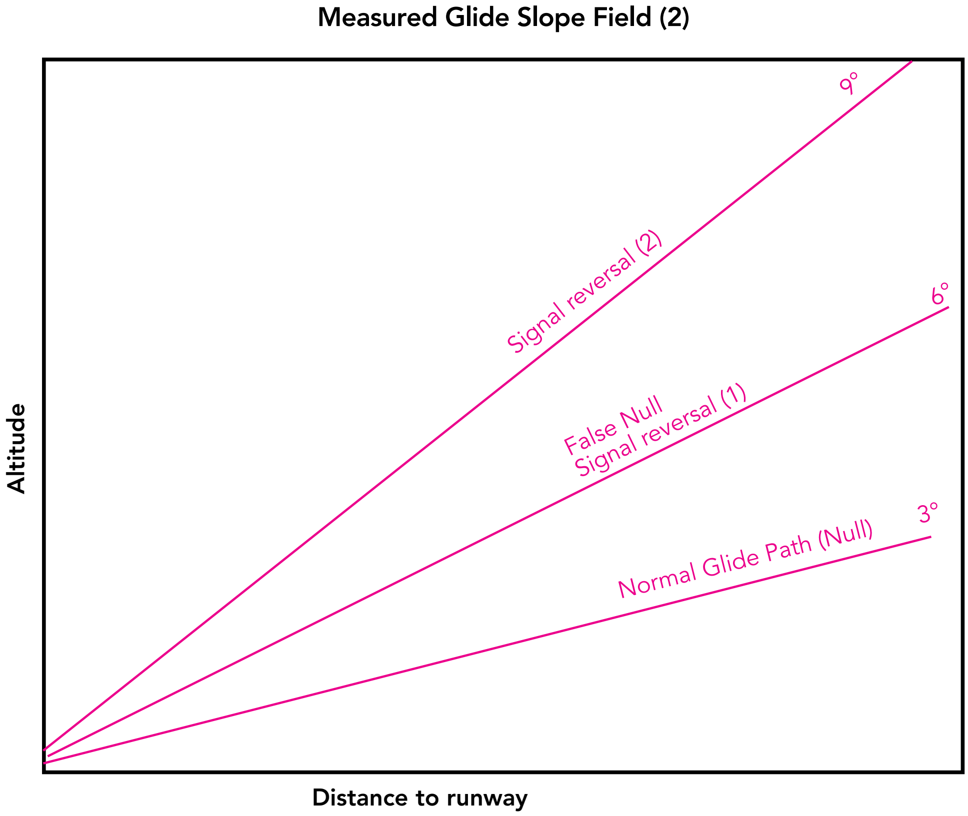

Figure 23: Cross section second Glide Slope field characteristic; first signal reversal at 6 degree Glide Path (Null reference and M-array).

The characteristic of this second Glide Slope field (Figure 23) means that at the 3 degree Glide Path a Normal (Null) Glide Path is present as expected. At an angle of approximately 6 degrees a Signal Reversal occurs thereafter a False Null is present. At the 9 degree angle, a second Signal Reversal occurs.

An overview of the characteristics of all the ILS Glide Slope antenna systems which were measured are presented in the table 5 below.

ILS Glide Slope antenna system type	Glide path angle (degrees)						
	0 - 3	3	3 - 6	6	6 - 9	9	9 - 12
Null	↑	O	↓	Reversal 2 x (O)	↓	Reversal	↑
Sideband	↑	O	↓	No Change	↓	Reversal	↑
M-array field 1	↑	O	↓	Reversal 2 x (O)	↓	Reversal	↑
M-array field 2	↑	O	↓	No Change	↓	Reversal	↑

Legend: ↑ = GS signal "Fly Up" ↓ = GS signal "Fly Down"

Table 5: Summary signal direction for the three Image Type Glide Slope antenna systems.

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As described in paragraph 3.2 there is general awareness that False Glide Slopes exist; according to popular belief these phenomena invariably occur at regular intervals from the normal 3 degree signal. The results of the measurements as described above do not match heretofore extant information and received wisdom. Signal reversal occurs at approximately either the 6 and/or the 9 degree False Glide Path, a fact not well known or publicised to flight crews.

As described in paragraph 3.2 is the that a warning flag may be displayed in some aircraft when crossing a False Glide Slope. The measurements conducted showed that above the 3 degree Glide Path, signal strength was well above the signal threshold and therefore no warning flag appeared. As a result no warning flag will appear in the cockpit before crossing a False Glide Slope.

The measurements at Eindhoven Airport, where identical M-array antennas are used for both runways (03 and 21), showed that each runway had a different Glide Slope signal characteristic. According to the manufacturer, local deviation in ground plane and/or system configuration could explain this difference. The presence of other Glide Slope field characteristics with M-array or other types of Image array antenna systems cannot be discounted, but that was beyond the Dutch Safety Board's scope in this investigation.

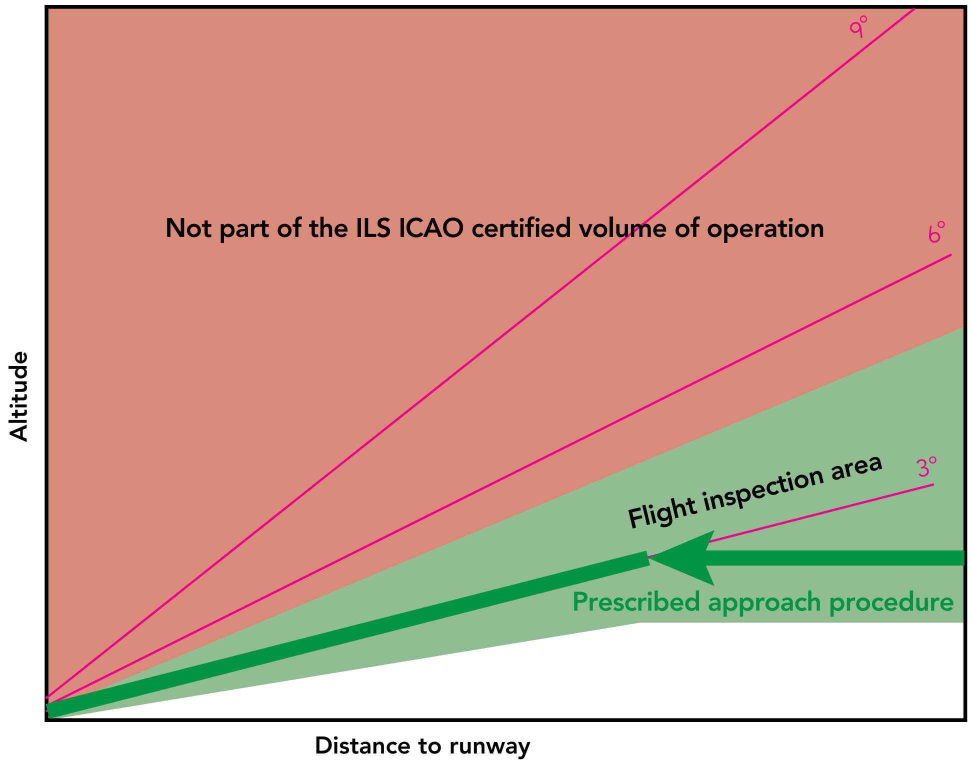

Figure 24: Cross section of ILS Glide Slope signal that is inspected and certified for operational use.

The measurements to determine the Glide Slope field as were done for this investigation are not part of a normal Flight Inspection. From paragraph 3.1.6 it is known that Flight Inspections are performed to assure the quality of the signal-in-space for navigation. Flight Inspection is performed on the 3 degree Glide Path. Above an angle of 5.25 degrees, the Glide Slope field characteristic is neither checked, nor is this required by regulations (ICAO). This means that when flying above the 5.25 degree Glide Path the aircraft is flying beyond the reliability envelope which is certified and periodically checked by Flight Inspection. See figure 24.

Conclusions
Accessible information and received wisdom do not make a distinction between two types of False Glide Slope; False Null and Signal Reversal. As a result the False Glide Slope phenomenon was not fully understood.

Measurements performed on the three Image Type category ILS Glide Slope antenna systems revealed two different Glide Slope signal characteristics. Signal reversal occurs sometimes at approximately 6 degrees and always at the 9 degree angle.

Measurements have shown that for the Image Type Glide Slope antenna systems, a warning flag will not necessarily appear in the cockpit before crossing a False Glide Slope - contrary to accessible information and received wisdom.

The area above the ILS 5.25 degree Glide Path is not part of the ILS Flight Inspection programme and associated Glide Slope signal characteristics are not measured or certified for use.

Received wisdom available to flight crews does not fully reflect the different Glide Slope field characteristics and possible automatic flight system reaction.

3.5 Intercepting Glide Slope from Above

3.5.1 Boeing 737NG procedure

In the Boeing 737NG FCTM guidance is given on how to intercept the Glide Slope from above in the 'intercepting Glide Slope from above' section. The guidance starts with the explanation that normally the ILS profile is depicted with the aircraft intercepting the Glide Slope from below in a level flight. However, there are occasions when flight crews are cleared for an ILS approach when they are above the Glide Slope. In this case there should be an attempt to capture the Glide Slope prior to the Final Approach Fix (FAF). The map display can be used to maintain awareness of distance to go to the FAF. Boeing recommends the use of the autopilot.

For ILS procedures, the FCTM describes that the Glide Slope may be captured before the Localizer in some aircraft. This is an option that is not available in all aircraft. It is stated that the Glide Slope may be captured from either above or below.

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Intercepting Glide Slope from above – Boeing 737NG FCTM, June 2013 (excerpt from page 5.17 and 5.18)

'The following technique may be used for ILS (...), however it is not recommended for approaches using VNAV.

The following technique will help the crew intercept the Glide Slope safely and establish stabilised approach criteria by 1,000 feet Above Field Elevation (AFE):

- *select APP on the MCP and verify that the Glide Slope is armed*
- *establish final landing configuration and set the MCP altitude no lower than 1,000 feet AFE*
- *select the V/S mode and set -1,000 to -1,500 fpm to achieve G/S capture and be stabilised for the approach by 1,000 feet AFE. Use of the VSD (as installed) or the green altitude range arc may assist in establishing the correct rate of descent.*

Monitor the rate of descent and airspeed to avoid exceeding flap placard speeds and flap load relief activation. At Glide Slope capture observe the flight mode annunciations for correct modes and monitor Glide Slope deviation. After Glide Slope capture, continue with normal procedures. Comply with the recommendations on the use of speed brakes found in chapter 4 of this manual.

Note: If Glide Slope is not captured or the approach is not stabilised by 1,000 feet AFE initiate a go-around. Because of Glide Slope capture criteria, the Glide Slope should be captured and stabilised approach criteria should be established by 1,000 feet AFE, even in VMC conditions.'

The goal of the recommended technique is to meet the stabilised approach criteria at an altitude of 1,000 feet AFE. Vertical guidance is provided to intercept the Glide Slope from above. The Glide Slope should be intercepted before the FAF, if this is unattainable, continuation to 1,000 feet AFE is allowed. The Boeing FCTM provides guidance to verify the position of the aircraft in respect to its distance from the runway in the final approach section (page 5.16). Using this technique, it is possible to continue the descent to 1,000 feet AFE while the position and the energy state of the aircraft make a successful Glide Slope intercept impossible. In this case the aircraft is flown at low altitude much closer to the runway than it would normally be when intercepting the Glide Slope at 1,000 feet. If the descent path is not actively being monitored and managed additional crew actions beyond the technique described in the FCTM may be required as conditions require to achieve the desired descent profile.

3.5.2 Airbus A330/A340 Flight Crew Training Manual

In the airbus A330/A340 FCTM general recommendations concerning intercepting the Glide Slope from above are given, while the Flight Crew Operating Manual (FCOM) gives more specific operators procedures, aimed at preventing an undetected descent to a too low altitude, which is possible in the procedure described in the FCTM. However the FCTM suggests an option of a 360 degree turn when established on the Glide Slope, albeit without indicating what purpose it seeks to serve. Neither procedure mentions the distance to the threshold in relation to the altitude of the aircraft.

Intercepting Glide Slope from above – Airbus A330/A340 FCTM

The following procedure should only be applied when established on the localizer. There are a number of factors which might lead to a Glide Slope interception from above. In such a case, the crew must react without delay to ensure the aircraft is configured for landing before 1,000 ft AAL.

In order to get the best rate of descent when cleared by ATC and below the limiting speeds, the crew should lower the landing gear and select CONF 2. Speed brakes may also be used, noting the considerations detailed in the sub-section 'Deceleration and configuration change' earlier in this chapter. The recommended target speed for this procedure is VFE 2 - 5 kt. When cleared to intercept the Glide Slope, the crew should:

- *Press the APPR pb on FCU and confirm G/S is armed.*
- *Select the FCU altitude above aircraft altitude to avoid unwanted ALT*.*
- *Select V/S 1,500 ft/min initially. V/S in excess of 2,000 ft/min will result in the speed increasing towards VFE*

It is vital to use V/S rather than OP DES to ensure that the A/THR is in speed mode rather than IDLE mode. The rate of descent will be carefully monitored to avoid exceeding VFE. When approaching the G/S, G/S will engage. The crew will monitor the capture with raw data (pitch and G/S deviation). The go-around altitude will be set on the FCU and speed reduced so as to be configured for landing by 1,000 ft. In such a situation, taking into account the ground obstacles and if ATC permits, it may be appropriate to carry out a 360 ° turn before resuming the approach.*

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3.5.3 A330/A340 Flight Crew Operating Manual procedure

Airbus defined a procedure in the FCOM for intercepting an ILS Glide Path from above using autopilot for an Airbus A330/A340 (see box below). The chapter regarding ILS interception and the capture of Localizer and Glide Slope beam starts with a general note.[27]

Procedure for intercepting the Glide Path from above – A330/A340

– G/S CAPTURE .... MONITOR
If above the glideslope :
– V/S Mode .... SELECT
– FCU ALTITUDE .... SET
Set FCU altitude at minimum stabilization altitude
– GO-AROUND ALTITUDE .... SET
Set GA altitude on FCU.

Note: If the aircraft intercepts the ILS above radio altimeter validity range (no radio altitude indication available on the PFD), CAT 1 is displayed on FMA. Check that the FMA displays the correct capability for the intended approach when the aircraft is below 5,000 feet.

Both Boeing and Airbus describe the procedures to meet the stabilised approach criteria at 1,000 feet AFE, or other specified minimum stabilised approach altitude. Vertical guidance is provided to intercept the Glide Slope from above. Boeing states that the Glide Slope should be intercepted before the FAF; if this is unattainable, continuation to 1,000 feet AFE is allowed. Airbus does not make such a reference, however in the Airbus FCTM an ambiguous remark is made about a 360 degree turn, which is a general accepted method of losing altitude on intermediate approach, but hardly feasible on final.

The described procedures provide insufficient guidance to verify the position of the aircraft with respect to the distance from the runway. It is possible, using both procedures, to continue the descent to 1,000 feet AFE while the position in relation to the Glide Slope antenna would make a successful 3 degree Glide Slope intercept impossible.

It should be noted that a Glide Slope interception from below ensures a capture of the correct 3 degree Glide Slope. In most of the five pitch-up upset incidents described in chapter 2 the aircraft was flown to its stabilisation altitude of 1,000 feet significantly closer to the runway than it would normally be when intercepting the 3 degree Glide

27 Note: ICAO defines the envelope where the quality of the G/S signal ensures a normal capture. This envelope is within 10 NM, +/- 8 deg of the centreline of the ILS Glide Path and up to 1.75 * and down to 0.3 *(*= nominal Glide Path angle). When arming the approach well outside of the normal G/S capture envelope, a spurious G/S* engagement may occur due to a wrong G/S deviation signal. This spurious G/S capture will order a pitch up, if the aircraft is below the glide beam, and a pitch down attitude, if the aircraft is above the glide beam. Whenever the pilot notices the pitch movement, or the spurious G/S*, or the trajectory deviation, he will immediately disconnect the AP, if engaged, to re-establish a normal attitude and will disengage APPR mode. It is then recommended to arm/rearm APP (ILS) mode within the normal capture zone.

Slope at 1,000 feet, and captured a false 9 degree Glide Slope with an associated fly up signal. Therefore the risk of a False Glide Slope capture or upset is much higher when intercepting the Glide Slope from above than when intercepting the Glide Slope from below. Furthermore, as noted previously, ILS systems are not designed or certified for operations above the 5.25 degree Glide Path angle.

Finally, the Safety Board noted that in the Final Report regarding the BEA investigation of the pitch-up upset investigation at Paris Charles de Gaulle in 2012 reference is made to the Air France FCTM procedure to intercept the Glide Slope from above to select not more than 2,500 fpm in the V/S mode without minimum altitude restriction. Although the FCTM is not for operational purposes, the Dutch Safety Board notes that this procedure does not define an altitude restriction. This controlled descent, without altitude restriction, can ultimately result in a Ground Proximity Warning System (GPWS) terrain warning and is an unwanted effect that poses a subsequent risk.

Conclusion
The Boeing 737NG FCTM and the Airbus A330/A340 FCOM procedure or A330/340 FCTM for intercepting the Glide Slope from above do not warn of possible Glide Slope capture with a pitch-up upset when using automatic systems.

3.6 ILS interaction with on board automatic systems

In the aftermath of the Safety Alert publication a common reaction was that these situations rarely occur and that 'pilots know what false Glide Slopes are and are trained to handle these situations'. This feedback was not consistent with the data and available information. Aircraft were flying above the 3 degree Glide Path and in some cases crossing the Signal Reversal at the 6 or 9 degree Glide Path; clearly there was a perception error and this should be corrected in both training and available information.

The outcome of this investigation that was focused on the area above the (nominal) 3 degree ILS Glide Slope, is that False Glide Slopes (Null and Reversal) are now identified and explained; action can be taken to mitigate the associated risks. These actions should include the risk assessment of new flight procedures in developments such as Continuous Descent Approaches in relation to Signal Reversal. Several stakeholders have taken actions or are working on implementing changes to mitigate the risks, for additional information see paragraph 3.8.

With the exception of the announced Boeing 737NG FCC software update, the above mentioned actions involve the provision of education and procedures. Regarding regulations, it follows from paragraph 3.4 that ILS signals above the virtual 5.25 degree Glide Path are not inspected and these signals must be treated as 'non-certified' for use. In addition the approved Aircraft Flight Manual, or training manual(s) do not warn of the risks when flying in the area above the virtual 5.25 degree Glide Path. If aircraft always fly the nominal 3 degree Glide Slope from below this may be sufficient. However, in practice, intercepting the 3 degree Glide Slope from above is common practice and will become more common in the future with the previously mentioned Continues Descent Approaches. Aircraft manufacturers and airline operators have developed additional operational procedures for this purpose, as described in paragraph 3.5.

In paragraph 8.9.3.6 (ICAO Document 4444 Procedures for Air Navigation Services - Air Traffic Management, PANS-ATM) states: "*The final vector shall enable the aircraft to be established in level flight on the final approach track prior to intercepting the specified or nominal Glide Path if an (...), ILS or (...) is to be made (...).*" According to ICAO, the status of this PANS-ATM procedure is that it is recommended to intercept the (published) 3 degree Glide Path from below and Member States are responsible for it's implementation and enforcement.

Besides regulation the investigation also considered the design and the logic of the aircraft systems. Assuming that the ILS sometimes will be intercepted from above with use of the automated systems (intentionally or unintentionally), the flight crew must be warned for an unexpected pitch-up upset when crossing the 6 or 9 degree False Glide Path. And with the severity of the pitch-up, there is little time for flight crew intervention.

Given that the flight crew are the last safety net and should always be able to intervene, automated systems must support the flight crew who are responsible for a safe flight. The Dutch Safety Board is therefore of the opinion that on-board automated systems should not bring the aircraft into danger without a preceding clear and recognizable warning and with ample time for flight crew to intervene. This principle applies to the failure of non-primary aircraft systems and should also apply to automated systems when these could bring the aircraft into danger as a result of, for example, an unexpected pitch-up response caused by the on-board automatic systems.

Boeing has announced actions to mitigate similar occurrences in the future for the Boeing 737NG fleet, but it is not known what actions will be taken for the classic Boeing 737 fleet, or what the actions will be taken by other aircraft manufacturers. The Safety Board is therefore of the opinion that all stakeholders should take all appropriate actions. On the one hand improved safety can be achieved by ICAO Member States when the recommended procedure from paragraph 8.9.3.6 in Document 4444 to only intercept the published ILS Glide Path from below is raised to a Standard. If this solution is not adopted, in addition to education and training, additional procedures should be developed to intercept the published ILS Glide Path from above safely, whilst respecting the lack of current certification for use of the ILS above the virtual 5.25 degree Glide Path.

On the other hand manufacturers of landing systems could try to ensure that signal reversal does not occur above the area of the 5.25 degree ILS Glide Path. Such a measure - if achievable - is expected to be a long-term measure. To ensure that measures are taken in the short-term, such as for the B737NG, aircraft manufacturers should ensure that the on-board automated systems in all types of aircraft do not respond to ILS signal reversal, and that flight crews are provided with timely warnings of a potential pitch-up as a result of signal inversion with ample time allowed for the flight crew to intervene and take over the control of the aircraft.

Conclusion
Automated on-board systems when in use must support the flight crew and should not bring the aircraft into danger without a preceding clearly recognizable warning and with ample time for flight crew intervention.

3.7 Flight Path Management and automation

The incident at Eindhoven that triggered the Dutch Safety Board's investigation and the other four similar incidents that were found during the investigation gave rise to the question why the aircraft involved end up in these situations?

While all five incidents (including Eindhoven) took place at different airports with three different aircraft types and three different operators, there are several remarkable similarities.

Similarities between the five incidents

- Four of the five incidents occurred in instrument meteorological conditions; the runway was not visible.
- The aircraft were vectored to the runway by ATC.
- The flight crews were unaware of the effects of the 9 degree Glide Slope signal on their automation.
- The aircraft was so close to the runway when the false capture occurred, that a normal landing was already impossible.
- The capture of the False Glide Slope signal occurred above 1,000 feet. This is the altitude at which an approach of the aircraft should normally be stabilised.
- In four of the five incidents the flight crews indicated that they would have executed a go-around if not stabilised at 1,000 feet.
- The incidents involved occurred with 3rd and 4th generation aircraft, these aircraft have well developed and normally reliable automation.
- All flight crews had a degraded awareness of their descent profile in relation to the position of the runway.
- In four of the five incidents the flight crews insufficiently appreciated the aircraft performance during the approach.
- In the Airbus and Boeing incidents, the flight crews did not follow the manufacturer's guidance for capture of Glide Slope from above.

All five incidents showed that the ILS signal reversals and its effects, especially the pitch-up manoeuvre, on automated aircraft without warning to the pilots were unknown to the aviation community. The old concept of a 'False Glide Slope' that can be recognised by the aircraft's higher than normal rate of descent could not be verified to be true for the majority of ILS systems in use worldwide. Consequently, pilots are not trained to recognise and handle these situations.

In order to be vulnerable to a False Glide Slope the aircraft must be flying in an area were the remaining distance to the runway requires excessive descent rates in order to be able to comply with the stabilised approach criteria at 1,000 feet. If the flight crews would have been in VMC and had visual contact with the runway than it should have been clear to them well before approaching the 6 or 9 degree ILS False Glide Slope that the descent performance of their aircraft would have been insufficient. The distance versus altitude awareness in relation to the aircraft performance was therefore degraded because of the IMC conditions.

The incidents flights were trying to intercept the 3 degree ILS Glide Slope before the stabilised approach criteria of 1,000 feet. Therefore the flight crews gave more priority to the execution of the flight procedures than to the management of the flight path, in particular the distance versus altitude awareness.

In all these cases the crews were flying reliable and highly automated aircraft. High levels of automation in aircraft has become 'a standard' in all aircraft nowadays. Automation has improved flight safety, but it has also changed the function and demands of the pilots over the years. From a hands-on role, directly controlling the aircraft's flight path to a system operator's role, checking if the programmed systems function properly as required for safe flight. From this perspective the automation in aircraft has expanded the comfort zone of flight crews to more complex operations because of traffic congestion demands and/or environmental issues. This includes Glide Slope interceptions from above, safely executed on a daily basis. Several human studies, such as a British study in 2004 on pilots' reliance on automated systems ('automation dependency') showed that pilots place a lot of trust in and dependency on systems with high levels of automation because they are seen as very reliable. The term 'automation bias' can be used in this case. It is a natural state of mind of humans as a consequence of a history of reliable human-machine interaction. The Dutch Safety Board also raised this issue in its investigation of the Turkish Airlines accident in 2009.

Automation bias[28]

The availability of automation and automated decision aids encourages pilots to adopt a natural tendency to follow the choice of least cognitive effort. When faced with making decisions pilots will rely on these automated aids as a replacement for vigilance, and actively seeking and processing information, to control the flight path.

With regard to ILS approaches, for many decades aircraft flew the prescribed standard ILS approaches, which is intercepting the Glide Slope from below and after first intercepting the localizer. This is a proven concept and which utilises the ILS ground aids

28 Civil Aviation Authority (UK) (2004). *Flight crew reliance on automation* (CAA report no. 2004/10). Gatwick:CAA Safety Regulation Group (authored by S. Wood, Cranfield University)

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in accordance with their certification. A symposium organised by the French DGAC, relating to stabilised approaches, identified in 2006 intercepting the Glide Path from above as being a warning of a non-stabilised approach.[29]

All flight crews from the incidents flights were aware that they were flying above the 3 degree Glide Slope. They were also aware of the need to increase the descent rate in order to capture the 3 degree Glide Slope signal. Their predictions (flight path management) on where the 3 degree Glide Slope signal would be intercepted were however inaccurate and unrealistic.

The most effective way of avoiding pitch-up upsets due to ILS False Glide Slopes is to eliminate ILS Glide Slope intercepts from above by following ICAO guidance, complying with published procedures and staying within the certification envelope of the ILS. As the events have shown that in some cases it is not feasible to follow the ICAO prescribed procedures, therefore it is important that the predictions when a 3 degree Glide Slope will be intercepted during ILS Glide Slope intercepts from above should be improved. For that reason additional means should be used in the cockpit or procedures developed for flight crew in order to protect aircraft entering the ILS False Glide Slope area in autoflight. This will help flight crews to decide whether continuation of the approach can be performed safely and warrants a decision to go-around at an earlier stage.

While these additional means or procedures can avoid flight crews flying in the critical ILS signal area with False Glide Slopes, it should not substitute distance versus altitude crosschecks by conventional methods belonging to basic flying skills. In that respect the Dutch Safety Board is concerned that the use of advanced automation can lead to situations where the flight crew's flight path management degrades. Flight crews should be more cognisant of this.

One of the side effects of reliance on high levels of automation is that the basic (airmanship) skills tend to be neglected, as there is less need to rely heavily on the 'old' skills. Studies have shown that this is a natural, human reaction when performing automated tasks. Pilots need to be constantly reminded of this potential danger. It is, after all, not a new insight. Another factor of influence is that the currency of the basic skills can be diminished because they are used less often during daily operation. A recently published study of aircraft accidents between 1995 and 2009 and the role of cockpit automation identified this.[30]

To maintain and improve safety it is important that the adaptation and training of pilots keeps pace with the use and development of automation in aircraft. A balance must be found between the use of basic flying skills, knowledge and the use of automation to control the flight path in the modern complex environment.

29 Final Report on www.bea.aero - report '*Approach above Glide Path, interception of ILS sidelobe signal, increase in AOA angle commanded by autopilot*', September 2013. Intercepting the Glide Path from above was identified in 2006, during a symposium relating to stabilised approaches organised by the DGAC, as being a warning of a non-stabilised approach. In a handbook published for this event, mention was made of advice for controllers as well as for pilots. *Stabilised approached good practice guide, DGAC AUTORITÉ DE SURVEILLANCE.*

30 Operational Use of Flight Path Management Systems, Final Report of the Performance-based operations Aviation Rulemaking Committee/Commercial Aviation Safety Team, Flight Deck Automation Working Group, September 5, 2013.

Conclusion
The high level of reliable automation in the cockpit can degrade pilots basic flying skills for flight path management.

3.8 Actions taken

3.8.1 Ryanair – Murcia (2011), Eindhoven and Treviso (2013) incidents

In the immediate aftermath of the Eindhoven (2013) event, the operator issued a Safety Alert on its crew website. The Alert also includes a recommendation on how to prevent similar incidents occurring.

The Eindhoven incident was also included in the November 2013 issue of the company safety newsletter 'Hotspots'. The newsletter is available on the pilots website and is circulated in hard copy form at all bases.

In addition to recent crew bulletins and articles in Hotspots, a safety presentation was developed to highlight the threat of a false Glide Slope event to all crews. This presentation was rolled out across all of the operator's operating bases and was presented by the companies senior Flight Operations managers.

Following this incident, the preventive and recovery barriers (hazards) in the operator's Loss of Control In-flight (LOC-I) Bow Tie have been reassessed and the operator is developing more prescriptive mitigating measures for intercepting the Glide Slope from above. The revised policy includes a new horizontal landing gate for ILS interception from above, 4 NM for VMC operations and 5 NM for IMC operations. In addition to horizontal (and vertical) landing gates the operator is developing a standard operating procedure for the introduction of Vertical Situation Display (VSD) to line operations. The new policies and procedures have been simulator evaluated.

3.8.2 KLM Cityhopper - Amsterdam Airport Schiphol incident (2011)

The operator included lessons learned from the incident during flight crew recurrent training as part of the type recurrent 2013 for its whole fleet, combined with modular Crew Resource Management training on information acquisition and processing, situational awareness, workload management and decision making.

3.8.3 Ministry of Infrastructure and the Environment – The Netherlands

On 26 December 2013 the Dutch Human Environment and Transport Inspectorate (Part of the Ministry of Infrastructure and the Environment) published an Aeronautical Information Circular A (AIC-A) 07/2013. The AIC-A 07/2013 incorporated the Safety Alert published by the Dutch Safety Board on 18 November 2013. The goal of the AIC-A was to warn of possible upsets and to generate awareness of a False Glide Slope.

The Minister of Infrastructure and the Environment notified ICAO with an official letter on 18 December 2013 that the found hazard has the probability of recurrence and it has the

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potential for significant consequences. All parties involved in the operation of aircraft should be informed about the actions to improve safety. The Minister considered the Safety Alert a Safety Recommendation of Global Concern (SRGC) and encouraged ICAO to complete the development of the ICAO Accident Investigation Section website in order to publish this Safety Alert as a global concern.

The Minister also recommended to ICAO that additional attention should be given to the Safety Alert in the Air Navigation work program and the relevant panel(s) be tasked to develop or modify provisions in the related Annexes or Procedures for Air Navigation Services, as necessary, to mitigate the risk of aircraft pitch-up upset due to capturing a False Gilde Slope, which can lead to (approach to) stall conditions.

3.8.4 Aircraft manufacturer Boeing

Boeing is planning an update to the B737 FCTM information on False Glide Slopes that will include the statement that an unexpected rapid pitch-up command is possible.

Boeing has announced it will incorporate a software change to the 737NG Rockwell Collins Flight Control Computer (FCC) as part of continuing improvements to its B737NG. The FCC software change will incorporate a change that will limit the aircraft climb rate in Glide Slope Mode. This change has been shown to eliminate the pitch-up when the airplane captures the reversed signal 9 degree Glide Slope beam. The FCC software change is scheduled to be implemented in the 4th quarter 2014 on new B737NG aircraft. Operators will be informed by a Boeing Service Letter about the availability of the new FCC software; aircraft already in service can be retrofitted.

During the investigation Boeing informed that on basis of simulation it was proven that the 747-400, 747-8, 757, 767, 777, and 787 aircraft use different Glide Slope capture and anomaly detection logic that prevents capture of the signal reversal 9 degree Glide Slope beam.

3.8.5 European Aviation Safety Agency

The European Aviation Safety Agency (EASA) announced that its Experts in Flight and Avionics have reviewed the Safety Alert and the recommendations in the BEA report of the Paris Charles de Gaulle 2012 incident. A Safety Information Bulletin, SIB No. 2014-07 '*Unexpected Autopilot Behaviour on Instrument Landing System (ILS) Approach*' based on the Safety Alert and BEA's investigation was issued on 25 March 2014 to officially inform the European aviation community and highlight the issue. Furthermore, EASA announced it will present the issue at the next Air Operations Standardisation meeting organised for Authorities and industry.

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4 SAFETY MANAGEMENT

The occurrence at Eindhoven Airport and the subsequent four similar events gave rise to the question: why did aviation Safety Management Systems (SMS) not identify the ILS Glide Slope Signal Reversal as a potential serious safety deficiency?

This chapter describes the general concept of SMS as they are currently implemented in the aviation system. The description is general in nature and serves only to gain a general understanding of SMS. The chapter goes on to describe the applied SMS methodology. The final section suggests an explanation as to why the Glide Slope Signal Reversal was not identified as a safety deficiency.

4.1 Introduction implemented ICAO Safety Management System

ICAO mandates all Contracting States to implement a State Safety Program (SSP) wherein aviation organisations are required to establish a SMS. SSP and SMS are complementary. The European Union adapted the ICAO requirements for Safety Management in Regulation (EU) 290/2012 and Regulation (EU) 965/2012. In some cases this regulation pre-dates the events described in this report. The overall SMS structure for all organisations is based on the following four components, also known as 'pillars of the SMS'.

Safety Management Systems '4 pillars'

- Safety Policy:
  - Management Support
  - Responsibilities & Authorities
- Safety Risk Management:
  - Proactive Hazard Identification
  - Risk Assessments and Control Measures
  - Corrective and Preventive Actions
- Safety Assurance:
  - Process Evaluation
  - Safety Performance Monitoring
- Safety Promotion:
  - Safety Communications and Culture
  - Safety Training

The level of development and implementation of SMS depends on the size, nature and type of operation. Depending on the number of aircraft and destinations an operator can have thousands of flights per week, with hundreds of safety reports being filed. All these safety reports must be captured, assessed and analysed to identify risks if further investigation and corrective actions is warranted.

4.2 Safety Risk Management

For the pitch-up upset occurrences different parties can be identified dealing with the Safety Risk Management: the manufacturer, the regulator, ATC and the operator. Each party has a database and is involved in Safety Risk Management. This paragraph highlights the obligations of the parties concerned and actions taken by the different parties involved in the SMS.

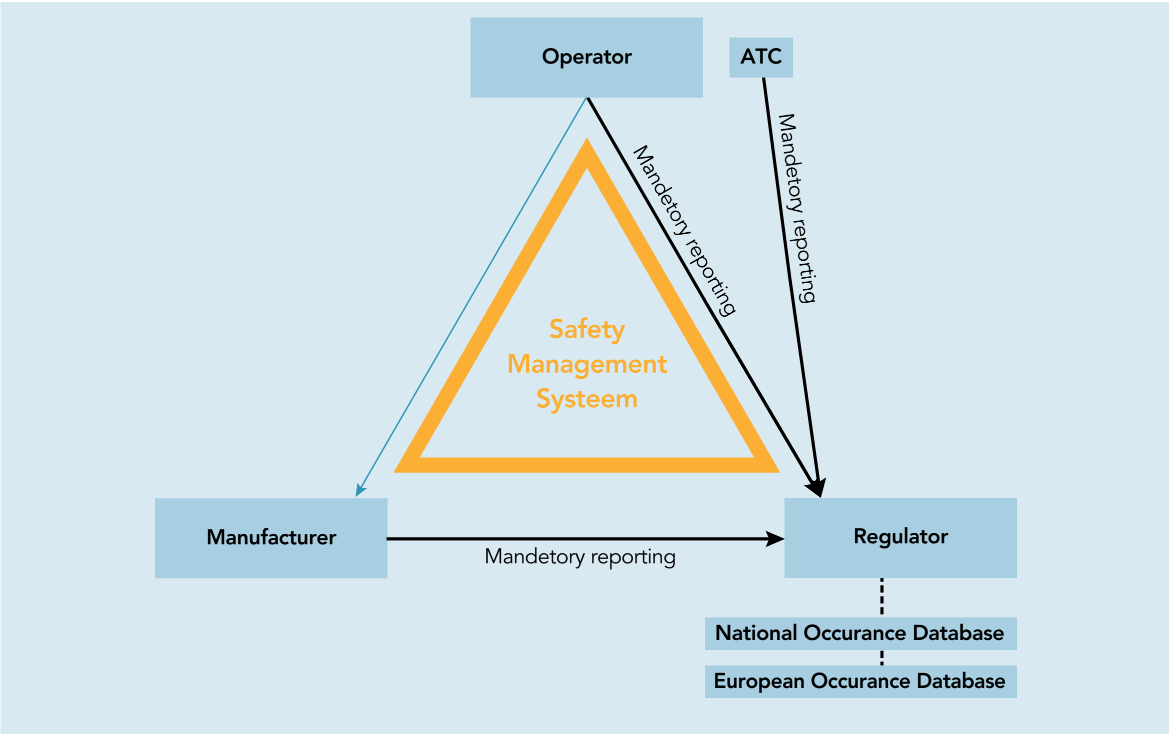


Figure 25: Overview Safety Management System mandatory reporting.

4.2.1 Operator

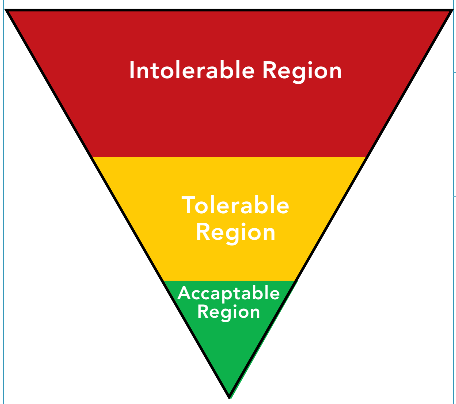
Operators rate occurrences using a Risk Identification Matrix as part of SMS methodology. The combination of severity and probability of the occurrence results in a total Safety Risk Assessment. Depending on the level of Safety Risk, mitigating measures are required. In the matrix shown in Table 6, three different levels of Safety Risk can be distinguished:

1. Intolerable (mitigating measurements should be taken),
2. tolerable (mitigating measurements could be taken) and
3. acceptable (no measures are required).[31]

31 The nomenclature used in the various types of risk matrices may differ.

Risk probability		Risk severity				
		Catastrophic A	Hazardous B	Major C	Minor D	Neglectable E
Frequent	5	5A	5B	5C	5D	5E
Occassional	4	4A	4B	4C	4D	4E
Remote	3	3A	3B	3C	3D	3E
Improbable	2	2A	2B	2C	2D	2E
Extremely improbable	1	1A	1B	1C	1D	1E

Suggested criteria



Assessment risk index	Suggested criteria
5A, 5B, 5C, 4A, 4B, 3A	Unacceptable under the existing circumstances
5D, 5E, 4C, 4D, 4E, 3B, 3C, 3D, 2A, 2B, 2C	Acceptable based on risk motivation. It may require management decision.
3E, 2D, 2E, 1A, 1B, 1C, 1D, 1E	Acceptable

Table 6: Example Safety risk assessment matrix [ICAO Safety Management Manual (SMM)].

The Dutch Safety Board investigated the assessment of the five reported incidents described in Chapter 2. It was established that all three operators assessed the Safety Risk in accordance with internal operator SMS policy. It was found that the assessments of these occurrences were subjective. This is not unusual due to the subjective nature of occurrence assessment and the many variables involved which make it difficult to assess risk objectively. Therefore it was difficult for the investigation to reproduce the assessments and judge their merit. What was identified is that all occurrences were assessed as tolerable and mitigating measures were taken.

	2011	2012	2013	Totaal
KLM Cityhopper	1	-	-	1
Ryanair	1	-	2	3
Air France	-	1	-	1

Table 7: overview of reported pitch-up incidents per operator.

Following the risk assessment process the operators initiated an internal investigation whereby hazards and barriers related to the occurrence were identified. Following the

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identification of the hazards and barriers, recommendations were formulated to prevent reoccurrence. However, the internal operator reports did not identify fully the cause of the pitch-up upset as the False Glide Slope. Regarding the two incidents in 2011, neither operators' internal final report identified the root cause of the pitch-up upsets. Limitations in knowledge were likely to have been a contributing factor as there was no common understanding of the False Glide Slope phenomenon. In addition, there may have been a belief that any remedial action to mitigate the autopilot response was outside the span of control of the operator. The Final Report of the 2012 Air France incident was published in the first quarter of 2013. The findings had not been fully communicated to the aviation community at the time of the principal event, the 'Eindhoven incident'.

3.2.2 National Occurrence Database

The National Occurrence Database is used to identify and monitor safety performance within the State. The type of safety data to be collected may include accidents, incidents, non-conformance or hazard reports. This data is than statistically analysed to identify safety deficiencies and to enable effective decisions to improve safety. The following report (see box) from the national occurrence database system in 2011 was received from the Netherlands' Occurrence Analysis Bureau (Refer to paragraph 2.2.1):

CAA-NL Occurrence Database report
Title: go-around due unstable approach

Date of Occurrence: 12-2-2011

Summary: Aircraft became high, above Glide Slope, on ILS approach RWY 06 AMS. Believe a/c at one point eventually picked up a false Glide Slope, during go-around stick-shaker activated, pitch lowered in response to this. After go-around another successful approach and landing to RWY 06 was made.

This occurrence report shows that reference is made to a stick shaker and a False Glide Slope but no additional data is available. No factors describing why the aircraft became high are identified, only the result: after go-around a successful landing was made. This text does not allow the reader to realise the essence of the False Glide Slope characteristic and the associated autopilot response. When a statistical analysis is performed this event would probably be categorized as an unstable approach. Furthermore, the operator did not inform the involved State that it had initiated an occurrence investigation, nor was the operator required to do so.

After the completion of the operator's internal investigation, the knowledge and results from this investigation were not shared and inserted into the occurrence database. This example illustrates that lack of detailed information can camouflage a safety issue and make it unlikely to be detected with a state occurrence database.

In Ireland the three incidents (one in 2011 and two in 2013) were reported by the operator and inserted into the national occurrence database managed by the Irish Aviation

Authority (IAA). The IAA met with the operator to review each incident. The operator completed its internal investigations and submitted copies of the reports to the IAA. Having reviewed and accepted the recommendations of each report the IAA confirmed that the recommendations contained therein were implemented and updated its database accordingly. This was not the case with the 2011 Schiphol event in the Netherlands. The Occurrence Analysis Bureau did not communicate with the operator about the incident, nor was the internal report discussed or used to update the national database. In both the Irish and Dutch cases however, the root cause of the pitch-up upset was not addressed in any of the internal operator reports.

The five identified occurrences in this investigation were from three different operators; each had a different EU-country as state of operation. Three different national mandatory occurrence database systems were therefore involved. The fact that also three different aircraft types had an occurrence shows the diversity and complexity of this occurrence type. Furthermore it is noted that the Occurrence Analysis Bureau in the Netherlands receives about 12,000 reports annually. The likelihood of identifying one stick shaker report which might be important is remote.

4.2.3 Air Navigation Service Provider

As operators, Air Navigation Service Providers (ANSPs) have a reporting obligation to the national occurrence database. It was found that reports related to False Glide Slope events were not submitted by ATC. All five occurrences in Chapter 2, including the ASRS reports on pitch-up upsets or False Glide Slope, were filed by operators/pilots. It is known that in several occurrences the flight crew informed ATC that False Glide Slope capture was the reason for performing a go-around. The Dutch Safety Board did not investigate why these occurrences were not (also) reported and/or investigated by the ANSP's themselves.

As the False Glide Slope characteristic was thought to be an understood phenomenon at the time, it is unlikely that the ANSP's involved could appreciate the nature and seriousness of the pitch-up upset incidents. However the occurrences show that ATC actions played a part, either directly or indirectly, in positioning the aircraft at a certain speed, altitude and distance from the runway. This could lead to an aircraft to be positioned in a (high energy) state making it challenging for flight crews to land the aircraft in accordance with standard procedures. The ATC instructions positioned flight crews in a situation which affected the stabilised approach criteria in the identified occurrences and other investigated occurrences.[32] The fact that ANSP's did not report the occurrences identified in this investigation could be an indication that there is insufficient awareness of the False Glide Slope effects on aircraft by ANSP's. This would explain why sometimes during ILS interceptions challenging instructions are given by ATC to flight crews. The Dutch Safety Board is of the opinion that ATC should be more aware of the effects of these kind of instructions to flight crews. In that respect the Safety

32 See also final report by the Accident Investigation Board Norway Gardermoen on 13 October 2012 aircraft proximity between LN-DYC and LN-NOM, November 2013.

Board refers to the findings and recommendations made by the BEA to the DGAC regarding stabilised approaches.[33]

What the investigation also established was that ILS systems are annually checked and verified to operate within operational specifications for a certain area up to a 5.25 degree Glide Path. The pitch-up upset related occurrences were happening well above the checked and certified Glide Slope area. In essence, aircraft were flying in airspace which is not part of the ILS ICAO certified volume of operation using automatic flight systems. Neither the ANSPs, the operators nor the regulators identified this latent safety deficiency.

4.2.4 Manufacturer

Within the SMS framework the aircraft manufacturer has an obligation to report identified occurrences that are related to the certification of the aircraft. The investigation established that pitch-up upset occurrences were reported to the national authorities and some were investigated. However these occurrences were generally unknown to the aircraft manufacturer. In one case where the BEA investigated the A340 pitch-up upset occurrence, the manufacturer was involved in the investigation as mandated by Annex 13.

Although operators can request assistance from manufacturers to help in an internal investigation, this is not always common practice. As in the Eindhoven incident and in two other internal investigation reports from the same operator, maintenance did not find aircraft ILS equipment faults. The aircraft ILS was functioning as designed, so that from an operator's perspective there was no need to inform and involve the manufacturer.

Because aircraft systems had not failed, it could be argued that there was no manufacturer problem. However a severe pitch-up and stick shaker event is an occurrence that the manufacturer needs to be aware of. Similar on a State level, a manufacturer uses statistical analysis to identify risks. Occurrence data yield valuable information in identifying possible component, model or fleet problems for a manufacturer. The manufacturer's lack of occurrence data may result in missing a possible serious issue.

The M-array ILS antenna manufacturer did not have occurrence information related to False Glide Slope events. This could be related to the fact that the antenna monitoring system did not indicate any failure type and a False Glide Slope was a 'known phenomenon' which did not trigger ATC to file reports. Consequently, occurrence reports were not filed to the antenna manufacturer.

4.2.5 Summary

As has been described in this paragraph, SMS methodologies were applied and resulted in data being captured in the mandatory state occurrence databases and Operators' SMS databases. However due to event coding and insufficient detail in event descriptions, the complexity of the occurrence was not identifiable.

33 Intercepting the Glide Path from above was identified in 2006, during a symposium relating to stabilised approaches organised by the DGAC, as being a warning of a non-stabilised approach. In a handbook published for this event, mention was made of advice for controllers as well as for pilots. *Stabilised approached good practice guide, DGAC AUTORITÉ DE SURVEILLANCE.*

The initial mandatory reports into to the State occurrence database were not always appended with the results of the follow-up investigations conducted by the operators. Furthermore the root-cause of the events was not identified during the operators investigation. The result was that due to the absence of valuable additional background information, the possible detection of a safety deficiency in the future became remote. As SMS are mainly driven by statistical analysis, a limited number of reports is statistically insignificant and on that basis no action was required.

Despite SMS methodologies and previous investigations, the reported pitch-up upset incidents occurred in airspace which is not part of the ILS ICAO certified volume of operation. None of the parties identified this latent safety deficiency.

Conclusions
The pitch-up upset occurrences were reported by operators to the national authorities' mandatory occurrence databases, but not always to the aircraft manufacturer.

The Netherlands and Ireland both operate a mandatory occurrence database system but the two countries are different in occurrence information feedback methodology. The Irish system appends occurrence reports following operator reports, the Netherlands' does not.

The reports filed into the national databases did not contain sufficient information to identify a potential safety deficiency related to Glide Slope Signal Reversal and aircraft automatic flight systems.

Neither the Air Navigation Service Providers, operators nor the regulators identified that events with automatic flight systems engaged were happening in airspace which is not part of the ILS ICAO certified volume of operation.

4.3 Risk complexity

This investigation has shown that despite the implementation of SMS, the global aviation system was unable to 'connect the dots' when related serious incidents occurred. On a national level occurrences are analysed mathematically and the identified risk indicators are monitored and serve as the present Safety State. As has been shown in this case, the unidentified or misidentified indicators which in some cases are mathematically insignificant, but nonetheless important, are not dealt with in current SMS occurrence report analyses methodology. This shows that new techniques and information sharing strategies are required to be embedded in safety management systems to search for and identify latent safety risks at present and in the future.

It could be argued that a more holistic systems approach in risk identification might be a way to supplement current SMS occurrence report analyses methodology in the future.

As an example, in the fourth quarter of 2013 the Flight Safety Foundation and MITRE[34] announced collaboration in creating Transform Global Aviation Analytics. The background to the collaboration was given as the complexity of today's global air navigation system; the analysis of diverse types of data is essential to correlate accurately multiple attributes, which in combination have the potential to identify systemic vulnerabilities that elevate safety risks. This is an example of a possible approach in addressing the safety challenge of the future.

ICAO recently published Annex 19 'Safety Management Systems'.[35] This new Annex focuses on the identification of existing safety provisions and serves as the basis for consolidating existing safety management provisions. In essence, it describes the current framework of safety management as it is implemented globally. The framework includes the SSP, which include all aviation organisations (operators, service providers and manufacturers).

Annex 19 is dedicated to:

- Safety management and address safety risks proactively
- Manage and support strategic regulatory and infrastructure developments
- Reinforce the role played by the State in managing safety at the State level, in coordination with service providers
- Stress the concept of overall safety performance in all domains

The future development of ICAO Annex 19 phase 2, can accommodate the challenge and make it possible to identify potential risks and further improve aviation safety by sharing knowledge in creating an integrated safety management system.

In Europe a new regulation is expected to enter into force in May 2014.[36] It will apply in full 18 months later. The new regulation addresses the issue that experience has shown that accidents are often preceded by safety-related incidents and deficiencies revealing the existence of safety hazards. Safety information is therefore an important resource for the detection of potential safety hazards. In addition, whilst the ability to learn from an accident is crucial, purely reactive systems have been found to be of limited use in continuing to bring forward improvements. Reactive systems should therefore be complemented by proactive systems which use other types of safety information to make effective improvements in aviation safety. The Union, its Member States, the European Aviation Safety Agency and organisations should contribute to the improvement of aviation safety through the introduction of more proactive and evidence based safety systems which focus on accident prevention based on the analysis of all relevant safety information, including information on civil aviation occurrences.

34 MITRE is a not-for-profit organization that operates research and development centers sponsored by the government of the United States of America.
35 1st edition has an applicability date of 14 November 2013.
36 2012/0361 (COD) Aviation safety: occurrence reporting in civil aviation - European Parliament

The Dutch Safety Board supports the regulation goal to complement the current reactive system with a proactive based system to further enhance aviation safety in the future.

Conclusions

Unidentified or misidentified indicators, which in some cases are mathematically insignificant but nonetheless important, are not dealt with in the current SMS framework.

The large amount of reports and information available has meant that the currently implemented SMS occurrence reporting analyses framework, using mathematical methodologies and assessments, might be reaching its potential limit for safeguarding safety.

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General

Findings from the Eindhoven incident are published contemporaneously in a separate investigation *Stick shaker warning on ILS final* on 26 June 2014.

Main conclusions

The conclusions in the analysis have led to the following main conclusions:

1. The ILS Image Type antenna system (Null Reference, Sideband and M-array) signal characteristics of false Glide Paths and corresponding cockpit instrument warnings do not correspond with received wisdom and training. Glide Slope signal measurements of these antennas revealed two different Glide Slope signal characteristics; False Null and Signal Reversal. Signal Reversal occurs sometimes at approximately 6 degree Glide Path and always at the 9 degree Glide Path angle. Additionally, cockpit instruments do not present corresponding ILS warnings.

2. The area above the certified 3 degree ILS, which is the 5.25 degree Glide Path and onward, is not part of the ILS Flight Inspection programme and therefore not part of the ILS ICAO certified volume of operation. Consequently, aircraft flying above the certified volume of operation are exposed to risks related to ILS Signal Reversal and subsequent unexpected automatic flight system response resulting in severe pitch up.

3. Automated on-board systems when in use must support the flight crew and should not bring the aircraft into danger without a preceding clearly recognizable warning and with ample time for flight crew intervention.

4. The existing framework of Safety Management Systems neither identified the occurrences related to ILS False Glide Slope Signal Reversal as serious incidents separately, nor was the potential hazard understood and/or addressed. Contributory to this was that accessible information and received wisdom did not make a distinction between the two types of False Glide Slope characteristics. Also the exchange of occurrence report information between operator, manufacturers and (inter)national database managers was insufficient. The result was that a latent safety deficiency how the ILS was used remained unidentified.

5. Flight crews’ decisions to execute a go-around or to challenge Air Traffic Control seem to be postponed too long when flying high above the normal vertical profile during an ILS approach. There is reason to believe that the high level of very reliable automation in the cockpit contributes to this and that altitude versus distance basic flying skills are insufficiently practiced.

6 RECOMMENDATIONS

Based on the findings and conclusions the Dutch Safety Board made the following recommendations.

The Dutch Safety Board made the following recommendations to the regulators involved with the manufacturing of transport category aircraft; European Aviation Safety Agency (Europe), Federal Aviation Administration (USA), Agência Nacional de Aviação Civil (Brasil), Civil Aviation Administration of China, Federal Air Transport Agency (Russian Federation), Japan Civil Aviation Bureau, and Transport Canada.

1. **Information and awareness**
   Ensure that the established False Glide Slope characteristics and the possible associated consequences for aircraft are made widely known and are modified accordingly in the published manuals and training material used in the aviation sector. This specifically refers to:

   a. the area above and below the published or nominated ILS Glide Path;
   b. the absence of warnings in the cockpit when flying with the automatic flight systems engaged in the area above the published or nominal ILS Glide Path.

2. **Short term measures**
   Ensure with oversight that aviation operators, manufacturers, and Air Navigation Service Providers take mitigating actions to prevent pitch-up upsets due to aircraft exposure to False Glide Slope Reversal as a result of flying with the automatic flight systems engaged in the area above the published or nominated ILS Glide Path. This can be achieved by means of:

   a. operational measures;
   – raising the interception of the ILS Glide Slope from below to a Standard, or in the event of an interception from above,
   – developing additional operating procedures.

   b. technical measures;
   automated on-board systems when in use should not cause a pitch-up upset, at least not without a preceding clearly recognizable warning and with ample time for flight crew intervention.

3. **Long term measures**
   Stimulate that aircraft manufacturers in the long term develop new landing systems to accommodate new approaches for aircraft with automatic flight systems engaged and ensure that airports are equipped with these landing systems.

4. Occurrence reporting and analyses

Assess the aviation Safety Management System occurrence reporting and analyses methodology, including the use of the existing ECCAIRS databases on the levels (operator, Air Navigation Service Provider, manufacturer, national-international level) whether measures are required to achieve the goal of the system to identify potential safety deficiencies in a timely manner. The review should also take into account: (a) the possibility to add internal investigation results into the ECCAIRS databases (feedback-loop), (b) the necessity to exchange investigation information with the manufacturer.

5. Training regulations

Review the applicable regulations on initial and recurrent flight crew training to assess whether they adequately address the potential degradation of situational awareness (basic pilot skills) and flight path management due to increased reliance on aircraft automation by flight crews.

The Dutch Safety Board made the following recommendation to the International Civil Aviation Organization.

6. International regulations

Raise the recommended procedure in paragraph 8.9.3.6 (*ICAO Document 4444 PANS - ATM*) to intercept the published or nominated ILS Glide Path from below to a Standard.

In the event that interception of the Glide Path from below is not adopted as a Standard, horizontal and vertical operating landing gate limits need to be added to prevent aircraft exposure to pitch-up upsets due to False Glide Slope Reversal.

The Dutch Safety Board made the following recommendation to the Flight Safety Foundation.

7. Update of stabilised approach criteria

Update the Approach and Landing Accident Reduction (ALAR) toolkit stabilised approach criteria to include guidance to prevent pitch-up upsets due to aircraft exposure to False Glide Slope Reversal in the area above the published or nominal Glide Path.

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APPENDIX A

JUSTIFICATION OF INVESTIGATION

In accordance with international and European agreements and guidelines, contact was made with the involved states; Ireland (the state of registration of the aircraft as well as state of the operator), United States of America (the state of the aircraft manufacturer and state of design). Also the European Aviation Safety Agency was informed about the investigation.

In accordance with ICAO Annex 13, each of the above mentioned states appointed an Accredited Representative to participate in the investigation with advisors to assist. The Spanish Comisión de Investigación de Accidentes e Incidentes de Aviación Civil (CIAIAC), the French Bureau d'Enquêtes et d'Analyses pour la Sécurité the l'Aviation Civile (BEA) and the Italian Agenzia Nazionale per la Sicurezza del Volo (ANSV) joined the investigation team at the request of the Dutch Safety Board as similar occurrences were reported in these States.

The following parties and organisations participated in the investigation and provided information and documentation:
1. Air Accident Investigation Unit (Ireland)
2. National Transportation Safety Board (United States of America)
3. Federal Aviation Administration (United States of America)
4. Delft University of Technology, faculty of Aerospace Engineering (The Netherlands)
5. Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (France)
6. Agenzia Nazionale per la Sicurezza del Volo (Italy)
7. Comisión de Investigación de Accidentes e Incidentes de Aviación Civil (Spain)

The following investigation activities were performed:

- 11 October 2013: Test Flight (PH-LAB) Delft University of Technology, measurement Woensdrecht Air Base and Eindhoven Runway 21 ILS M-array antenna.
- 30 October 2013: Flight Inspection Eindhoven Airport (PH-NLZ) operated by NLR, a Test Flight for additional data Eindhoven Runway 03 was combined with a bi-annual Flight Inspection of Eindhoven Airport, a Dutch Safety Board investigator as an observer during that flight.
- 13 November 2013: Flight Inspection measurement preformed by the Federal Aviation Administration (FAA), measurement Null and Side Band ILS antenna in the United States of America.
- 13-14 November 2013: Technical Review meeting Air Accident Investigation Unit (AAIU), Interview Flight Crew and exchange of information relating to other similar events with Operator and, Dublin, Ireland

- 16 December 2013: Technical Review meeting Federal Aviation Administration (FAA), Flight Inspection Services and Navigational Aids experts, Aeronautical Center Oklahoma City, USA.
- 18 December 2013: Technical Review meeting National Transportation Safety Board Washington DC, USA.

Guidance committee	
E.R. Muller	chairman
J.B. Benard	captain Boeing 747
P.M.J. Mendes de Leon	professor, University of Leiden
M. Mulder	professor Aerospace Human-Machine Systems, Technical University Delft
L.F.M. Ruitenberg	aviation safety consultant
R.M. Schnitker	judicial expert aviation

Project team	
K.E. Beumkes	project manager
G.J. de Rover	senior investigator
M.J. Schuurman	senior investigator
Dr. N. Smit	advisor research and development
J.M. Schuite	legal officer
H. Kiffen	expert military ATC
G. Stigter	captain B737, aviation safety expert Dutch Airline Pilot Association
H. van Duijn	investigation manager

Assisting experts:	
T.J. Mulder	research test pilot
M. Nijhof	safety management system expert
V.H. Telkamp	captain Airbus 330
Dr. A.C. in 't Veld	research test pilot

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COMMENTS PARTIES INVOLVED

A draft report (without consideration) was submitted for inspection of factual inaccuracies to the parties directly involved in accordance with the Dutch Safety Board Act. In so far as non-textual, technical aspects and factual inaccuracies are concerned, the Safety Board has incorporated the comments received into the final report. The remarks which were not incorporated are mentioned in a separate table with reasons why the Board has not amended the report on these points. The paragraph and chapter numbers refer to the numbering in the draft report and do not always correspond to the numbering in the final report. The table can be found at the investigation concerned on the Safety Board's website: www.safetyboard.nl.

The Draft Final Report was sent to the following parties for their comments:

Supervisory and regulatory authorities

1. Minister of Defence
2. Military Aviation Authority
3. Minister of Infrastructure and the Environment
4. Dutch Human Environment and Transport Inspectorate
5. International Civil Aviation Organization (recommendations only)
6. European Aviation Safety Agency (EASA)
7. Federal Aviation Administration (FAA)
8. Irish Aviation Authority (IAA)

ILS calibration flights in the Netherlands

9. National Aerospace Laboratory (NLR)

Airline operator and Air Navigation Service Providers

10. KLM Cityhopper
11. Air Operations Control Station (Nieuw Milligen)
12. Air Traffic Control the Netherlands
13. Eurocontrol

Foreign Civil Aviation Safety Investigating Authorities
14. Air Accident Investigation Unit (Ireland): Ryanair and IAA
15. ANSV (Italy): Ryanair incident Treviso Airport
16. BEA (France): Air France incident Paris CDG, Thales and Airbus
17. CIAIAC (Spain): Ryanair incident Murcia Airport
18. NTSB (United States of America): Boeing, FAA and Flight Safety Foundation

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TERMS OF REFERENCE

The following relevant (international) legislation, regulations, guidelines, operating and training manuals were used for this investigation:

- Annex 10 Aeronautical Telecommunications - Volume I: Radio Navigation Aids, International Civil Aviation Organization, 6th edition July 2006
- Annex 13 Aircraft Accident and Incident Investigation, International Civil Aviation Organization, 10th edition July 2010
- Annex 19 Safety Management Systems, International Civil Aviation Organization, 1st 14 November 2013
- ICAO Doc 8071 Testing of radio navigation aids- Volume I: Testing of Ground-based Radio Navigation Systems, 4th edition 2000
- ICAO Doc 9859 Safety Management Manual (SMM) AN/474, International Civil Aviation Organization, 3rd edition 2012

- Regulation (EU) No 996/2010, The investigation and prevention of accidents and incidents in civil aviation, 20 October 2010
- Regulation (EU) No 1178/2011 technical requirements and administrative procedures related to civil aviation aircrew 3 November 2011
- Regulations (EU) 290/2012 technical requirements and administrative procedures related to civil aviation aircrew, 30 March 2012
- Regulation (EU) 965/2012 technical requirements and administrative procedures related to air operations, 5 October 2012

- Airbus A330/A340 Flight Crew Operation Manual, 13 Dec 2012
- Airbus A330/A340 Flight Crew Training Manual, 17 Nov 2011
- Boeing 737NG Flight Crew Training Manual June 30, 2013

- Instrument Flying Handbook FAA-H-8083-15B U.S. Department of Transportation Federal Aviation Administration, 2012
- Operational Use of Flight Path Management Systems, PARC/CAST, Flight Desk Automation WG, 5 Sept 2013
- Flight Inspection Handbook TT8200.52, November 2007, The Federal Aviation Administration
- United States Flight Inspection Manual 8200.1C, Departments of The Army, The Navy, and The Air Force and The Federal Aviation Administration, October 2005

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INTERIM SAFETY ALERT LETTER

[Translated]

Interim Safety Alert

[To the addressee]

Risks concerning ILS approach from above
The Dutch Safety Board has started an investigation into the occurrence of and sequence of events during a serious incident with a commercial aircraft earlier this year, which occurred while the aircraft was on approach to Eindhoven Airport. During this approach the Instrument Landing System (ILS) was used. A preliminary finding of the investigation is that approaching an airport under Instrument Meteorological Conditions (IMC) with the Glide Path being approached from above using the autopilot involves greater risks than during an approach according to the ICAO guidelines (see below). The greater risk is not related to the aircraft type. The Dutch Safety Board believes it is important that this information is shared with you now, in anticipation of the final investigation report.

During this incident the nose of the aircraft pitched up within a short period of time at about 0.5 miles from the runway threshold, causing the airspeed to decrease rapidly and to come close to the stall speed, as a result of which the 'stick shaker' was activated. The crew responded adequately to the stick shaker warning. Following a successful go-around, the aircraft landed safely.

False Glide Slopes
During a standard approach, an ILS approach with a 3 degree Glide Slope is followed. Procedures and instruments are designed to perform this standard approach safely. Apart from the 3 degree Glide Slope, one or more False Glide Slopes exist, which occur due to the design of the ILS antennas and reflections via the earth's surface. We know that the False Glide Slopes are located at multiples of 3 degrees: 6, 9, 12, etc. For the 9 degree Glide Slope the guidance signals are the reverse of the signals for a standard 3 degree Glide Path. Although procedures and instruments are not designed to intercept and follow these False Glide Slopes, still these Glide Slopes are regularly intercepted during an ILS approach. So far, the Dutch Safety Board is aware of three relatively recent incidents during which the ILS was intercepted from above, which led to risks while executing the approach. In addition to the incident at Eindhoven Airport, these incidents occurred in 2011 (Amsterdam Airport Schiphol) and in 2012 (Paris Charles de Gaulle

Airport). The latter incident was investigated by the French Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) and was published last month.[1]

Risks

In anticipation of the results of the investigation, the Dutch Safety Board believes that air traffic controllers and flight crews should be aware of the risks stated below, associated with commercial aircraft intercepting the ILS from above. The Board therefore recommends that you announce these risks within your organisation or company. The risks relate to:

1. the receipt of False Glide Slope signals by the aircraft navigation equipment, whereby the reverse guidance signals may cause the aircraft's nose to suddenly pitch up, the airspeed to rapidly decrease and, depending on the aircraft type, the stick shaker to be activated as a result of inappropriate corrections by the autopilot;
2. the aircraft's (excessive) rate of descent being too high to intercept the Glide Slope, causing GPWS[2] alerts to be triggered;
3. the execution of a non-stabilised approach;
4. the increased workload in the cockpit during a critical phase of the flight.

Investigation

During the investigation by the Dutch Safety Board, the ILS approach procedures of military and civil air traffic control will be studied in relation to the approach procedure standards and recommendations from the International Civil Aviation Organization (ICAO). Regarding ILS approaches, this means – in short – that flight crews should be given the opportunity to line up for the final approach path (Glide Slope) at ample distance from the runway, to then approach the Glide Slope from below. The Board made a similar recommendation in response to the Turkish Airlines accident in 2009 (Amsterdam).

Finally, the Dutch Safety Board would like you to report to the Safety Board any incidents within your company or organisation involving the interception of False Glide Slopes. These reports can be incorporated into the current investigation. Please send your reports by email to 2013079@onderzoeksraad.nl.

Yours sincerely,

Mr T.H.J. Joustra
Chairman

[1] www.bea.aero, 'Approach above Glide Path, interception of ILS sidelobe signal, increase in pitch angle commanded by autopilot' report, f-zu120313e / September 2013.

[2] Ground Proximity Warning System.

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SAFETY ALERT

Date: November 18, 2013

UNEXPECTED AUTOPILOT BEHAVIOUR ON ILS APPROACH

Potential severe pitch-up upset when intercepting the instrument landing system (ILS) glide slope from above, which can lead to (approach to) stall conditions.

The particulars

- Different types of Instrument Landing System (ILS) glide slope systems are used worldwide. Signal characteristics in the area above the (standard) 3 degree glide slope are system dependent.
- Similar glide slope capture logic in automatic flight control systems (autopilot) is used for the majority of aircraft types currently in service worldwide.
- While intercepting the ILS glide slope signal from above the 3 degree flight path with the automatic flight control system engaged, the aircraft can capture a false glide slope resulting in an unexpected rapid pitch-up command (automation surprise).

Preliminary investigative findings

The Dutch Safety Board is investigating a severe and sudden pitch-up upset during an ILS approach to Eindhoven Airport in 2013. The airspeed dropped rapidly to a near stall situation (stick shaker). The crew carried out a go-around. During the investigation the Board has become aware of similar events. Analysis revealed that the common factor linking these events is the ILS antenna type; M-array (Capture effect) ILS antenna. The M-array ILS antenna type is used around the world, including at major airports and military air bases in the Netherlands.

Regulations mandate that ILS systems be periodically checked with a Flight Inspection in order to be certified for operational use. The Flight Inspection focuses exclusively on the 3 degree glide slope area. The signal characteristics in the area above the 3 degree glide slope were examined as part of the Dutch Safety Board's investigation. Flight tests were conducted to measure the M-array antenna signal and determine the 'glide slope field' characteristics above the 3 degree glide path while established on the localizer.

Analysis of the measurements show that between the 3 and 9 degree glide path, signal strength changes. For the pilot this can result in observable movement of the ILS glide slope marker on the primary flight display. At this time two important characteristics of the M-array ILS antenna 'glide slope field' have been identified:

1. A signal reversal was <u>always</u> present at approximately 9 degree glide path.
2. A signal reversal was <u>sometimes</u> present at approximately 6 degree glide path.[39]

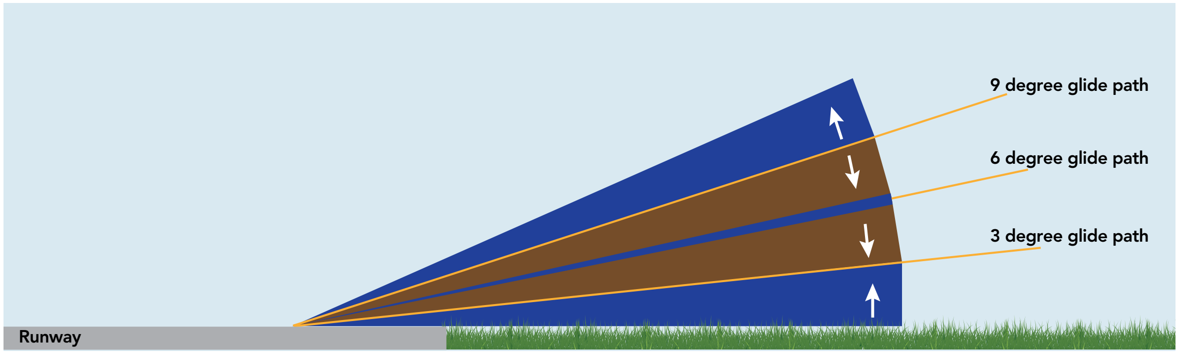

Figure 1: Cross section view of the M-array ILS antenna system. Schematic overview of the "Fly up"(blue) and "Fly down"(brown) indication.

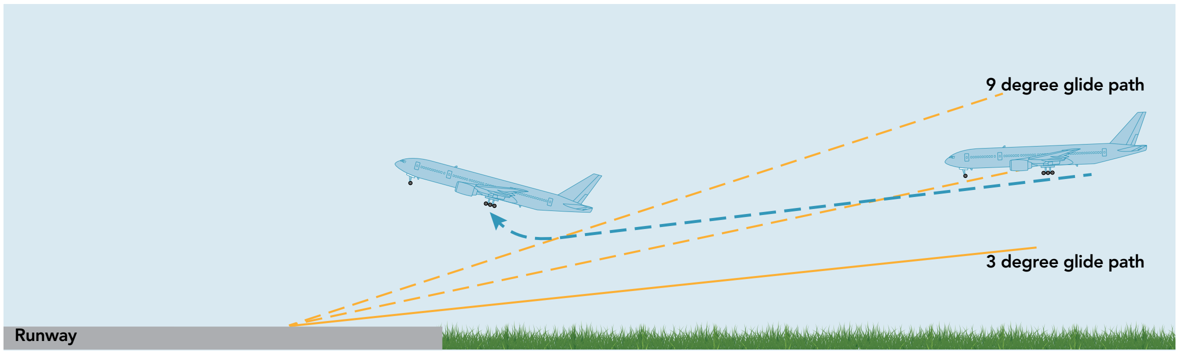

Figure 2: Example of glide slope capture with a pitch upset above 3 degree glide path.

Depending on the glide slope field, signal reversal occurs occasionally at 6 degree, and always at the 9 degree glide path. This reversal activates the glide slope capture mode after which the autopilot follows the glide slope signal without restrictions. During flight tests the reversal resulted in the automatic flight control system commanding a severe pitch-up. Immediate flight crew intervention was required to regain aircraft control.

39 During measurements at two different Airports in the Netherlands the 6 degree glide path reversal was not always present.

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Furthermore the flight tests have shown that commonly available information on false glide slope (internet, manuals and literature) does not necessarily reflect glide slope signal characteristics of all ILS antenna types in use worldwide. For example, in some aircraft manuals it is noted that a false glide slope signal can be identified by a higher than normal descent rate. This particular description does not accurately reflect what happens when a false glide slope of a M-array antenna is captured.

Thus far the investigation has revealed that aircraft from four different manufacturers operated by different airlines have experienced a pitch-up upset caused by a false glide slope either under test conditions or during operation.

This investigative information has led the Dutch Safety Board to issue this Safety Alert to address the following safety concern: to generate awareness of different ILS signal characteristics and the potential of aircraft pitch-up upset due to capturing a false glide slope, which can lead to (approach to) stall conditions.

Related incidents
During the ongoing investigation the Dutch Safety Board was notified of a similar event with a different aircraft type at Amsterdam Airport Schiphol in 2011.

In 2012 the French Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) investigated a pitch upset of an Airbus A340 on approach to Charles de Gaulle Airport. Also in this case the airspeed dropped rapidly and the crew carried out a go-around. The Dutch Safety Board has been provided with information that the M-array antenna system is used at Charles de Gaulle Airport.

For more information www.bea.aero - report "*Approach above glide path, interception of ILS sidelobe signal, increase in pitch angle commanded by autopilot*", September 2013.

Information for pilots; what can you do?
Pilots should be aware of the ILS glide slope signal characteristics and the dangers accompanying flying in the area above the 3 degree glide path during the approach. In particular the aircraft behaviour while flying on autopilot with the glide slope mode armed should be noted.

Information for operators; what can you do?
Operators should consider the need to implement additional operational procedures or provide additional guidance in order to mitigate the risks of unexpected autopilot behaviour when on ILS approaches.

If after reading this Safety Alert you think a similar occurrence has taken place within your company, please contact your investigation authority agency and provide any relevant information of the event.

Information for Air Traffic Control; what can you do?
Adhering to prescribed navigation procedures reduces the flight crew workload and will position the aircraft to intercept the glide slope from below.

Information for Aircraft Manufacturers; what can you do?
Aircraft Manufacturers should consider the need to provide additional guidance in order to mitigate the risks of unexpected autopilot behaviour when on ILS approaches.

What can the Aviation Authorities do?
Thought should be given by the Aviation Authorities to monitor and enforce the need for mitigating actions by the relevant parties to reduce the risk of false glide slope encounters.

This Safety Alert is not intended to apportion blame or liability to any party. The sole purpose of the Safety Alert is to inform the aviation community of a safety concern which has been identified by the Dutch Safety Board during an investigation.

The publication of the Final Report (Stick shaker warning during ILS approach, Boeing 737-800, May 31, 2013 - Eindhoven Airport) is scheduled for May 2014.

T.H.J. Joustra
Chairman of the Dutch Safety Board

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RELEVANTE ASRS-DATABASE MELDINGEN

ASRS ACN 443810	Date 199907	Make Model Name MD-80 Series (DC-9-80)	Altitude.MSL.Single Value 3500	Event Detector Person Flight Crew

Narrative: At 5000 ft we were clred for the ils RWY 27L apch with an intercept HDG of 300 degs. GS and LOC were alive when we came out of the turn on a 300 deg HDG. I lined up with the RWY and started down on the GS. When CLR of clouds, it was obvious that we were not on the appropriate GS. I leveled off at about 3500 ft MSL and observed the GS CLB to a full scale fly-up. We intercepted that GS and it chked correct at the om. Lndg was uneventful. We advised apch of the false GS and said they were wondering where we were going. A chk of the cabin found no electronic devices in use.

ASRS ACN 449482	Date 199909	Make Model Name MD-80 Series (DC-9-80)	Altitude.MSL.Single Value 600	Event Detector Automation Air Traffic Control; Person Air Traffic Control

Narrative: We were apching oak arpt and the current ATIS was rpting the field to the 300 ft OVCST and 2 mi visibility, and the GS for RWY 29 was rpted to be inop. This would put the ceiling approx 60 ft below our minimums for the existing rwy conditions. Our other alternative was to use rwy 27r which is 5400 ft, which I considered to be adequate, but nevertheless a shorter rwy than we are used to using. Minimums for RWY 27R are 250 ft and 3/4 mi visibility, and we were informed that we would be using rwy 27r as had other carriers. I briefed the fo on the apch to RWY 27R, but after several mins had elapsed and a hdof to bay apch, we were informed that the rwy would now be RWY 29. We chked atis only to get the same wx we had before, ie, 300 ft ovcst and 2 mi visibility. We then called oak TWR and were informed that the ceiling was now 800 ft OVCST. This was a last min change for us while being vectored for the apch to RWY 29. We were high for the profile due to ATC tfc and thereby had to remain at alt and it prevented our normal dscnt. In addition to this, apch was turning us close to the FAF, compounding our prob of the need for a higher than normal dscnt rate. We were clred for the apch to RWY 29 when established on the LOC. At this point I incorrectly selected 'GS' on the MCP. The acft captured a false GS and began dscnt. At first, the rate of dscnt appeared normal but as we apched the fix I could see that it was indeed too high a rate of dscnt. I then disconnected the autoplt and hand flew the apch. During this time of brief confusion, I realized that I might be at an alt that was lower than called for. I queried the FO as to what the alt was supposed to be, but did not hear a response. When I was able to xchk the alt, I verified that I was too low. I believe this was about 800-600 ft MSL at about 2 mi prior to the FAF. I began to correct, but by the time this occurred, I was at the FAF and minimums for us were 400 ft MSL. I therefore continued to hold this alt, and it was at this point inside the FAF that apch ctl or twr (I'm not sure which at this point) called 'low alt alert.' i then queried the FO again as to the correct alt, and he verified that 400 ft MSL was correct for inside the FAF. We broke out on schedule and landed uneventfully. I felt the last min change of rwys, both with marginal sets of conditions, each different in its own way, contributed to the confusion during the high rate of dscnt, and the eventual capture of a false GS. I feel that I selected the 'GS' under the idea that i was using RWY 27R for a brief moment, then realizing my error tried to correct for the alt when my error was realized.

ASRS ACN 457801	Date 199912	Make Model Name B727 Undifferentiated	Altitude.MSL.Single Value 1000	Event Detector Person Flight Crew

Narrative: Apching sat from the n, we were clred for the visual apch for RWY 12R. The ctlr was first vectoring us for RWY 12. We asked for RWY 12R and he clred us for the visual. At about 6 mi from the arpt, the PNF set LOC freq for the PF. PF started down to a full scale deflection on ILS. PF left 3000 ft and was dsnding, when we all noticed we were too low, even with the full fly down needle. It took several seconds to realize we were trying to intercept a 'false' GS. We were too far to the n of the RWY to receive a valid signal. We clbed back to a good visual glide path, then turned final and followed GS to a lndg. It is likely that we went below an electronic GS where one was available. To correct this, better cockpit discipline is needed. I should have been looking outside more because it was a visual.

ASRS ACN 458720	Date 199912	Make Model Name B727-200	Altitude.MSL.Single Value 1500	Event Detector

Narrative: Apching sat from the n, we were clred for the visual apch for RWY 12R. The ctlr clred us for the visual. At about 6 mi from the arpt, the PNF (capt) set the LOC freq for RWY 12R on #1 VOR/ILS and idented the station, then reached forward to tune the ADF freq. The PF (FO) started down to the full fly down GS needle. He left 3000 ft and was dsnding when we all noticed we were too low, even with the full fly down needle. It took several seconds to realize we were trying to intercept a false GS (we were too far to the n of the LOC to receive a valid signal). We clbed back to a good visual glide path then turned final and followed the GS to a lndg. It is likely that we operated below the electronic GS on a visual apch where one was available. To cure this, better cockpit discipline is needed. I should have not have been tuning radios so close to the arpt. Supplemental info from ACN 458719: on visual apch for sat RWY 12R on base. Approx 4-6 mi out, the FO (flying) dsnded lower than normal due to false GS. My focus was on fe duties. I was looking for the arpt when the capt called too low and the FO quickly recovered to 1500 ft AGL

ASRS ACN 473903	Date 200005	Make Model Name B727-200	Altitude.MSL.Single Value 4000	Event Detector Person Flight Crew

Narrative: Intercepted 20 nm final RWY 17C dfw. At 4000 ft and 12 nm out we captured false GS. FO flying and dsnded well below glide path. Corrected by vasi and normal lndg. Conditions were VFR and noticed b747 holding short on e side of RWY 17C. Possible disruption of GS signal. I believe no acft should hold short so close to the antenna. Could have been hazardous IFR even if unprotected at 800 ft and 2 mi visibility. ATC had no idea of the possible hazard and did not notify apching acft until the complaints started. Callback conversation with rptr revealed the following info: capt stated that the prob with the GS was discovered when the crew noted the altdev via the vasi lights on rwy 17c. They didn't have time, due to freq congestion, to complain to the TWR until after they were on the gnd and other flts began complaining. They called in and agreed with the comments on freq. The b747 was right up to the RWY hold short line. Rptr believes that 800 ft and 2 mi are the limits where ATC starts protecting the ILS GS xmitter by having acft hold further back.

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476065	200006	B737-200	1000	Automation Aircraft Other Automation; Person Flight Crew

Narrative I received vectors to the final apch course ILS RWY 10 at BWI. Wx was approx 600 ft ovcst visibility 2 mi. The reason for the missed apch was an inaccurate GS indication that caused me to dsnd below a normal glide path. We did not get a GPWS warning or a low alt alert from ATC, but went around when the capt recognized that we were too low considering our distance from the RWY. His situational awareness was the only warning sys that worked for us. While intercepting the LOC I got an immediate intercept of the GS as well. At that moment I didn't think much of this, as a very tight vector to final with GS intercept at or prior to course intercept happens all too often at BWI. This factor -- one of reduced expectations of ATC svc -- helped set the trap for me. I immediately called for lndg gear and more flap extension while decelerating and starting down the GS. I had less than desirable pos orientation at that point, as being tuned to the LOC freq I did not have a BWI dme indication, and there is no longer an om beacon on this apch. I was working quickly to get the airplane stabilized as according to the radio altimeter we were already getting close to 1000 ft agl and we were still too fast. I knew that the apch was not going well, but other than being caught by surprise, I hadn't been able to figure out exactly why yet. As we went below about 1000 ft radio alt the capt directed a gar, saying, 'we're too low, gar.' as we were not much below 1000 ft and indicating on the GS I was initially confused by this command, but understood why when he told me we were at least 4 mi from the rwy. He confirmed that I was indicating on glide path with no red flags in view, but this info must have been false. The capt did not have a glide path indication to back mine up, as his VHF was (thankfully) tuned to BWI VOR to ident the GS xing alt, as I had requested. He saw that we were too low for our DME from the field. We do not know why I had an inaccurate GS indication. It may have been momentarily radiating or reflecting falsely, or more likely my GS indicator simply ctred and stuck without warning flags. All the equip worked perfectly normal on the second and completely successful apch, so this remains a mystery. Here is the point I wish to make with this rpt: the lack of an OM or an ILS DME is an unacceptable safety hazard. Chking alt when xing the marker or fix will catch an incorrect GS or altimeter. An ILS apch should preferably be equipped with both pieces of equip, but must have at least one of them. Too many non-DME ILS apchs, such as the ILS RWY 10 at BWI, have had their marker beacons removed for unjustifiable reasons. There are still many acft that do not have RNAV or an extra DME receiver, and we rely on the marker beacon for this chk. Not doing this chk seriously degrades safety. As these marker beacons disappear it is becoming common for unconcerned plts to simply tune the loc on both VHF NAV radios and follow the glide path, without any means to perform the GS alt chk. In fact, this is the proc for a cat II/III apch, where if you are late tuning the second receiver you will not be able to complete the coupled apch. With both receivers tuned to the LOC the VOR DME cannot be received, and no warning of a false GS or an incorrect altimeter setting will be available. On a CAT I apch a concerned and aware crew can leave 1 receiver on the VOR/DME, but this is itself a less than ideal solution. With no comparison btwn receivers a GS error such as occurred in this incident may go undetected. The PF may not have a DME indication, and must rely on the PNF, who is busy with other tasks, for this vital xchk. Flying the apch becomes a fully 2 plt job, rather than a 1 plt job with the other plt as a backup. Interestingly, our b737-200's do have an indicator that repeats the other plt's dme readout, but the view of this readout is blocked by the coplt's arm when hand-flying. If a highly experienced crew that is aware and concerned can be caught i

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
479330	200007	Regional Jet CL65,	1600	Person Flight Crew

Narrative The flt was routine until the dscnt into myr. During the dscnt, I lost my situational awareness and ended up high on the apch. I had to execute a missed apch proc. During the dscnt, the autoplt was engaged until after GS capture. After GS capture, the GS indicator fluctuated full deflection up and down rapidly. The autoplt was trying to follow the GS indications which resulted in large pitch attitude changes from a few degs nose down to 15 degs nose up. At this point I disconnected the autoplt and overcompensated for the nose up attitude with an increase in thrust and attitude adjustment that resulted in an indicated airspace of 220 KIAS. As we were passing through 1600 ft, we saw the RWY through the broken cloud layer, realized we were too high and going too fast, and a missed apch was carried out. Contributing factors: ATIS wx 10000 ft broken, visibility 4 mi, light rain, calm winds, RWY 17. Actual wx 800 ft broken, visibility 6 mi in haze, calm winds. The clouds obscured our view of the arpt and I did not really mentally prepare myself for an IFR apch, even though we carried out a briefing and properly set up the navaids. Also, after being clred for the apch, we must have captured a false GS which led to the erratic GS indications and large pitch attitude changes. What really caused the prob: my inattn to detail on this flt led to loss of situational awareness which led to the high and fast apch. Corrective action: when on duty, maintain an appropriate level of alertness at all times to avoid a future recurrence.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
482987	200008	B737-300	4000	Person Air Traffic Control

Narrative We were on a vector to intercept the RWY 27L ILS. We were told to maintain 5000 ft until xing WAVIE and then clred for the apch. The autoplt captured a false GS and we crossed WAVIE at about 4000 ft. The ctlr saw it and then clred us to 3000 ft and for the apch. There was no conflict. You have to be aware that false GS capture happens and watch the DME at all times.

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495996	200012	Medium Large Transport, Low Wing, 2 Turbojet Eng	3000	Person Air Traffic Control; Person Flight Crew

Narrative — While on apch to RWY 27L at ORD, on ILS, all cockpit indications showed we were on GS and LOC. As we got closer to field, we could see PAPI showed us very low. There were no cockpit warnings to correspond. As we started to clb back up to get back on GS via the PAPI, apch asked if we were low. We informed them of false GS info. They said they would look into it. Callback conversation with rptr revealed the following info: rptr has not encountered a similar type incident and has been into ORD frequently since the prob occurred. Rptr did not observe any other acft activity on the adjoining ramp or xing to dep rwy 22.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
501202	200102	Fokker 100	4000	Automation Aircraft Other Automation; Person Flight Crew

Narrative — Inbound to dfw on ILS RWY 17C, we received and followed a false GS near penny. When we realized we were on a false GS, we rpted same to TWR. They advised a hvy had just departed RWY 17R. The acft following us on apch rpted similar event. Conditions were VMC and no conflicts were rpted.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
501539	200102	A319	2800	Automation Air Traffic Control; Automation Aircraft Other Automation; Person Air Traffic Control

Narrative — This prob turned out to be a mixture of late ATC instructions, false GS, and equip failure. We were on a vector from PIT apch. We had initially set up and briefed for RWY 32 in PIT, then they changed our lndg RWY to RWY 28R. They then wanted to change it back to RWY 32 after we had already set up and briefed RWY 28R. The capt asked the ctlr if we could keep RWY 28R, and they both agreed. We received a clrnc to cross COFEE at 4000 ft and on the vector we were clred for the ILS RWY 28R in PIT. The apch push button was selected, second autoplt engaged, and then we realized that the turn was given late and we were already past the LOC. The capt disconnected the autoplt, and started a r turn back to the LOC. Somehow he thought we were high, thought the GS dev was showing high, and he initiated a dscnt. I was busy reloading the lndg data in the apch phase which had somehow dumped. The apch ctlr gave us a 300 deg hdg to reintercept the LOC, and queried us as to if we had RRWY 28R tuned in for the apch, because to him it looked as if we were lined up for RWY 28L. (this was due to the winds, and the late turn-on.) In the meantime, we had dsnded to 2800 ft and broken out of the clouds. There were 2 distinct radio twrs directly ahead, and ATC said maintain 3000 ft. Since we had the arpt in sight, we asked for a visual apch. The ctlr said no, not yet. But as we clred the twrs, he clred us for the visual. Even though the apch mode was selected, it is my opinion that the alt alerter should not be inhibited until GS capture. I had no idea we had dsnded that low until the ctlr told us to clb to 3000 ft. I do not know if the false GS had anything to do with the inhibit function of the alt alerter. But, if the ceiling was any lower, the event could have been much worse. Due to task loading, airbus anomalies -- such as known false GS captures, and poor situational awareness -- all added to the seriousness of this event. Callback conversation with rptr revealed the following info: the rptr said that the change in RWY assignment required the reprogramming of the apch data. This caused him to be heads down and lose positional awareness. The capt apparently reacted to a false GS and without chking pos, dsnded below the normal apch alt for the pos of the acft. The rptr says that there is anecdotal evidence of false GS capture at CLT, NC, specifically and other arpts used by his carrier as well. This anomaly occurs primarily in the a319 version of the Airbus. His company is aware of it and is investigating. The aural alt alerter is inhibited any time the autoplt is engaged. There should have been an aural alt alert since the capt was hand flying at the time of the alt excursion and there was no GS capture.

ASRS ACN 512017	Date 200105	Make Model Name B757-200	Altitude.MSL.Single Value 3700	Event Detector Automation Air Traffic Control; Automation Air Traffic Control; Automation Air Traffic Control; Person Air Traffic Control

Narrative Arr at Hong Kong int'l arpt, afternoon local time in VMC wx conditions. On apch to RWY 25L we were given the clrnc 'turn l heading 270 maintain 4500 ft report established'. I entered 4500 ft in the MCP altitude window and the FO who was the PF turned the heading bug to 270 pushed fl change to dsnd and armed the apch mode. The localizer for 25L is unusable past 7 degs left of course and up until this time i had been unable to identify it. At some point while the airplane was dsnding to 4500 ft and i was looking at my chart to identify the localizer, the glide slope came alive and the autoplt captured it and the localizer. When I had finished identifying the localizer and looked at the ADI glide slope and localizer were captured and the acft was dsnding. Shortly there after we received an autoplt caution with an amber line through the G/S fma indicating a loss of signal. The autoplt continued the dsnd and we waited several seconds to see if it was a temporary loss of signal. We discussed why it had happened and the FO stated it could be a false glide slope and maybe we should select altitude hold. He then asked for altitude hold and i selected it but it would not engage since the localizer and G/S were captured. The altitude alert caution then went off since we had dsnd below 4200 ft. The FO then commented that we needed to be at 4500 ft until lotus intxn. We had extended our rte off the final fix so LOTUS was not on our map display. I looked at the apch chart to get the DME for LOTUS and was switching my map display to ILS mode for the DME when the apch ctlr called and said we were too low, clb to 4300 ft. The FO disconnected the autoplt and began to clb. We then reintercepted the G/S and continued the apch to ldg. On a phone call to the atc supvr I was told the G/S at Hong Kong was unusable beyond 15 miles. I could not find this info on the apch chart or any where else in the many pages of for Hong Kong. Contributing factors were, our failure to keep track of our pos with regards to the proper glide slope intercept. A clrnc that did not specify to maintain 4500 ft until LOTUS intxn. Our anticipation of starting down the glide slope shortly after the final vector and clrnc. Not remembering that altitude hold was not available when the localizer and glide slope were captured. Some degree of complacence caused by day VMC conditions. Not chking the FMA to see that altitude hold had engaged. Not disconnecting the autoplt in a timely manner and stopping the dscnt.

ASRS ACN 515608	Date 200106	Make Model Name Regional Jet CL65, Undifferentiated or Other Model	Altitude.MSL.Single Value 10000	Event Detector Person Flight Crew

Narrative It's difficult to get ZLA to give us a lower alt (phx to bfl) until we're nearly over the field. Steep dscnts for the visual apch are common. On this flt the autoplt intercepted a false GS indication and caused the stick to vacillate and release the autoplt. The faa observe in the jump set thought we had stalled the plane. Is there a way to ident and chart the location of false GS's? Just to add, there was no upset, no injury, and no acft damage. However, others have indicated different occasional outcomes.

ASRS ACN 522450	Date 200108	Make Model Name Super King Air 200	Altitude.MSL.Single Value 5000	Event Detector

Narrative On ILS RWY 23L coupled autoplt apch at IND. ATC asked for best forward spd (approx weldo intxn) join RWY 23L LOC dsnd and maintain 5000 ft (from 7000 ft) upon joining LOC autoplt captured. While dsnding the GS captured, autoplt now was following both vert and horiz guidance. ATC asked several (2) times if I would like a 360 deg turn to rejoin. I declined. My coplt had gnd contact. Still imc, I continued to the OM. At the OM GS fell off. ATC asked again for a turn to rejoin, I declined. At this point, I realized I had a false GS. I continued visually to rejoin the GS but did not inform ATC that I was VMC. I had an abnormal apch dscnt rate to rejoin the GS. During this time I was VMC. I landed within the touchdown zone and made a safe and normal rollout. Spd, distance and alt contributed false GS and abnormal dscnt to rejoin GS. Safety was not compromised. A dscnt at flt idle flaps and gear increased drag to rejoin GS.

ASRS ACN 541533	Date 200203	Make Model Name A319	Altitude.MSL.Single Value 3600	Event Detector Person Flight Crew

Narrative We were on apch to RWY 36r at clt, 8 nm s of LANSER intxn. The Fo was PF with the autoplt on. We were given an intercept hdg and 'clred for apch' at 3600 ft MSL. The FO armed the autoplt for apch. As soon as the LOC captured, the autothrust increased and the acft started to clb like it was trying to capture the GS. The FO disconnected the autoplt to recapture the alt. The acft clbed to 4300 ft before we quickly recovered to 3600 ft. We also slightly overshot the LOC course during this recovery. Once we were back to 3600 ft and on loc course, we re-engaged the autoplt then reselected the ILS apch. The remainder of the apch was normal. Evidently the autoplt sensed a false GS.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
545241	200204	B737	1800	Automation Aircraft Other Automation; Person Flight Crew

Narrative: On a vector to intercept the final apch for the ILS to RWY 8 at SJU in btwn patty om and wesen intxn, the autoplt captured what appeared to be a false GS signal. The MCP was on apch, the autoplt engaged, and the acft was at about 2000 ft dsnding to an assigned alt of 1800 ft about 7 nm from the RWY and intercepting the LOC on the extended ctrline. The GS indicated on glide path before MCP apch selection. The acft was only about 2.5 nm from the OM dsnding through 2000 ft with a GS xing alt at the marker of 1552 ft with an on glide path indication and joining the loc when apch was selected on the MCP. Immediately after selection of apch, the GS dev scale went from no dev to more than 1 dot below glide path and at the selected MCP airspd of 180 kts the autoplt started a clb for the new GS indication from leveling at the assigned alt of 1800 ft. Autoplt and autothrottles were disconnected and the acft was returned to the proper alt, but not before first clbing to 2500 ft. I was the PF and was totally taken by surprise by the automation actions. I immediately disconnected autoplt and autothrottles but it took me a few seconds to interp the insts and this delay caused the altdev. I have become automation dependent and was not monitoring the autoplt as I should have been. I'll make efforts to improve in this area immediately.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
561822	200210	A319	3000	Person Air Traffic Control; Person Flight Crew

Narrative: We were 'clred for ILS RWY 26' at IAH. Ctlr did not mention nor did we notice ils ots on atis. Clred for the ils rwy 4000 ft, pf thought for a second that we had a false GS capture since the aft pitched up unexplainably and momentarily began a clb. Pf disconnected the autoplt and called for 'flt directors off.' dsnding on GS, ctlr asked if we were going to be able to make it down ok and then mentioned that the GS was ots. PF elected to execute a gar. Thinking we had an auto thrust reverser sys malfunction, we selected auto thrust reverser off. We then tried a couple of times to re-establish automation with confusing results, since monitoring plt only selected his flt director off when called for by PF.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
581505	200305	B737-500	3000	Person Air Traffic Control

Narrative: We were vectored from the e for the 'mall visual' to RWY 34L at Seattle. It was early morning with the sun at a low angle and a bit hazy. We were at 5000 ft heading w toward the mall area when the ctlr asked us to rpt the mall in sight. I had the ILS to RWY 34L set in, and set a point in the LNAV 8 mi out (location of the mall). We had plenty of info to back up our pos. Shortly, we saw some roof tops ahead, in the light haze, that we were both sure was the mall. I became fixated on this point so that I could turn final just s of this pos. As we apched the area, I was at the recommended 3000 ft. As I got closer, I started a slight dscnt to follow the GS and began a turn toward the radial. Apch corrected us by saying we should be at 3000 ft till the mall and we needed to turn l. That was the first time we realized that we weren't looking at the mall, but some large white roofed commercial buildings e of the mall. The GS was actually a false GS several degs e of the actual desired course. We corrected and finished the apch uneventfully. I had more than enough equip to help me find the correct course guidance. There were acft ahead of me that did the apch fine. We both got fixated on the wrong point. The haze impaired visibility as the sun was at a low angle in the sky, but it didn't trigger any alarm because we were so sure we were looking at the right point. The only thing that could have prevented this would have been to rely on my insts more. However, this was a visual apch and we were believing our eyes. When the visibility is good enough for the mall visual, but less than perfect, there is a large group of buildings e of the mall that is very easy to confuse.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
593593	200309	PA-28R	10000	Person Flight Crew

Narrative: Apched grand canyon arpt in IMC. Ctlr vectored me to the ILS for circling arr. Wx was rough and there was a strong wind (btwn 20-30 kts). ATC apparently did not take wind into consideration and gave me a very shallow intercept angle. As a result, missed OM before capturing LOC. Caught false GS and dsnded rapidly under autoplt. Disengaged autoplt and hand flew. Called twr to rpt missed apch. Twr asked if i could see the rwy. Rpted 'no rwy in sight, going missed.' began missed apch at 6.7 DME (approx 1 nm late). Missed apch called for straight-out to 10000 ft. With wind and slow clb rate experienced in turb and air, did not reach 10000 ft until in or over grand canyon restr airspace. Called ctlr to tell him I was still on RWY hdg and not yet at 10000 ft. He told me to go direct to VOR. Circled back and ultimately given instructions for second and ultimately successful apch. Issues as I see them: 1) atc gave bad instructions for first apch. Possibly did not understand wind conditions. 2) missed apch proc at gcn provides insufficient room to avoid incursion in restr space.

ASRS ACN 607781	Date 200402	Make Model Name Medium Transport	Altitude.MSL.Single Value	Event Detector Automation Air Traffic Control; Person Flight Crew

Narrative First leg of the day, early morning dep out of spokane intl. On apch to PDX (ILS RWY 10R) using hud for more precise flying as wx was marginal with gnd fog. (tops approx 800 ft.) (PDX at sea level.) Had flt director programmed to intercept LOC and GS. Loc captured at 15 DME (FAF at 8.1 DME). Was sure GS was captured through hud (looking out the front window). Started down what I thought was a captured GS by cue prompts on hud. Just inside FAF (8.1 DME) I happened to glance down at my PFD on the panel and noticed GS was full scale deflection above our alt. Immediately initiated missed apch proc and overflew the arpt (which I could see through the fog layer (downwind visibility)). At no time did we enter the clouds and had all terrain including i-t bridge in sight for the entire apch. As we were clbing out on the missed apch, PDX twr issued a 'low alt alert.' we complied with missed apch vectors and came around for another uneventful apch to lndg about 8 mins later. We thought the GS may have been compromised by gnd tfc and asked TWR if they were showing anyone near the ILS hold line. They replied that the apch sys was protected. In conclusion, I was flying with a brand new FO. We had an early morning wake-up call that and the previous morning, but I still can't figure out why the hgs sys was prompting me to follow this 'false GS' which caused the full scale deflection to occur. Both I and my FO learned a valuable lesson on xchking more diligently in the future.

ASRS ACN 627813	Date 200408	Make Model Name MD-11	Altitude.MSL.Single Value 5000	Event Detector Person Flight Crew

Narrative Following an intercept of the loc, a GS was intercepted, but when we visually acquired the field, we were obviously too high and would require a gar. Apparently the autoplt intercepted and displayed a false GS. We were issued a non-standard GA (standard was 3000 ft to a fix with l turn to intercept an outbound radial). The issued GA was to 5000 ft and a turn to a hdg. Whether this was a vector to downwind or a vector to intercept published radial was unclr. During the GA, the 5000 ft limitation was violated. I noted 5500 ft twice during maneuvering. While we were maneuvering to intercept published outbound missed apch radial, apch ctl finally made it clr we were on vectors for another apch to the RWY. Vectors back to the final apch course and normal lndg was then accomplished. The prob started because we could not start a dscnt when required. A second prob was the request to go-down and slow-down at the same time, a difficult thing to do in a large acft. The third prob was the unanticipated non-standard GA, with confusing instructions as to the required hdg (is this a vector to someplace or a vector to intercept published outbound radial?). Atc's contribution to the developing prob was the issuance of incorrect or inappropriate freqs to establish a dscnt, but as a plt, I should have refused atc's request to correct the prob with spd and high rates of dscnts. Such maneuvers do not work well, especially in an FMS acft. A non-standard GA also became a prob because FMS programmed parameters interfered with the verbal instructions. Having never been to zzzz before and being unfamiliar with the specific apch also contributed to the difficulties.

ASRS ACN 639934	Date 200412	Make Model Name DC-9	Altitude.MSL.Single Value 2300	Event Detector Person Air Traffic Control; Person Flight Crew

Narrative ILS RWY 23 apch vectored at 2300 ft. Approx 800 ft OVCST, 2 mi visibility. Note briefed on apch that the 'GS unusable from r.' vectored from r on intercept hdg. No DME on LOC. Both capt and FO on ILS freq due to procs to ensure good signal. Turned on LOC and clred for apch from a point I guessed would be very close to ADF OM at an alt that should intercept GS prior to ADF. Loc started coming across and loc capture light illuminated and I called it. The autoplt intercepted the GS at a point that I thought was acceptable as we were near the LOC. The dscnt rate of the autoplt increased at an unusual rate and what I thought was the needle swing of ADF marker passage was actually the needle moving with the card as we intercepted the LOC. About that time I sensed something was not right. A false GS capture was not suspected at that moment but I knew something was wrong, as we had not passed the marker yet. I turned autoplt off and leveled about 500 ft below assigned alt just as the formerly captured LOC went full l on the hsi. At that moment, apch questioned our alt and mentioned false GS probs from r side. Clbed back to 2300 ft and re-intercepted LOC and GS for a successful lndg. This apch is a big trap and the FO and I both interped the apch note that if we did have a prob it would just be 'no' GS not a false one. Our non-glass acft with no DME on apch and a false LOC (also with no flags showing) are big factors. From now on, I will have the PNF tune any DME that can help with pos and realize that a note on 'GS unusable' could mean a false GS. Also, our trained proc to always select auto apch on autoplt when clred for apch may not always be appropriate. This buf apch needs to be fixed. One other factor might be that I have been off the dc9 for approx 14 months and just re-qualified on dc9 and have flown only 3 trips when this happened.

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ASRS ACN 646725	Date 200502	Make Model Name Regional Jet 700	Altitude.MSL.Single Value 2300	Event Detector Person Flight Crew

Narrative Prior to apch at RWY 23 in buf, i discussed with my fo that many times i have received a false GS on the ils rwy 23. He said he was aware of the prob. The wx was foggy and the RVR was going up and down btwn 1800 ft and 2000 ft. We were vectored for the apch and given 2300 ft and a hdg to intercept the LOC, clred for the apch. It was kind of a late turn for the LOC, but the apch was armed and captured the LOC and GS almost at the same time. Immediately the GS started moving up and the acft began a clb. My FO disconnected the autoplt and made the corrections to dsnd back down to 2300 ft. We were still outside the OM and decided we would try to get re-established on a stabilized apch. If we could not, prior to the OM, we could go missed. We got back to our assigned alt and we were able to make a stabilized apch to lndg. I informed the apch ctlr of our dev and the reason. I also talked to the twr ctlr about the prob. I called the supvr and she told me that there is a NOTAM about the GS. She faxed it to me. It has been like this for yrs! I have had this prob many times. This GS needs to be fixed! Or maybe they should not use a r downwind, since it only happens on the r downwind for RWY 23.

ASRS ACN 656860	Date 200505	Make Model Name Commercial Fixed Wing	Altitude.MSL.Single Value	Event Detector Person Flight Crew

Narrative Recently, while making an ILS apch in IMC, I had an acft pitch up event occur as a result of the FO selecting apch instead of VOR/LOC. This occurred after being clred for the apch via vectors. In this case we were 12-13 mi out and just about to capture the LOC when a false GS sit occurred. The GS pointer had been at the top of the indicator and then quickly ctred briefly only to go back to the top of the indicator. However, it had been ctred long enough for the autoplt to capture it and then follow it back up to the top of the indicator. A rather alarming acft pitch up was the result -- not good close to the gnd in IMC! When I was first hired, I recall being instructed to always select VOR/LOC first and then when (and only when) the LOC was captured and an obviously correct GS was available -- select apch. The concern was that GS capture could occur prior to LOC capture and the acft would start to dsnd. That concern is still mentioned in the fom (page 3.16.5). However, if it is not a concern (as obviously it was not in the sit above) the plt is instructed to go ahead and select apch right away. I had been using the old method during upgrade training, but was corrected and instructed to go ahead and select apch right away. Dutifully, I was doing this out on the line until a scenario much like the one described above (fortunately in VMC) occurred. I elected to revert back to the old method from then on. Nevertheless, it appears that new hires are being instructed to use the select apch right away method and pitch ups are occurring. If it has happened to me twice, it has probably happened many times throughout our sys. Obviously, the above described scenario could present a potentially dangerous sit some dark and stormy night. Based on what i have seen out on the line, my suggestion is that the recommended proc be revisited for safety's sake.

ASRS ACN 713905	Date 200510	Make Model Name B757-200	Altitude.MSL.Single Value 4000	Event Detector Person Flight Crew

Narrative Clred for ILS RWY 27l in VFR conditions. Gs captured at 3000-4000 ft. Outside of the marker, FO said, 'this looks low,' I agree, chk the OM GS xing alt and note it to be 2100 ft MSL. Over the marker, on GS: altimeter read 1500 ft and vasi clrly indicated low. We leveled off, disregarded the GS, picked up the vasi and landed uneventfully. The ILS receiver had captured a false RWY 27L GS. In 25 yrs of flying, I have captured false GS before, but never at ord. If this had been low IFR, the only chance to catch the false GS would be the marker altimeter chk, no other abnormal indications. No FAR's were violated and no pltdevs occurred.

ASRS ACN 721031	Date 200612	Make Model Name Skyhawk 172/Cutlass 172	Altitude.MSL.Single Value 500	Event Detector Person Air Traffic Control

Narrative Clred for RWY 9R apch at OPF. Ctlr correctly gave me instructions 'maintain 1700 ft until established.' once on the LOC I did not chk my pos relative to the OM (MOLTZ) and acted as if I was inside of MOLTZ (ie, btwn MOLTZ and the arpt). I initiated dscnt and followed a false GS signal down until advised to 'chk alt' and told that I was still outside of MOLTZ. At this point I clbed until reestablished on the apch and proceeded to land normally.

ASRS ACN 763694	Date 200711	Make Model Name Challenger CL600	Altitude.MSL.Single Value 5000	Event Detector Person Flight Crew

Narrative During an inst apch in hvy rain and full IMC, we were assigned 5000 ft till established on the ILS RWY 8R apch into iah. We were still approx 12-15 mi from the arpt when the LOC was captured and tracking. The GS was still intermittent at this point. The autoplt then seemed to capture the GS and lose it or capture a false GS. Either way, the autoplt initiated a clb to capture it. With no visual refs I initiated an immediate pwr input to prevent a stall as the acft lost airspd. I then realized it was clbing and turned off the autoplt to avoid any further clbing. The plane clbed to 5700 ft before I was able to correct the faulty GS capture. I leveled and upon advice of the capt, we turned on the autoplt again. It captured the GS and followed it down properly without incident.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
779841	200803	Lancair Columbia	1700	Person Flight Crew

Narrative — I had requested and was told to expect ILS RWY 9L at zzz. A few mi from the OM, ATC switched me to ILS 12 for noise abatement. I changed the apch in my avionics but did not sufficiently brief the apch because of the last min notice of the change and the immediate need to intercept the LOC. The ctlr was so busy that it was almost impossible to break in to the chatter. When I was seconds from blowing through the LOC, I broke in to request turn to intercept. He gave me the turn, told me to maintain 1700 ft until established and clred for the ILS. I then canceled IFR. He acknowledged. I changed freq. I appeared to be established on LOC but too high for GS. I dsnded quickly to catch the GS. I pulled pwr, spd brakes up, dsnding more than 1000 fpm and couldn't catch the GS. Thank god it was VMC so at 500 ft AGL, when I could not ident the RWY environment, I reapplied pwr and clbed. When I looked at the gps, I was still 5 mi from the arpt. I had followed a bad GS. False GS's are not supposed to exist below the real GS, but standing water or interference may have played a part. In the end, nothing bad happened. My only potential violation was being too low over people and structures. Had I been IMC, the result may not have been as happy. Probable cause: the rushed changing of the apch did not allow me sufficient time to brief it properly. Had I briefed properly, I would have known to not begin my dscnt as early as I did. The false GS indication was a contributing factor.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
784297	200804	Commercial Fixed Wing	1300	Person Flight Crew

Narrative — At 1600 ft initially cleared direct to WESEN. Approaching WESEN SJU approach assigned us a 110 heading and cleared us for the approach. They also told us to switch to tower. It was a tight turn on, estimate a join 2.5 to 3 miles outside the FAF (GS) at 1600 ft. It was daylight and we had ground contact, but there were some scattered clouds. I believe I was heads down to switch to TWR when the captain verbalized a suspect the glide slope. When looking up I noticed a yellow line through GS. Captain initiated a climb back to 1600 ft, and I cycled the FDS and reselected apch. I observed 300 ft low (from 1600 ft) and while correcting tower informed us that approach had assigned us 1600 ft until established on the approach. I flew 3 months in a row of SJU and false GS capture is something I have observed multiple times on ILS RWY 08. However, when I have previously observed false GS capture we were at 3000 ft and remained in protected airspace (above 1600 ft) when the false capture occurred. Since we were already at 1600 ft I did not expect a false capture. I am convinced that there is a problem with the GS to ILS rwy 08 at SJU and the technique used by the many of pilots that fly SJU a lot is to arm the LOC first and then apch when you are very close in.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
798114	200807	B737-700	2200	Person Flight Crew

Narrative — We were on an assigned hdg to intercept the apch course just outside of HASDO at 3100 ft. We were clred for the apch ILS RWY 12R. I selected VOR/LOC initially then selected app as the acft (on autoplt) intercepted the LOC. I confirmed LOC and GS captured on the flt director annunciator panel. At approx 2200 ft MSL, I heard the capt/PM state my name and say, 'we are low, start a clb back up to 2800 ft.' as I was clbing back up to 2800 ft I heard 'caution obstacle' and say same annunciation. Threats and errors 1) did not know GS was rpted unusable on the acars wx rpt. I hear twr clr another acft for the ILS GS unusable apch, but didn't verbalize it and then forgot about it when I was clred for the apch. 2) wx was marginal VMC so I briefed ILS RWY 12R and the visual apch planning on a visual apch. 3) I verbalized VOR/LOC selected but not app selected. 4) when I confirmed LOC and GS were captured, I apparently believed I was on the proper GS and had tunnel vision on that even though after the fact I realized I had intercepted a false GS. I still cannot believe I made such a stupid mistake. 5) ATC did not verbalize 'GS unusable' to us when clred for the apch. 6) the PM told me after we were on the gnd that the twr ctlr told us twice to clb back up to 2800 ft. I never heard any of those calls. Why i didn't hear them, I do not know. Follow our procs all the time.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
812899	200811	Embraer Jet	5000	Person Flight Crew

Narrative — During approach to RWY 28 at ORD, we were cleared to maintain 5000 ft until WAVIE at 180 kts and cleared for the approach. Approach was armed on the fgp, and it armed and captured both LOC and glide slope. Not long after this, approx 5 miles outside of WAVIE , the aircraft pitched up aggressively to 10-12 degs nose up. (we believe it was a false glide slope indication because the glide slope 'needle' which was dead on at capture suddenly showed us way below the glide slope.) The airplane responded as it thought it should with a hard pitch up to recapture, with a subsequent rapid loss of airspeed. I immediately disengaged the autopilot and added necessary thrust to return us to 180 kts, while pitching over to recapture the glide slope. (at the apex of the pitch up we had climbed to roughly 5800 ft, at a very high vertical speed, with airspeed rapidly bleeding off.) The altitude was recaptured and re-intercepted the glide slope and continued the approach. There was no more glide slope fluctuations, and even if there were, the rest of the approach was hand flown to a normal approach and landing. There was no ATC communication to us regarding the incident.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
813124	200811	B757-200	6000	Automation Aircraft Other Automation; Person Flight Crew

Narrative At 6000 ft given 130 deg heading to join RWY 16R from the west. Strong crosswind from approx 45 degs from the right at 54 kts. Autopilot captured LOC and I armed the approach mode. Glideslope was alive and at approx 1 dot the autoplt made a false GS capture and aircraft began an abrupt climb with autothrottle adding power. At approx 6300 ft I disconnected autopilot and hand flew back to 6000 ft and continued approach by hand. No conflict with traffic known, however this could be a safety issue on a close parallel approach.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
813316	200811	B777-200	2500	Automation Air Traffic Control; Person Flight Crew

Narrative We were turned onto the ILS for runway 28. Intercepted the localizer. After we were established on the localizer the glide slope signal falsely captured the glide slope approximately 3 miles prior to where it should have. This led to a low altitude alert from ATC. The aircraft was flown to zzz later in the day where the LOC/GS function worked fine.supplemental info from acn 813477: approach descended us to 2500 ft just outside of WILLT. We captured a false glide slope and stated descending. At 2000 ft I realized we were on a false glide slope and as I was informing my copilot to level off ATC issued us a low alt alert. We climbed back to 2200 ft. We reset our flight directors and intercepted the true glide slope. First time in 37 years of flying that I encountered this. Contradictory flight guidance is harder to resolve than it seems.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
814945	200812	B767-300 and 300 ER	5000	Person Flight Crew

Narrative At 5000 ft MSL inbound on the ORD ILS Runway 28 approach and about 8 miles outside WAVIE, we were cleared for the approach. After capturing the LOC, approach mode was selected. Shortly afterward we had a false GS capture. The GS captured and the airplane started a steep descent -- 1,500-2,000 fpm. I clicked off the autothrottle and increased the power and started to click off the autopilot when the line went through the GS on the ADI. I started pulling up, but we went down to about 4,600 ft MSL before climbing back to 5,000 ft and continuing the approach to a normal landing. The Controller reiterated 5,000 ft to WAVIE and we told him we had a false GS capture.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
830430	200904	B757		Person Flight Crew

Narrative Right traffic for Runway 23 BUF. When given an intercept for the ILS 23, we noted a 'False GS' indication. Since I had read the bulletin, I did not select 'Approach' until established on the LOC, even though we had been cleared for the approach prior to LOC capture. Normal procedures call for 'Cleared for the approach select/request Approach Mode.' The 'False GS' indications occurred exactly as described in the memo. Information has been received indicating it is possible to obtain a significant nose pitch-up, in some cases as much as 30 degrees, if the GS is allowed to capture before established on centerline. Pilots who are preparing to configure and land have the potential to experience abrupt pitch up, slow airspeed, and approach to stall if conditions present themselves in a certain manner. This effect is the result of an earthen obstruction close enough to the ILS to affect the integrity of the GS signal. This has resulted in the issuance of an advisory given on ATIS which states that 'the ILS GS for Runway 23 is unusable beyond 5 degrees right of course.' When attempting to intercept the Runway 23 ILS from right traffic, the ILS GS indication may read full deflection down. Just prior to intercept it may then move up in such a manner as to enable approach mode to capture in such a way as to result in a nose-up pitch and loss of airspeed. Flight crew suggestions/narrative: There is a briefing note on the approach plate noting that the GS is unusable beyond 5 degrees right of course. This small note could be missed during the approach briefing. The 'Approach selection procedures' for BUF Runway 23 would enhance safety for IMC operations if included on the BUF Airport advisory page.

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836678	200905	PA-31 Navajo	1900	Person Flight Crew

Narrative: The weather conditions were at ILS approach minimums at San Luis Obispo, CA and I was cleared for the ILS Runway 11 approach. I was cleared for the approach, told to maintain 2500 until established. Once cleared for the approach, I intercepted the localizer course and glideslope normally. Nothing seemed out of place. As I passed over the outer marker (DOBRA intersection LOM) I checked my altitude and noticed it was significantly off. I should have been at 2182'. Instead I was at only 1900' and perfectly on 'glideslope'. I immediately executed a go-around and queried tower. I confirmed the altimeter setting and it was correctly set. It seems I was on a 'false glideslope' which was slightly lower than the actual glideslope. I came back around for another approach and this time the altitude checked at the FAF and the approach went normally (although I was issued a 'low-altitude alert' by tower despite being established perfectly on the correct glideslope this time). After landing, I did some research and a local flight instructor said that this 'false glideslope' is common at that airport and that they do know about it and can't fix it. I called the ATC tower to report and the Controller also seemed aware of the problem, and expected that was why I went missed. That morning, I had checked the NOTAM which warned 'check altitude at DOBRA 2182' and I think this made it a very easy decision to go-around when I saw a different reading nearly 300 FT off. HOWEVER, I think the NOTAM could have at least been worded more strongly to convey the problem, or this problem should be included on the IAP chart itself if the problem cannot be corrected. Apparently, other air carriers (including a passenger air carrier have experienced the same problem and executed a go-around). The danger of this problem is that it is very subtle and it takes an alert and competent instrument pilot to even realize there is a problem... This could be very dangerous if someone neglected to cross-check altitude at the Outer Marker and found themselves unknowingly on a low false glideslope!

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
838369	200905	B737 Next Generation	2500	Person Flight Crew

Narrative: Downwind leg setting up for ILS 33 to BDL. Altitude 5000 FT, speed 220 KTS. Abeam airport descent was given to 2500 FT. Approximately abeam HADUX (12.2 DME) a left turn to 360 degree was given to intercept the Loc and I was cleared for the approach. I was cleared to join the LOC at or above 2500 FT. I was level at 2500 FT by that point however. I selected auto approach once steady on the heading or 360 as I could see from the map that we were being turned just inside HADUX and we were tight abeam. We also had a 5 or so knot wind from the southwest that would further make the turn to final busy. After selecting auto approach on the MCP, I called for Flaps 5. The pilot monitoring was responding to our approach clearance so I backed up my call with a hand signal. He did select F-5. The localizer captured as I began to feel the aircraft make a sharp turn to the left (30 degree angle of bank) and load up (come under g load). I felt this was normal for the speed we were at, and a tight turn to final with a pushing through the localizer wind. Unfortunately at this point my scan really broke down and I was focusing on the map display and airspeed. Not the gyro and altitude. About this time I began hearing from the pilot monitoring, 'Dude, what are you doing?' I responded, 'What?' Another, 'Dude, what are you doing man?' I said, 'What do you mean?' 'You're climbing, why are you climbing?' At this point I finally got my eyes on the gyro and saw that we were about 15-17 degrees nose up still in a 20 degree plus angle of bank left turn. The altimeter was winding up through 3300 FT, but the glideslope was indicating that we were approximately 1/2 dot low! (Yes, I was a little confused at this point!) I disengaged the autopilot, added a lot of power expecting to be getting slow real fast. We did not get slow. In fact we did not slow below 170 KTS, which was above Flaps 5 speed. I leveled the wings and stabilized the jet at 4000 FT. I felt comfortable with being able to configure and achieve a stabilized approach prior to HOMEY. I asked the pilot monitoring if he was comfortable with that, and he said yes. We configured to Flaps 40, and the glideslope, LOC and map display were all saying the same things. We easily made a controlled descent (1200'/min) to the FAF and I then used the HUD for an ILS to landing. We broke out at around 600 FT AGL. When taxiing in to the gate, I called Approach to ask them if they were having any problems with the glideslope and they said no. I then told them we had a commanded climb on the glideslope just inside HADUX. We climbed up to 4000 FT and I inquired if that caused them any problems. They responded that it did not and that we had an at or above clearance down to 2500 FT. There was no traffic in the area. What I 'think' happened was that the autopilot captured a false glideslope. There was an aircraft that landed about 6 miles in front of us and was taxiing in. I don't normally select auto approach until I am established on the Loc within 10 degrees or so of the final course. I chose to select it on this approach as I felt that I was going to be task saturated with a tight turn to final, and a slight tailwind. Also, since we were at 2500 FT and being turned just inside HADUX, I felt that we would be very close to 'on glideslope' on our 360 heading. I was in the, 'It's been a long day and a long flight. I'll take the help from the autopilot mode.' I think the largest contributing factor to this incident was the breakdown of my scan while in the turn to final. The autopilot was established on alt hold and heading select. I had selected auto approach, and was watching the map as we approached the localizer. I could not fathom why the aircraft would climb, as I knew if anything we were a little high. I did not notice if the GS had captured, but I knew the localizer had as the aircraft was in a tight turn to get on the Loc. I think the non-standard callouts from the pilot monitoring did not make anything clearto me as to what was going on. In fact I think it added to my confusion. I would have almost preferred that he simply taken the aircraft and we could have talked about it later. We debriefed the callouts and how, 'Dude, what are you doing man?' doesn't mean anything to someone that thinks the aircraft is doing everything normally.

ASRS ACN 843674	Date 200907	Make Model Name B757-200	Altitude.MSL.Single Value	Event Detector Person Air Traffic Control

Narrative: We were given a runway change on base leg at 3000 FT from ILS Runway 4R at Kennedy to ILS Runway 4L. We experienced a false glideslope capture and followed the glidepath to 2400 FT until we were queried by approach. We then climbed to 3200 FT and re-established ourselves on the localizer and glidepath to Runway 4L. Approach and landing were uneventful afterwards.

ASRS ACN 845298	Date 200907	Make Model Name B737 Next Generation Undifferentiated	Altitude.MSL.Single Value	Event Detector Person Air Traffic Control

Narrative: Flight to ZZZ to an ILS. We were at 5000' MSL 10 miles NW of the field at 180 knots, dropped the gear when we were vectored to the dogleg, and cleared the approach. Weather was expected to be 2500' SCT with a ceiling of 4000' BKN, 5 miles VIS due to -RA/BR. Captain was PM and F/O was PF. We leveled off, configured to flaps 40, and tried to descend aggressively to below the 4000' ceiling and into VMC. Rain precluded us from picking up the runway, and a steady 18-20 knot tailwind kept us high on final. We crossed the FAF approximately 1000 feet high (2900' MSL), with the glideslope coming off the bottom of the case. PF engaged the approach mode when we were within a dot, and then soon thereafter realized this was a false glideslope when it showed us going below the glideslope. We then told Tower we were initiating a missed approach, since we were still IMC. They told us to turn to 330 heading at the departure end, which PM read back. We initiated a go-around, tried to find the departure end through the rain and clouds, and then were told by Tower to turn to 330 heading and contact Approach. 30 to 40 degrees into the right turn, Approach told us to turn left to the 330 heading. They later asked us why we made the right turn instead of going left which would in hindsight have been the shortest direction. I couldn't explain the thought process very well, which was we flew from a right downwind with an approach to the right runway with simultaneous traffic to the left runway and felt we needed to turn from any departures that might be on the other runway during our go-around. They asked us to call the Supervisor when we landed. The following approach was uneventful. Missed approaches are very busy! Flap cleanups and takeoff warning horns, trying to find the end of the runway through the weather in IMC when they think you are VMC, and radio calls. It's just important to pay attention to everything Approach tells you and read it back.

ASRS ACN 858669	Date 200911	Make Model Name B737-400	Altitude.MSL.Single Value	Event Detector Person Flight Crew

Narrative: We were being vectored for a visual approach. The weather was VFR with ceilings 3200' broken, visibility greater than 10 miles and light winds from the north. Approach cleared us to turn final outside the FAF and to contact tower. The ILS frequency was tuned. I made a 90 degree left turn toward the runway. Approximately 2 miles outside the FAF, I descended to 600' below the FAF crossing altitude on what appeared to be a false Glide Slope indication. The Captain noted the indication and the altitude. Corrective action was immediately taken to the normal glide path. The aircraft landed uneventfully. Contributing factors were associated with a long day and late night operations.

ASRS ACN 862115	Date 200911	Make Model Name Commercial Fixed Wing	Altitude.MSL.Single Value 6000	Event Detector Automation Air Traffic Control; Person Air Traffic Control

Narrative: Cleared direct to OM for visual approach to Runway 35L DEN. Acquired the airport and Runway 35R. Initiated a turn inbound to the facility and started a descent. Commanded stop descent at 6,000 FT MSL realizing visual picture and altitude were incorrect for our position on the approach. Subsequently received glideslope alert and Tower called low altitude alert. Commanded an immediate climb to 7,000 FT MSL and completed a stable approach to landing. Contributing Factors: Black Hole Approach. Perception of being high for the arrival. Time of day with both crew being up most of the previous day. Momentary distraction of visually acquiring the designated runway and a possible false glideslope in the cockpit. In debriefing this event we identified several indicators that should have alerted us to our loss of situational awareness. It was apparent we were seeing all the indications of our low approach but for a few moments we were not making the connection that was what was occurring. For just a few moments on the approach we both became subtly incapacitated.

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ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
863727	200912	Widebody, Low Wing, 2 Turbojet Eng	1700	Person Air Traffic Control; Person Flight Crew

Narrative I was the Captain and Pilot Flying. I was being vectored by Buffalo, NY approach control from a right hand pattern to the ILS for runway 23 at Buffalo, NY Int'l Airport. The conditions were: moderate rain, pattern altitude winds of approximately 140\50kts, and moderate turbulence. While at 2300' MSL, I was given a vector of 200 to intercept the localizer, and cleared for the ILS approach to Runway 23. The left hand wind was too much for that heading to intercept the LOC in time. I saw a distance of 10NM on my FMS's progress page, and that I was well above the Glide Slope (or so I thought). There is a note on the approach page that the Glide Slope is unreliable beyond 5NM of the localizer. I failed to note that, and began a 700fpm descent to attempt to capture the Glide Slope from above because we were now clear of the clouds, and the rain was less. The First Officer advised me where we were off the localizer, (still right), and that the airfield was not in sight. At that point both the Flight Crew, and now Approach Control realized that the ILS approach was being incorrectly flown. Approach Control advised the Flight Crew that their altitude was too low (1700' MSL), told us to climb. We then executed a missed approach to the left with Approach Control issuing a vector of 140 and 2500' MSL. A left hand pattern was flown, and an approach and landing on runway 23 was uneventful.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
869483	201001	Large Transport, Low Wing, 2 Turbojet Eng	2500	Person Flight Crew

Narrative I would like to highlight three reoccurring problems at SJU. The first is Approach Control keeping us too high while being vectored to Runway 08 from the North. We were kept at 2,500 FT and turned on to final virtually over the FAF (about 1,000 FT high). We ended up going around due to exceeding stable approach parameters. Our next approach pointed out another problem which is intercepting a false glideslope to Runway 08. At 2,000 FT, the autopilot abruptly pitched up to intercept wrong glideslope. I had to disconnect the autopilot to gain control of the aircraft. Third, it is often forgotten by us and SJU Approach Control that the Lagoon visual is not authorized at night! These problems need to be addressed in a more robust fashion than in the past they have existed for way too long and have not been corrected.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
878921	201003	B777-200		Person Flight Crew

Narrative First approach ILS 09, turned to final earlier than expected with gusty tailwind aloft. Aircraft captured false glideslope (high); vicinity of FAF crew realized this. Go-around executed. Second approach, again gusty winds aloft with multiple airspeed excursions. No flap exceedences observed. VMC by 1000 FT. Airspeed fluctuations diminishing. Approach missed Tower handoff (high workload). Tower gave green light, no time for voice landing clearance. Auto throttle had difficulty keeping up, overrode auto throttle and flew what would have been manual throttle approach speed. Had 13,000 feet of runway, light aircraft and knew I had deteriorating weather aloft. Maintained positive aircraft control throughout short final, flare and touchdown.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
883407	201004	Small Aircraft, Low Wing, 1 Eng, Fixed Gear	5400	Person Air Traffic Control

Narrative I was vectored for an ILS to Runway 14 at Medford, Oregon. After being cleared for the approach and intercepting the localizer, I observed the Glide Slope indicator showing Glide Slope interception. I began decent and tracked the Glide Slope and localizer about 2 miles prior to reaching the actual Glide Slope intercept as depicted on the approach plate. I decended 500 FT to an altitude of 4,500 FT at about AMASE (12.7 DME). Cascade Approach called to inform me that I was too low and to cross AMASE at 5,000 FT. I realized that the Glide Slope indication was false and began a climb. I then was instructed to climb to 6,300 FT and given vectors for another approach. On the second approach I used the localizer minimums. The false Glide Slope indication did not show an 'OFF' flag. I believe that the ILS/VOR receiver installed in the plane was very old and was not receiving signals adequately for navigation. The next day, in VFR weather I could not duplicate the problem. The aircraft owner, also a pilot, was in the right seat and also observed the false reading.

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ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
894153	201006	Widebody, Low Wing, 4 Turbojet Eng	3700	Person Air Traffic Control; Person Flight Crew

Narrative

On approach to Runway 25L at VHHH, we were cleared to 8,000 MSL and were proceeding direct to TD VOR, and cleared for the ILS Runway 25L approach. We were in a descent to cross the TD VOR at 8,000 MSL and had arrived at altitude slightly before the fix with VNAV engaged I began a speed reduction and flap selection to 180 KTS, I called for 4,500 to be placed in the MCP altitude window which was the altitude restriction at LOTUS the join point on the ILS. At approximately 7,500 MSL the ATC Controller advised us there was a possible altitude fluctuation, however VNAV VPI showed us on path, this transmission contributed to us feeling as though we were high, though I believe he merely saw us in a slowing segment. To be sure I would make the restriction I selected V/S and placed the altitude predictor approximately 1 mile prior to LOTUS. I then selected approach mode and planned to arrive at LOTUS at 4,500 MSL capture the altitude, and await localizer and Glide Slope capture. As we approached LOTUS we received an ALT CAP on my FMA and I checked the Glide Slope, to my surprise it showed us 1 dot high on the Glide Slope, which surprised me because at LOTUS at 4,500 MSL we should have been below the Glide Slope and have been awaiting capture from above. (The profile view indicated Glide Slope intercept at .9NM inside of LOTUS). At that point I tried to capture the Glide Slope by selecting a lower alt and engaging V/S. We captured the glide path and continued down, for about 30 seconds when I received a degraded Glide Slope signal FMA, followed sometime later by complete loss of the Glide Slope indication. Since we were in VMC conditions at that point and I thought it would only be a momentary loss of signal by a vehicle or something similar I selected V/S and continued the descent awaiting re-acquisition of the Glide Slope signal. At that point we received a transmission from ATC asking our current altitude, we informed him it was 3,700 FT and he informed us that that altitude was below Glide Slope for that distance. Almost simultaneously we reacquired the Glide Slope and it showed us 1.5 dot low on the Glide Slope, I immediately disconnected the autopilot and hand flew the aircraft back to Glide Slope and reengaged the autopilot. We landed without further incident. In reviewing the chain of events that lead up to and contributed to this incident I realized there were several factors. 1. First, I believe there was an element of mental fatigue, as it was the end of an 8 hour flight arriving in VHHH, this I believe hindered our recognition of what was happening. 2. My approach briefing did not emphasize the importance of 3 key elements: A. Glide Slope ball note-- Glide Slope signal unusable beyond 7 degrees left of LOC course. B. The profile view shows that there is actually a level segment at 4,500 FT for .9 NM before Glide Slope intercept, so any capture or indication supporting a descent prior to 14.1 NM should have been disregarded. C. Taking those factors into account I should have briefed that I would only select localizer until sure of a reliable Glide Slope signal 3. Another contributing factor was the ATC transmission we received notifying us of 'possible altitude fluctuation' as it served to contribute to the crews belief we were high, supported by a false high Glide Slope indication, when in fact we were not high. This combined with an over reliance in Glide Slope indication vs. approach plate altitude discipline influenced my decision to start a descent to capture the Glide Slope. D. Lastly, in retrospect with confusion on why we were indicating above Glide Slope, at a point in the approach where I knew we should have been below the Glide Slope, followed by loss of Glide Slope indication I realize that I should have executed an immediate go around to determine the inconsistencies regardless of the VMC weather conditions.

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ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
909385	201009	Falcon 10/100	2700	Person Air Traffic Control

Narrative While on vectors for the ILS XX we received the ATIS which reported 3,300 scattered with several broken/overcast layers above, 2.5 miles visibility, with light rain/mist. We were given a heading to intercept the localizer and told to descend to 2,700 FT. This was a distraction as the two altitudes depicted for the approach were 3,000 and 2,400 FT. As we intercepted the localizer I noticed that the Glide Slope had captured, the flight director was indicating properly and we had no flags. We both checked this as aircraft Glide Slope had problems in the past but it had always had flags when it did not operate properly. We initially did not notice that we were descending well before the actual Glide Slope intercept point. I called that the Glide Slope had captured and expected the Copilot to crosscheck that with his instruments, which he apparently did not. As we descended Approach called with a low altitude alert and told us to climb back to 2,700 FT, which we did. Thinking that we had captured a false Glide Slope I watched the needles as we started our climb and the Glide Slope indicators did not move from the on Glide Slope position. Once we were back on altitude we realized we were still outside the marker, checked the Copilot’s instruments, which appeared to be working and continued the approach using those. This decision was made in part based on the ATIS weather, which as it turned out was not nearly as good as they said. Had we known that we would have missed and tried an RNAV. We continued with a higher than normal workload and finally broke out at about 600 FT. The next day the Copilot said he thought we had landed without a clearance. I cannot be sure if he was talking to Approach or Tower and I do not remember Approach switching us over. I believe contributing factors were: 1. The Copilot, while type rated in the aircraft has very little experience particularly in abnormal/weather conditions and needs to be told what to do and then is fairly slow in getting things done. We did not have as much situational awareness as was possible on the intercept as he was slow getting the FMS set up. In abnormal situations he gets tunnel vision to a certain extent and things get missed – like crosschecking and finishing checklists. That being said it is my responsibility to get that done and I spent too much time trying to figure out what was wrong and not enough making sure he did his job. 2. I have never seen a Glide Slope that was not working properly give no indications. The autopilot and flight director both followed the indicator as if everything was normal and no flags were present. 3. The ATIS weather was nowhere near actual weather. Conclusions [are:] 1. The decision to continue the approach (based on location on the approach, weather, and passenger concerns) was wrong. Considering that the Copilot was weak (actually a good one would probably have insisted on going around) and the aircraft situation, the proper decision would have been to go missed. 2. Better crew communication needs to be readdressed to insure all functions are completed in a timely manner. I have been spoiled with many years of well trained Copilots with which CRM skills are second nature – this is not the case here. 3. More training in the use of and philosophy of the FMS is needed by the Copilot. I have tried to get this accomplished before but since he is also the mechanic he does not see the need to spend time improving his piloting skills.

ASRS ACN	Date	Make Model Name	Altitude.MSL.Single Value	Event Detector
914363	201010	Widebody, Low Wing, 3 Turbojet Eng	4000	Person Air Traffic Control; Person Flight Crew

Narrative We were on vectors for the ILS to Runway 28 by Chicago approach on a heading of 340, at 4000 FT, and assigned 210 KTS approx 15 miles southeast of the airport. We had preceding traffic about 10 miles ahead of us. Roughly 3 miles from ADAME, we were told to turn left to a 290 degree heading, maintain 4000 FT and cleared the ILS 28 approach; speed 170 KTS until WILLT (the FAF). Approach/Land was armed and while rolling out to 290 degrees, we received a false Glide Slope indication showing us momentarily on Glide Slope followed by the Glide Slope indicator going to the top of the scale. This was followed almost immediately by the localizer coming alive. The autopilot responded VERY AGGRESSIVELY by pitching up to regain the Glide Slope resulting in the aircraft gaining 400 FT before the Captain was able to manually override the autopilot and bring the aircraft back to our assigned altitude. We reported to approach control and tower of our deviation and also the erratic Glide Slope information. We were not aware of any ILS interference before commencing the approach and after reporting the incident to tower, another aircraft also reported the same problem with the Glide Slope. Tower reported that the ILS critical area was not being protected (due to the favorable weather conditions) during the entire approach, we were receiving a valid ILS identifier. Within probably a 10 second time frame we received the approach clearance, localizer becoming active, false glideslope, and airspeed instructions. I am now very aware of the fact that after the Approach/Land switch is selected and armed and the Glide Slope or localizer indicators meet the capture criteria, the flight director and autopilot will try to intercept the indicators whether the data is necessarily valid or not. I will make a better attempt in the future to be aware of ‘ghost’ indications during not only marginal weather, but during good weather as well.

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ASRS ACN 915577	Date 201010	Make Model Name B757-200	Altitude.MSL.Single Value 2500	Event Detector Person Flight Crew

Narrative: Intercepted 2 false Glide Slopes. Cleared by Center to WESEN Intersection for ILS 8 in SJU down to 3,000 FT. On SJU Approach Control cleared to WESEN Intersection for ILS 8 and down to 2,500 FT. Armed APPROACH (APP) on left autopilot. Glide Slope appeared and intercepted as normal on localizer and began to descend. After 300 FT or so I realized that the Glide Slope was wrong. I turned off APP/autopilot and it went away. We were VFR with no traffic so I just maintained my altitude and re-engaged. Glide Slope again came into play and once more intercepted. I followed down to about 1,800 FT realizing again this was a false Glide Slope. I disengaged and leveled off. I asked Tower if they had any low level alerts for me and if any thing abnormal was happening. I was told NO. I re-engaged at about 1,800 FT with what appeared to be the real Glide Slope that finally made sense. But now the localizer was way off with correct heading in the head. This was all very confusing and we got a little behind but it was all drawn back into an acceptable enviroNMent and never unsafe for the conditions. But could have been a real problem in weather. This problem demanded 2 heads and First Officer was great back up.

ASRS ACN 927209	Date 201101	Make Model Name B757-200	Altitude.MSL.Single Value 1000	Event Detector Automation Air Traffic Control; Automation Aircraft Other Automation

Narrative: Approximately 6,000 MSL on approach we selected flaps 1 and got a 'LE Flap Disagree' warning. The Captain was the pilot flying and asked to level off at 5,000 and abandon the approach to run the checklist. I ran the QRH as he took vectors with a left turn back around for another approach. Checklist gave us flaps 20 electrically and approach offered an approach to XXL.They vectored us a fix outside the OM to intercept at 4,000 and cleared us for the approach. The autopilot captured LOC and Glide Slope. We flew through a cloud layer between 3,000 and 1,000 FT and broke out at approximately 1,000 MSL with no runway in sight. Approach gave us a low altitude alert. We had ground contact so we leveled off and asked for a vector for the airport which was about 6-8 NM ahead. We had obviously followed a false Glide Slope but the LOC was accurate. The false Glide Slope had a rapid descent so we were occupied with speed control.Final landing was without incident. Queries to Tower revealed the Glide Slope may not have been operational but that they had no indication to it. They did inform us that a GA aircraft ahead of us reported inaccurate Glide Slope readings after landing but that it was too late to inform us of it. Another factor was that our aircraft was a flat panel display with which we are not quite as familiar with so some of the subtle clues such as distance to touchdown and radio altitude may not have been as obvious to us as in the more familiar format.

ASRS ACN 930004	Date 201101	Make Model Name A320	Altitude.MSL.Single Value 3000	Event Detector Person Flight Crew

Narrative: At flaps 2 and 180 KTS assigned with autopilot on, the aircraft pitched over to chase erroneous glideslope and accelerated past the 200 KTS limit for flaps 2 by 5 KTS before I could disengage the autopilot. There was no warning from previous aircraft on approach or from Controller. I called Tower upon landing and the problem had occurred previously but not to the extent our aircraft experienced.I was told that the close proximity of a taxiway to the glideslope antennae with passage of a wide body could cause the problem and a B747 was maneuvering in described area at time of event.

ASRS ACN 930349	Date 201101	Make Model Name Boeing Company Undifferentiated or Other Model	Altitude.MSL.Single Value 5000	Event Detector Person Flight Crew

Narrative: We were flying a flat panel aircraft and at about 7,000 when I asked for flaps to one. We got the warnings for a LE FLAP ASYM and declared an emergency. They descended us to 5,000 and gave us vectors. The First Officer did an excellent job completing the QRH check-lists to resolve the problem. As soon as we were cleared for the approach we went IMC. Unbeknown to us and ATC the Glide Slope was not working. We briefly followed a false Glide Slope for which we received no warnings, no flags. During the descent we both became acutely aware that something was wrong. Breaking out of the overcast nothing looked familiar. We asked ATC where we were. They gave us the heading that we were flying and to maintain 1,900 MSL, an altitude which was above us. Shortly after we saw the airport and proceeded to an uneventful landing.I then called the Tower Manager who said the technicians had passed the word that the ILS was up and running. What they meant was the opposite direction runway's was, not the approach we were on.

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ASRS ACN 942352	Date 201103	Make Model Name Gulfstream G200 (IAI 1126 Galaxy)	Altitude.MSL.Single Value 2400	Event Detector Person Flight Crew

Narrative We were on vectors to intercept DAL Runway 31R localizer at assigned 2,400 FT MSL. The autopilot was engaged. We intercepted the localizer with a tailwind and aggressive angle of intercept (late turn by ATC, in my opinion). The pilot flying selected APPCH mode and the LOC captured, but overshot into the approach corridor for Runway 31L. Simultaneously, the avionics indicated a glideslope capture. Position was 10 NM final and since we were 1,100 FT below the glideslope beam, the aircraft pitched up about 5 degrees and began a climb. I directed the pilot flying to disconnect the autopilot, that a 'false glideslope had been captured.' By the time he did this the aircraft was 600 FT high (3,000 FT MSL) and flying towards Runway 31L. I told the pilot flying to descend back down to 2,400 FT and turn right towards the ILS 31R. I estimate our deviation time from 2,400 FT MSL and the 31R localizer to be 45 seconds. No TCAS warnings or ATC query were made. I know of no conflicts to other traffic. The 31R localizer and glideslope were recaptured and a normal approach and landing occurred.My opinion is that the glideslope signal on our landing runway (31R) fluctuated – perhaps due to aircraft taxiing through the critical zone. I recall seeing the glideslope pop down (case break) and then go back up off the HSI. I believe the avionics captured this signal and the aircraft pitched up to maintain the glideslope (even though we were 1,000+ FT below the normal glide path). I will keep a vigilant watch for false captures of the glideslope on DAL 31R. Other pilots familiar with this airport report past fluctuations of this glideslope.

ASRS ACN 1008405	Date 201205	Make Model Name Challenger CL604	Altitude.MSL.Single Value 2400	Event Detector Person Flight Crew

Narrative After being assigned a heading to intercept the localizer on the ILS 19 at KTEB, ATC cleared us for the approach. We were established on an intercept heading at 2,000 FT MSL. I armed LNAV and the autopilot captured the inbound course. Once established on the inbound course and approximately three miles outside the FAF, I armed the approach and the autopilot immediately captured the inbound localizer course. The Glide Slope indicated armed or white GS mode on the PFD. At this point, I noticed the Glide Slope indicator on the PFD rapidly move from full scale up to full scale down and then full scale back up again. The autopilot captured the false Glide Slope and the airplane abruptly pitched up from our captured altitude and began to rapidly climb in an attempt to join the Glide Slope from below. I immediately disconnected the autopilot and began to pitch the noise down to stop the climb. However, our altitude increased between 300 and 400 FT above the assigned intercept altitude of 2,000 FT. This occurred so rapidly that ATC never noticed the altitude deviation nor did we mention it since we were told to contact the Tower for landing clearance. The remainder of the approach was hand flow with the autopilot disengaged. As I continued the ILS approach, I noticed the Glide Slope indication make another rapid up and down gyration. It is my belief that these erratic Glide Slope indications are caused by antenna interference from airplanes as they taxi across Runway 19 on their way to Runway 24 for departure. I recommend a statement be added to the TEB Airport Risk Assessment alerting crews to the potential for false Glide Slope capture when flying the ILS 19 approach.

ASRS ACN 1031520	Date 201208	Make Model Name Commercial Fixed Wing	Altitude.MSL.Single Value 3000	Event Detector Person Flight Crew

Narrative On approach to Runway 10 at MTPP, we got false glideslope information with the autopilot engaged. Localizer and glideslope were captured. The localizer had also been properly identified. We were descending through approximately 3,000 FT on the glideslope when the downslope all of a sudden showed us low. The aircraft pitched up to maintain glideslope. The Captain, who was the flying pilot, disconnected the autopilot and we continued the approach visually to an uneventful landing.

ASRS ACN 1093059	Date 201306	Make Model Name B767-200	Altitude.MSL.Single Value	Event Detector Person Flight Crew

Narrative On a high vectored left base to Runway 9 approaching KAVME, ATC asked if we had the airport in sight, I thought the First Officer said yes and I did have it in sight so I called the airport in sight. The Controller gave us a heading of 120 and cleared us for the visual to [Runway] 9. We were a bit high so the First Officer used speed brakes to increase descent and we were adding flaps. The heading we were given did not put us in position to intercept final and really just would lead us to about midfield of Runway 9. It was then I realized the First Officer did not have the runway in sight and I selected a heading to intercept final and tried to point out the approach lights. During this time the autopilot had picked up a false Glide Slope and started to follow it down. I noticed we were low and called for the First Officer to correct, at that time ATC gave us a frequency change and a low altitude warning. The First Officer disconnected the autopilot stopped the descent and intercepted final for a normal visual approach and landing.ATC was trying to fit us in ahead of another aircraft leaving us high and in close for the visual; we could have slowed things down by not accepting the visual approach. The Aircraft is very loud in the cockpit and helped cause the miscommunication between the crew about seeing the airport. Not selecting APP mode before being in a normal approach position would help prevent picking up a false Glide Slope when well off to one side of the localizer.

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ASRS ACN 1054754	Date 201212	Make Model Name B737-300	Altitude.MSL.Single Value 3000	Event Detector Person Flight Crew

Narrative

This event occurred during approach to Runway 28L. The ceiling was approximately 1,500 FT MSL, requiring ATC vectors to the approach. There was other traffic in the area and we were vectored to final behind them. ATC had slowed us to 150 KIAS, which, in our type of aircraft, requires landing gear down, and flaps 15. This is a high amount of drag to have, especially in level flight. I was the pilot flying. I was given an intercept heading to join the localizer, and cleared for the approach. The autopilot was engaged, and I armed the VOR/LOC mode. It was clear that the localizer was going to capture at about the same time as the Glide Slope was intercepted. As soon as the FMA changed VOR/LOC to green (captured), I selected the approach function, and the Glide Slope indication went to green (captured) almost immediately. The Glide Slope indicator then trended downward, showing that we were getting high on the desired path. The autopilot, instead of pitching down to follow the Glide Slope, began to pitch up. The airspeed then began to decrease below the minimum for the configuration. I had to add thrust significantly, disconnect the autopilot and manually push the nose over to increase the airspeed and try to regain the proper Glide Slope. I regained it successfully, and flew the remainder of the approach in a stabilized fashion, but the aircraft did not perform as it should have. Performing in the opposite of what it's supposed to do, in a low airspeed, high drag situation is very dangerous. This is not the first time that I have witnessed this kind of behavior in this type of aircraft. This is the third or fourth time that I have seen this, at different airports, but all on ILS frequencies. I have discussed this error with the Captains at the time, and I always get a response such as, 'Well, it's a -300.' This is completely unacceptable, and counter to safety. I can't understand how this equipment can be certified for use in IFR when it behaves in this fashion. Perhaps it's just in a series of autopilots, or series of aircraft, but it seems that a tracking by Maintenance or investigation of some sort is warranted. As we move more and more to a higher level of safety and automation, attitudes like, 'Well, it's a -300,' don't seem to have any place in our system. I have also seen these airplanes nose over suddenly to capture the Glide Slope if you happen to be above it. The pitch over moment is quite severe, and causes alarm to passengers and crew members alike. That may be a separate issue, but it seems like there is a regular deficiency with the autopilot system in this type of aircraft. I believe that this needs to be investigated by the Maintenance Department. Request that when crews witness this behavior, note the time, approach, configuration, frequency, etc. to see if there is a pattern. Have the autopilot system in the affected/reported aircraft checked for proper function. Consult with Boeing to see if there are other reports of this type of behavior.

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INSTRUMENT LANDING SYSTEM (ILS) M-ARRAY GLIDE SLOPE MEASUREMENTS

Delft University of Technology - Faculty of Aerospace Engineering

1. Introduction

This report gives an overview of the measurement of an Instrument Landing System (ILS) Glide Slope performed for the Dutch Safety Board as part of an investigation into a serious incident at Eindhoven Airport. The first goal of the test flight campaign was the measure the Glide Slope field (direction and strength), specifically above the 3 degree Glide Path. To accomplish this field measurement the aircraft was equipped with a Flight Inspection System (FIS). The FIS records various parameters and is normally used to verify and calibrate ILS at airports in The Netherlands.

For this test flight a pattern was created to measure the ILS Glide Slope signal strength and direction ('Fly Up' and 'Fly Down'). All flight runs were performed with the localizer established as the measurement focused on the vertical plane in line with the runway.

A second goal of the test flight was to test the reaction of the automatic flight system of the test aircraft. Three event scenario were formulated, which are part of the investigation, whereby a Glide Slope was captured and a pitch up of the aircraft occurred. Both at Eindhoven and Woensdrecht a M-array (Capture Effect) ILS Glide Slope antenna is installed.

2. Flight crew

The Flight Department of the Delft University of Technology operates a Cessna Citation laboratory aircraft suitable to conduct the test flight campaign. The staff is experienced in flying laboratory equipment, both from a flight operational and technical support point of view. The test flight campaign was conducted by two experienced Research Test Pilots.

3. Aircraft (PH-LAB Cessna Citation II)

Delft University of Technology operates a small business-jet aircraft as a laboratory aircraft, which serves as a platform for aerospace research and student experiments. The aircraft is suited for a wide range of research projects, and a number of systems and airframe modifications have been installed to accommodate various needs.

Figure 1: Cessna Citation II PH-LAB laboratory aircraft.

The Citation II is a twinjet aircraft with two Pratt & Whitney JT15D-4 turbofan engines enable a maximum operating altitude of more than 13 km (43,000 ft) and a maximum cruising speed of 715 km/h (385 KTAS). The flight envelope allows a wide range of operations to be performed. On-board equipment includes a three-screen Electronic Flight Instrument System (EFIS), a Flight Management System (FMS) with a Global Positioning System (GPS) sensor and a Flight Director/Autopilot.

4. Flight Test Instrumentation: Flight Inspection System (FIS)

The PH-LAB can be equipped with special dedicated hardware to collect radio navigation aids' data. This equipment is called a Flight Inspection System (FIS) and is normally used to validate electronic signals in space and certify the navigation aids like the ILS Glide Slope antenna system. The flight inspection computer records the aircraft position and data received by dedicated antennas and sensors. After post processing of this data the status of the navigational system can be verified and if found operating within required specifications certified for use.

The FIS equipment is necessary for reaching the objectives required in measuring the G/S signal for the flight campaign.

Figure 2: Flight Inspection System (FIS) installed in the PH-LAB.

5. Flight campaign ILS Glide Slope measurement plan

The first goal of the flight campaign was to measure the ILS G/S signal with the focus above the 3 degree Glide Path. It was determent that 5 horizontal measurements at different altitudes would yield enough information to determine the field strength and direction above the 3 degree Glide Path.

The altitude of horizontal measurements were chosen based on three known events where a stick shaker occurred after Glide Slope capture during the approach phase. As these events occurred on three different altitudes (1,050; 2,100 and 2,850 feet) these altitude were chosen as starting point. In order to acquire a homogeneous Glide Slope field measurement two additional altitudes were chosen (500 and 1,500 feet). This made the vertical separation between the horizontal measurements approximately 550 and 750 feet apart. Following the determination of altitude the measurement distance was determined from the runway. The determination was based on the premise that it should start before the 3 degree Glide Path and end at the top of the antenna (0 NM).

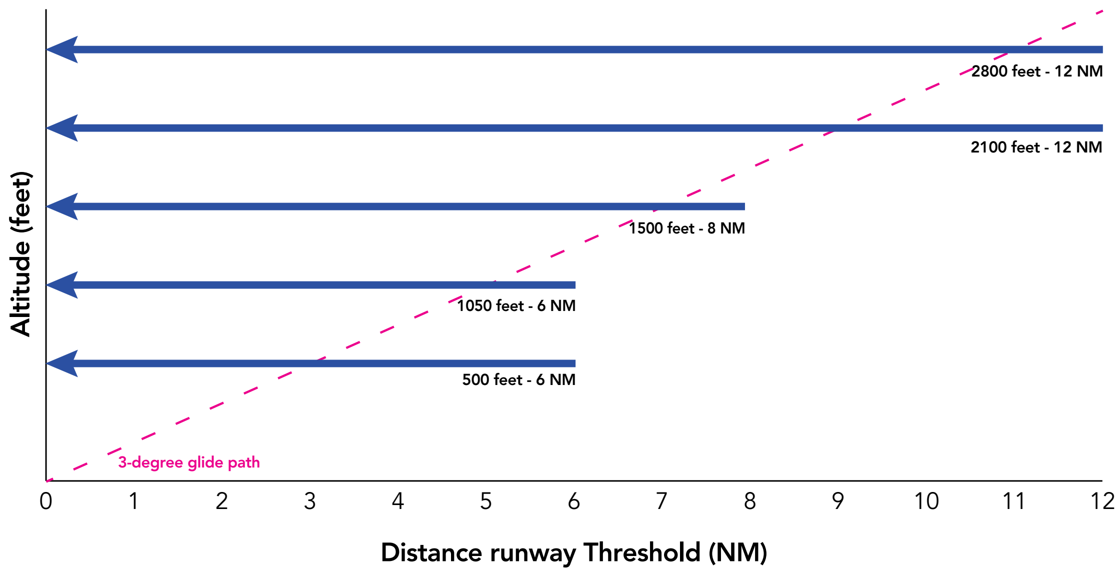

Figure 3: Determination of measurement altitude and distance [not to scale].

A second goal of the flight test measurement campaign was to determine the reaction of the automatic flight system of the Cessna Citation. In order to accomplish this, three scenarios were drafted which were based on three events where a stick shaker occurred after Glide Slope capture during the approach phase.

- Scenario 1; Airbus A340 Paris Charles de Gaulle Airport. This test run starts at 6,000 feet 9 NM out and ends at approximately 2,850 feet 2 NM out. The aircraft groundspeed was chosen to be approximately 160 knots, similar to the event recorded data.
- Scenario 2; Embraer E190 Amsterdam Airport Schiphol. This test run starts at 6,000 feet 9 NM out and ends at 2100 feet at 1.4 NM. The aircraft groundspeed was chosen to be approximately 140 knots, similar to the event recorded data.
- Scenario 3; Boeing 737-800 Eindhoven Airport. This test run starts at 2,500 feet 5 NM out and ends at 2,100 feet at 1.4 NM. The aircraft ground speed was chosen at approximately 140 knots, similar to the event recorded data.

In order to conduct the flight campaign it was necessary to have a runway with ILS system available for a certain period of time. Because Eindhoven is a busy airport it was decided to conduct field measurements at another airport. It was confirmed that Woensdrecht, a military air base near Eindhoven, has an identical ILS system in operation. At Woensdrecht Air Base it was possible to conduct the flight campaign without interruption from other traffic.

As the event which was under investigation by the Dutch Safety Board happened at Eindhoven Airport, it was essential to verify the Woensdrecht measurements at Eindhoven. Therefore two runs, one horizontal and scenario 3 (Eindhoven) were flown at Eindhoven for verification purposes. All flight runs were performed with the aircraft established on localizer, as the measurement focused on the vertical plane in line with the runway. Before each measurement run the aircraft had to be stable and established on localizer before the G/S measurement could start.

Flight campaign ILS Glide Slope measurement					
Run	Location	Profile	Altitude [feet]	Distance runway [NM]	Main objective (secondary objective)
1	EHWO	Horizontal	500	6	ILS G/S measurement at 500 feet, (A/P off –observe F/D)
2	EHWO	Horizontal	1,050	6	ILS GS measurement at 1,050 feet, (A/P off –observe F/D)
3	EHWO	Horizontal	1,500	8	ILS G/S measurement at 1,500 feet, (A/P off –observe F/D)
4	EHWO	Horizontal	2,100	10	ILS G/S measurement at 2,100 feet, (A/P off –observe F/D)
5	EHWO	Horizontal	2,850	12	ILS G/S measurement at 2,850 feet, (A/P off –observe F/D)
6	EHWO	Scenario 1	6,000	9	A/P on to test reaction automatic system Cessna Citation (ILS G/S measurement)
7	EHWO	Scenario 2	5,100	9	A/P on to test reaction automatic system Cessna Citation (ILS G/S measurement)
8	EHWO	Scenario 3	2,500	5	A/P on to test reaction automatic system Cessna Citation (ILS G/S measurement)
9	EHEH	Horizontal	1,050	6	ILS G/S measurement at 1,050 feet
10	EHEH	Scenario 3	2,500	5	A/P on to test reaction automatic system test (ILS G/S measurement)

Table 1: Description of the 10 test runs which were done at Woensdrecht Air Base (EHWO) en Eindhoven Airport runway 21 (EHEH).

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6. Flight campaign 1

The flight campaign was executed on 11 October 2013. During the flight observations were made by the Research Test Pilots. Also a video recording was made of the different runs for further analyses. Below is a summary of the observations.

Flight campaign ILS Glide Slope observations automatic system					
Run	Location	Profile	A/P	Observed reaction	
1	EHWO	Horizontal	Off	Fly Down, F/D Capture (6), no reaction F/D	No flag
2	EHWO	Horizontal	Off	Fly Down, F/D Capture (6), full Fly Up	No flag
3	EHWO	Horizontal	Off	Fly Down, F/D Capture (6), full Fly Up	No flag
4	EHWO	Horizontal	Off	Fly Down, F/D Capture (6), full Fly Up, Fly Down	No flag
5	EHWO	Horizontal	Off	Fly Down, F/D Capture (6), full Fly Up, Fly Down	No flag
6	EHWO	Scenario 1	On	Fly Down, A/P Capture (6), full Fly Up, Fly Down	No flag
7	EHWO	Scenario 2	On	Fly Down, A/P Capture (6), full Fly Up – A/C pitch-up crew intervened	No flag
8	EHWO	Scenario 3	On	Fly Down, A/P Capture (6), full Fly Up – A/C pitch-up crew intervened	No flag
9	EHEH	Horizontal	Off	Fly Down, A/P Capture (9), full Fly Up	No flag
10	EHEH	Scenario 3	On	Fly Down, A/P Capture (9), full Fly Up – A/C pitch-up (violent) crew intervened	No flag

Table 2: Observations 10 test runs which were done at Woensdrecht Air Base (EHWO) en Eindhoven Airport (EHEH).

Research Test Pilot comments EHWO

'At Woensdrecht Air Base during the level runs a normal 'Fly Up' command was recorded before crossing the 3 degree Glide Path. After passing the 3 degree Glide Slope the 'Fly Up' command became a 'Fly Down' command which was as expected. Subsequently, while flying through the 6 degree Glide Path, the Flight Director shoed an 'on glide' indication and captured the Glide Slope, to be followed directly with a (fairly strong) 'Fly Up' indication for the 6 degree Glide Path. The indication later changed into a steady 'Fly Down' command until the 9 degree Glide Path.

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At low altitudes (less than 1,000 ft) the indications were very unsteady through the 6 degree Glide Path. But when the 9 degree Glide Path is reached the indications became more steady.

Following these flight tests it was shown that while flying the scenarios at Woensdrecht Air Base the Auto Pilot Glide Slope logic activated when the 6 degree Glide Path was crossed. The autopilot subsequently followed the 'Fly Up' command and a pitch-up occurred, flight crew intervention was essential.'

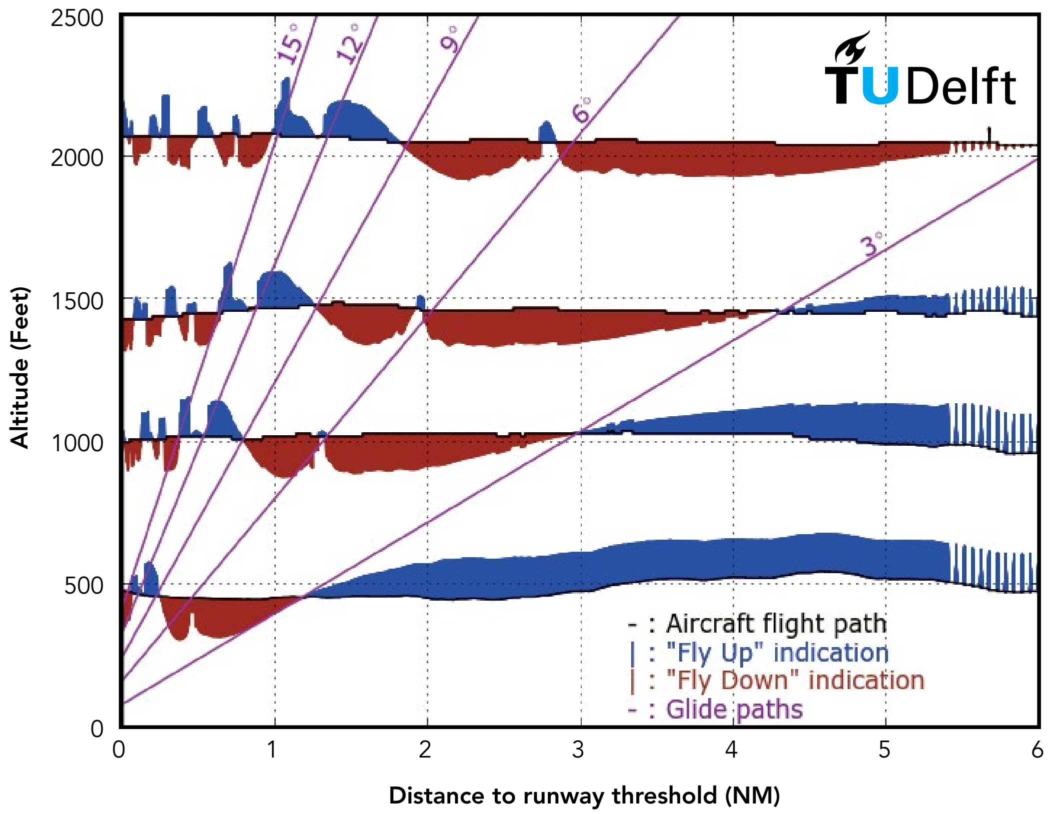

Figure 4: horizontal Glide Slope signal measurements Woensdrecht Air Base

Summary
The measurement at Woensdrecht showed that a 'Fly Down' indication was measured between the 3 and 6 degree Glide Path. At around the 6 degree Glide Path a small 'Fly Up' indication area is present. This area triggered the Glide Slope capture logic in the aircraft and the aircraft will subsequently follow the 'Fly Up' command. Between approximately the 6 and 9 degree Glide Path a 'Fly Down' was measured.

Research Test pilot remarks Run #10 EHEH, Scenario 3
'To follow the profile of the incident flight, we programmed a vertical profile in the FMS, providing vertical guidance on the PFD from 2,500 feet at 5 NM from the threshold, to 1,000 feet at 1 NM. This profile was tracked using the vertical speed mode of the flight director coupled to the autopilot with the Glide Slope armed, the same setup the incident flight had used.'

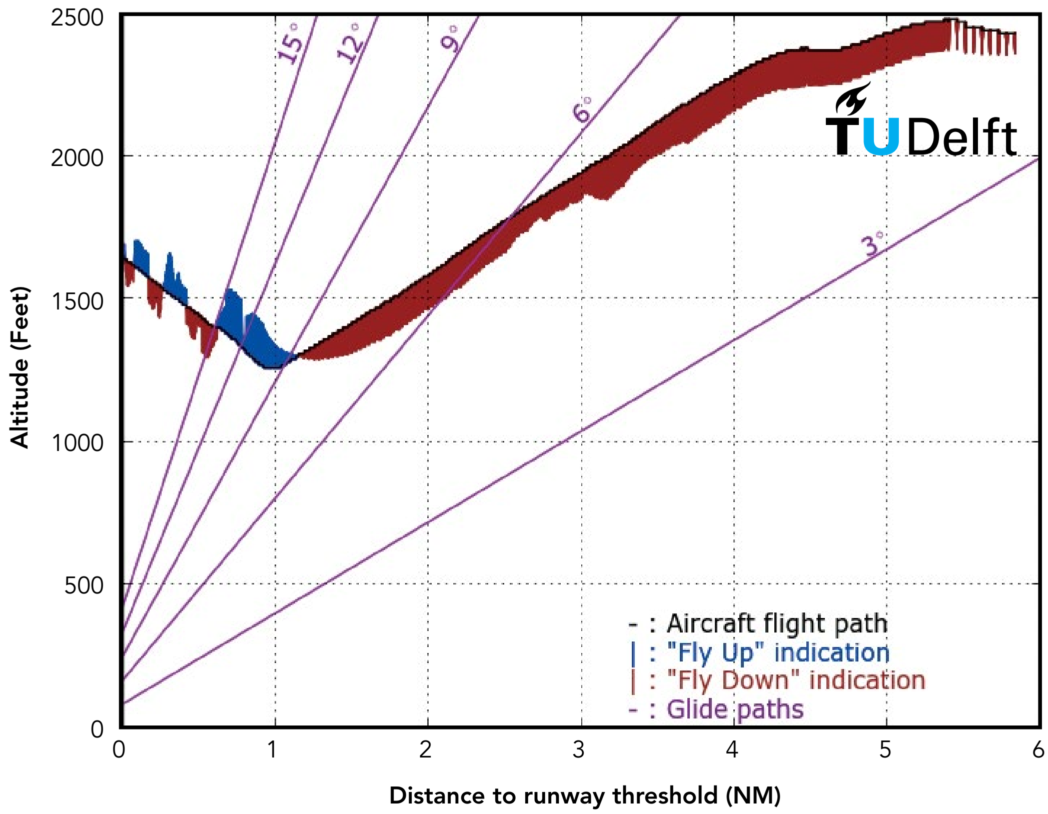

Figure 5: scenario 3 measurement flight Eindhoven Airport runway 21

'Flying the profile in this way we stayed roughly 1,000 feet above the normal 3 degree Glide Path all the way down, replicating the event flight exactly. In order to mimic the dynamics of the incident flight as closely as possible, the approach was flown at the recorded final approach speed of the Boeing 737 of 143 knots.'

'From the moment we started our descent at 2,500 feet, a full-scale 'Fly Down' indication was present on the Glide Slope indicator. Approaching 1 NM DME, the Glide Slope indicator came alive and the Flight Director switched to glide-slope capture. This was no surprise as we were briefed by the Dutch Safety Board to expect capture at the 9 degree Glide Path. At the 9 degree Glide Path the Glide Slope turned into an indicated full 'Fly Up' indication on the PFD and the aircraft pitched up sharply. Despite being briefed before hand, the sudden onset and loss of airspeed was amazing. Because the pitch up up-set was part of the test, the pitch-up was continued as long as possible to capture relevant data and crew intervention was delayed.'

Summary

The flight test campaign showed that at Eindhoven runway 21 a homogeneous 'Fly Down' field is present between the 3 and 9 degree Glide Path. At the 9 degree Glide Path a Signal Reversal occurs ('Fly Up'). This reversal will trigger the Glide Slope logic in the aircraft and the aircraft will subsequently follow the 'Fly Up' command.

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7. Flight campaign 2

A second flight campaign was done with a second aircraft, PH-NLZ operated by NLR, to measure the Glide Slope field at Eindhoven Airport runway 03. A horizontal measurement was done at 2,000 feet and a diagonal run down (scenario #3) was done with the autopilot not engaged. The focus of the measurement was to recorded additional data, therefore de autopilot en Glide Slope capture was disengaged as not to get pitch-up which would disturb the measurement run.

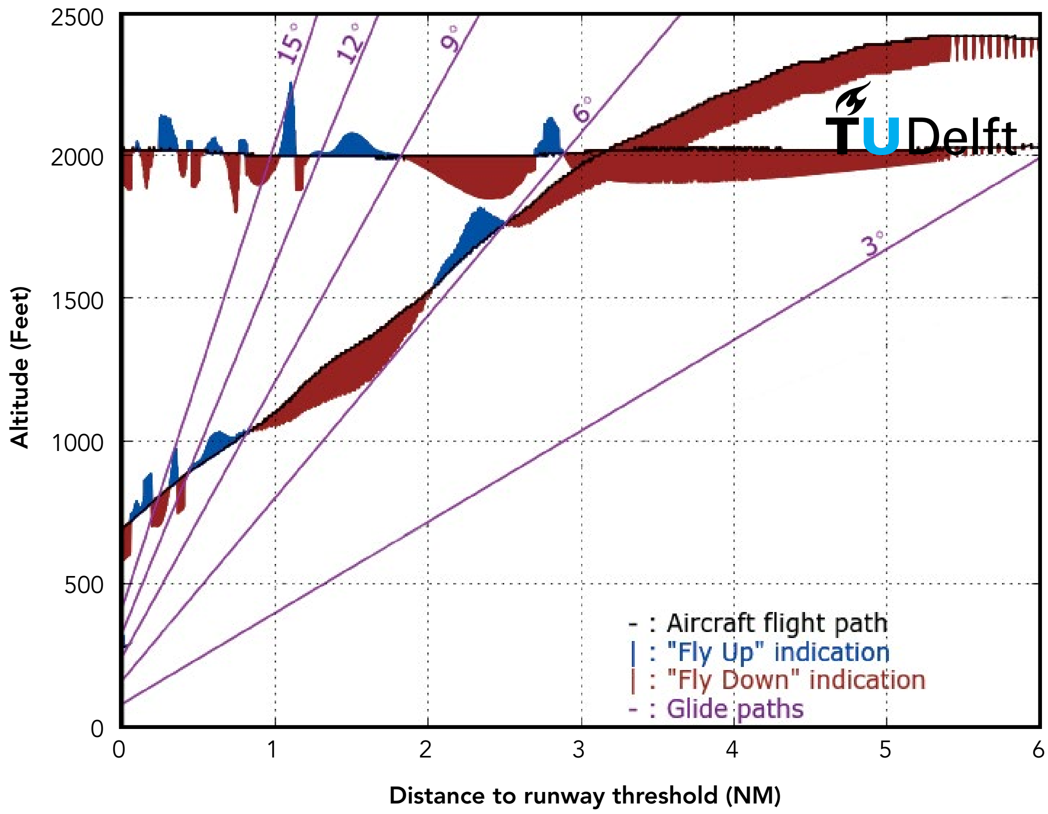

Figure 6: scenario 3 measurement flight Eindhoven Airport runway 03

Summary

The measurement at Eindhoven Airport runway 03 shows that a 'Fly Down' indication was measured between the 3 and 6 degree Glide Path. At around the 6 degree Glide Path a small 'Fly Up' indication area is present. The signal reversal triggers the Glide Slope capture logic in the aircraft and the aircraft will subsequently follow the 'Fly Up' command. Between approximately the 6 and 9 degree Glide Path a 'Fly Down' was measured. Hereafter a 'Fly Up' signal was measured. The measurement EHEH 03 was similar to that of Woensdrecht Air Base.

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8. Measurement results

A Signal Reversal will activated the Glide Slope capture logic of the Cessna Citation and the autopilot will follow the Glide Slope signal direction in whichever direction (Up or Down).

At Eindhoven Airport the Glide Slope field measurements showed that:

- Runway 03 a 'Fly Down' indication was measured between the 3 and 6 degree Glide Path. A small area of 'Fly Up' indication was measured around approximately the 6 degree Glide Path. Between approximately the 6 and 9 degree Glide Path a 'Fly Down' was measured.
- Runway 21 a homogeneous 'Fly Down' was measured between the 3 and 9 degree Glide Path. Hereafter a 'Fly Up' signal was measured.

At Woendrecht Air Base the Glide Slope field measurements showed that:.

- A 'Fly Down' was measured between the 3 and 6 degree Glide Path. A small area of 'Fly Up' was measured around approximately the 6 degree Glide Path. Between approximately the 6 and 9 degree Glide Path a 'Fly Down' was measured. Hereafter a 'Fly Up' signal was measured.

DUTCH
SAFETY BOARD

Visiting Address
Anna van Saksenlaan 50
2593 HT The Hague
T +31(0)70 333 70 00
F +31(0)70 333 70 77

Postal Address
PO Box 95404
2509 CK The Hague

www.safetyboard.nl