

The operation of
Ground
Proximity
Warning Systems

A Review of Warnings

BUREAU OF AIR SAFETY INVESTIGATION

INFORMATION PAPER

SAB/IP/95/02

The Operation of Ground Proximity Warning Systems (GPWS)

**A Review of Warnings
April–December 1994**

Released by the Director of the Bureau of Air Safety Investigation under the
provisions of Air Navigation Regulation 283

When the Bureau makes recommendations as a result of its investigations or research, safety (in accordance with its charter) is its primary consideration. However, the Bureau fully recognises that the implementation of recommendations arising from its investigations will in some cases incur a cost to the industry.

Readers should note that the information in BASI reports is provided to promote aviation safety: in no case is it intended to imply blame or liability.

ISBN 0 642 22589 3

April 1995

This report was produced by the Bureau of Air Safety Investigation (BASI), PO Box 967, Civic Square ACT 2608.

The Director of the Bureau authorised the investigation and the publication of this report pursuant to his delegated powers conferred by Air Navigation Regulations 278 and 283 respectively. Readers are advised that the Bureau investigates for the sole purpose of enhancing aviation safety. Consequently, Bureau reports are confined to matters of safety significance and may be misleading if used for any other purpose.

As BASI believes that safety information is of greatest value if it is passed on for the use of others, copyright restrictions do not apply to material printed in this report. Readers are encouraged to copy or reprint for further distribution, but should acknowledge BASI as the source.

CONTENTS

Abbreviations	iv
Foreword	v
1. INTRODUCTION	1
1.1 Preliminary review of Australian (GPWS) statistics April–December 1994 ..	1
1.1.1 Classification of GPWS warnings	2
1.1.2 Flight crew responses to GPWS warnings	2
1.1.3 GPWS warnings and ATS Procedures	3
1.1.4 Equipment mode of operation	4
2. SUMMARY	5
2.1 Further actions	5
2.2 Safety actions	5
Bibliography	6

ABBREVIATIONS

3LO	Public broadcast station
ATC	Air traffic control
BASI	Bureau of Air Safety Investigation
CFIT	Controlled flight into terrain
FSF	Flight Safety Foundation
GPWS	Ground Proximity Warning System
IASS	International Air Safety Seminar
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
IFA	International Federation of Airworthiness
IFALPA	International Federation of Airline Pilots' Associations
VMC	Visual meteorological conditions

Foreword

The objective of the project is to analyse GPWS warnings in Australia with a view to addressing ICAO steps (e) Investigation of GPWS warnings and (f) Reduction of unwanted warnings, of the circular AN11/1.1.19-93/61.

The analysis will concentrate on the rate, nature, cause and result of the warnings, and will assess their implications on flight crew actions, ATC procedures, aircraft equipment reliability and warning functionality. Determination of a warning's validity in relation to false or unwanted warnings will also be made during the analysis.

1. INTRODUCTION

'CFIT accidents are the most severe aircraft accidents. These kinds of accidents occur when an otherwise airworthy airplane is inadvertently flown into the ground or water. The number of fatalities per accident is extremely high as compared to any other type of accident. They also generally result in complete destruction of the airplane. If CFIT accidents were to be completely prevented, approximately half of the worldwide fatalities in aircraft accidents would also be prevented. CFIT accidents have a high leverage for safety improvement.' (Weener, 1993).

The 131st Session of the ICAO Air Navigation Commission addressed the subject of CFIT accidents and agreed that these constitute a significant flight safety problem. The Commission requested the ICAO Secretariat to submit a comprehensive program to address the issue as a matter of high priority. As a result, ICAO published State Letter AN11/1.1.19-93/61, dated 16 June 1993.

The State Letter details steps that ICAO recommends States should take to reduce the incidence of CFIT accidents. Two of these steps (e) and (f) are particularly pertinent to BASI. They read as follows:

- (e) Investigation of GPWS warnings.
States and operators should co-ordinate the investigation of all GPWS warnings to ascertain whether they were false, unwanted or actual warnings. This is the best way in which information can be used to further reduce the incidence of false or unwanted warnings and to increase the confidence in the GPWS equipment;
- (f) Reduction of unwanted warnings.
GPWS warnings, determined to have been unwanted warnings, should be further investigated to ascertain whether a change to a flight instrument, an ATC or a flight operations procedure could eliminate unwanted warnings in a particular location or whether a GPWS warning envelope modulation would be required.

Additionally, an industry CFIT task force has been established by the FSF in consultation with ICAO, consisting of membership from state regulatory authorities, airline operators, aircraft manufacturers, IATA, IFALPA and ICAO. The task force is also addressing many issues pertinent to the operational standard of current and future GPWS equipment.

1.1 Preliminary review of Australian (GPWS) statistics April–December 1994

Between April and December 1994, a total of 113 reports were received concerning GPWS warnings. Forty of the reports concerned Canberra (see fig.1) with 27 of these being associated with runway 35, mostly during the approach phase from the west and south-west. This approach path takes the aircraft over, or in the vicinity of, several peaks on the eastern edge of the Brindabella Ranges.

Melbourne was a distant second with ten reports. Again, the majority (six) were concerned with the approach from, or departure to, the west and north-west, while two of the reports were specific to the radio 3LO transmission mast.

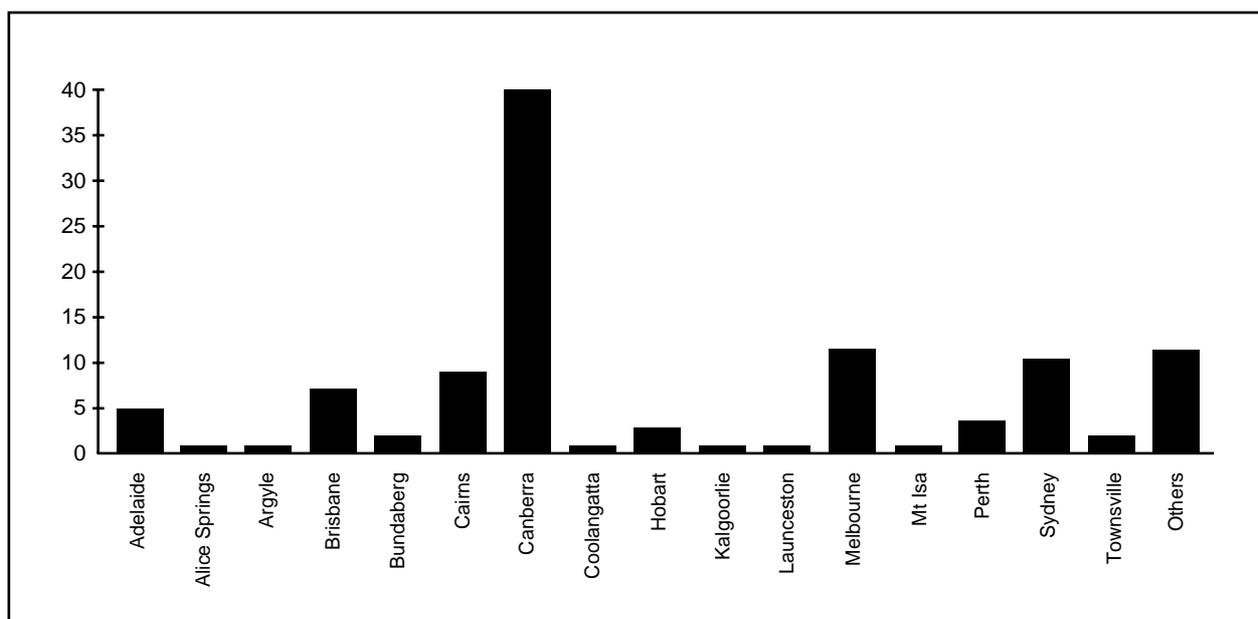


Figure 1 GPWS alerts by location

1.1.1 Classification of GPWS warnings

In order to provide information relevant to the project, the warnings were classified by the air crew as 'nuisance (operational)', 'technical' and 'genuine'.

Nuisance (Operational) warnings (66) are defined as those warnings that flight crew believed to be the result of penetration of the equipment envelope, or activation of the alarm that did not require immediate flight crew response because of other factors known to the crew (e.g. visual terrain clearance maintained).

Technical (21) are those resulting from known equipment malfunction or equipment design deficiencies (activation by weather phenomena, interference, etc.).

Genuine (26) are those that required reaction from the flight crew because no other factors were known to the flight crew that would give doubt as to the warning's validity.

In some instances, the warnings were classified as nuisance (operational) when in fact they could have been more correctly classed as genuine (the original assessment, by the crew, has been retained for the purpose of this analysis). The classification as nuisance rather than genuine was made in spite of the fact that it was clear from the report that the equipment was operating to its parameters and providing a valid alert.

1.1.2 Flight crew responses to GPWS warnings

While most of the reported GPWS warnings (69) occurred in conditions that were day VMC, the crew reaction to the warning varied quite considerably. Overall, the crew reaction to the warning was that 39 took action immediately, 51 took no action (mainly due to being visual with terrain), and in 23 reports the crew reaction was not given. In two instances the crew took action even though they classified the alert as a technical malfunction. In 23 of the nuisance warnings the crew took immediate action and in 16 of the genuine warnings the crew responded appropriately (see fig. 2). Flight crew response to seven genuine warnings was not reported.

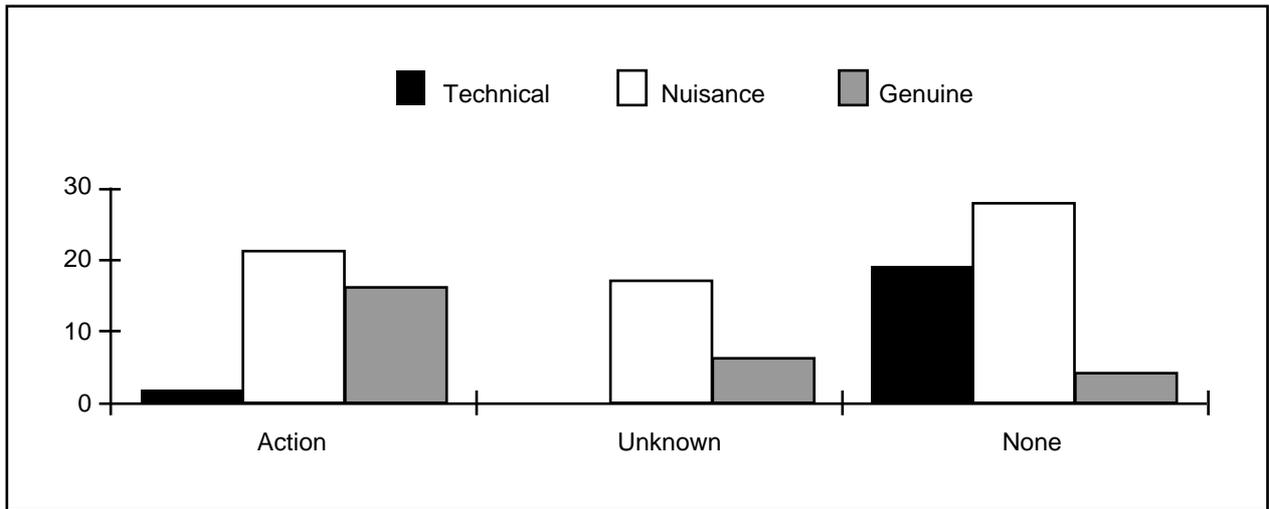


Figure 2 Flight crew action by classification of warning

1.1.3 GPWS warnings and ATS procedures

Forty-eight (42%) of the aircraft were under radar vectoring by ATC at the time of the warning (see fig.3). Of these, 16 (14%) were classified by the crew as genuine and 28 were classified as nuisance; however, some of the 28 warnings could have been more correctly classified as genuine. This would tend to indicate that ATS procedures at times take aircraft over areas and terrain where GPWS warnings are likely. Empirical evidence indicated that Cairns would be likely to have a high number of nuisance warnings. The fact that only nine warnings were recorded at that location could be the result of recently revised standard arrival routes and approach procedures that avoid such terrain. The phase of flight was significant in that 57 warnings were reported to have occurred during the approach phase and 29 during descent (BASI has been unable to clarify the significance of reports differentiating between the terms 'approach' and 'descent').

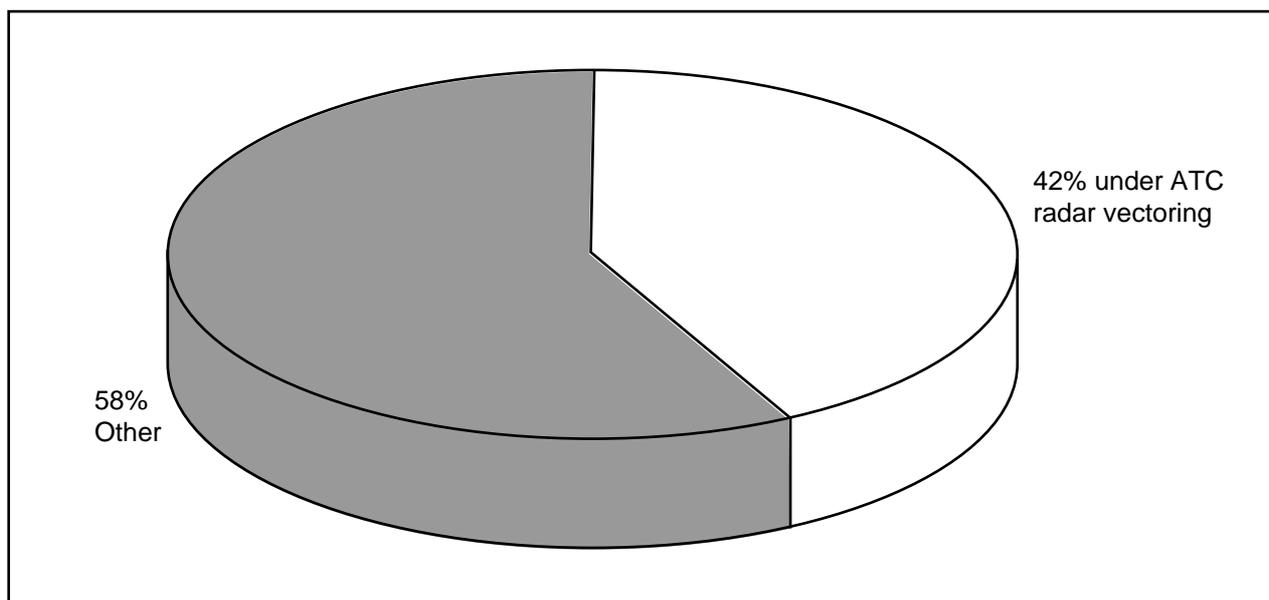


Figure 3 GPWS warnings – radar vectored

1.1.4 Equipment mode of operation

The mode in which the equipment was being operated ranged from Mode 1 'excessive descent rate alert/warning' (3 reports) to Mode 5 'alert to inadvertent descent below glideslope' (15 reports). The greatest number of reports occurred from warnings given while the equipment was being operated in Mode 2 'excessive closure rate to terrain warning' (74 reports).

2. SUMMARY

It appears from the reported responses to GPWS warnings in Australian operations, that flight crew reaction is to check visually, if possible, first, and then to initiate corrective action in response to the warning, rather than to react to the warning and then check visually.

As a result of the reported worldwide experience, the FSF issued the following recommendations:

- when a GPWS warning occurs, pilots should immediately, and without hesitating to evaluate the warning, execute the pull-up action recommended in the company procedure manual;
- in the absence of a company procedure, an immediate maximum performance full-power climb should be initiated and continued until the GPWS warning stops and the crew determines that terrain clearance is assured;
- this immediate pull-up procedure should be followed except in clear daylight visual meteorological conditions when the flight crew can immediately and unequivocally confirm a false GPWS warning; and
- air traffic control (ATC) should be notified as soon as possible after a GPWS warning or pull-up.

2.1 Further actions

The Bureau of Air Safety Investigation, as part of its commitment to the ICAO CFIT program, is continuing research into GPWS warnings with the intention of investigating whether a change to aircraft equipment, ATC or flight operations procedures could eliminate unwanted warnings in a particular location or whether a GPWS warning envelope modulation would be required.

2.2 Safety actions

There are no safety actions resulting from this preliminary analysis.

BIBLIOGRAPHY

Flight Safety Foundation, 'Safety alert concerning GPWS warning'

Haase, David 1992, *FSF 45th IASS & IFA 22nd International Conference*

Weener, Earl F. 1993, *FSF 46th IASS & IFA 23rd International Conference*

BASI CONTACTS

basi@dot.gov.au

Australia-wide

24-hour toll-free number:

1800 011 034

Brisbane

PO Box 10024
Brisbane Adelaide St Qld 4000
Level 2, Samuel Griffith Place,
340 Adelaide Street
Brisbane Qld 4000
Facsimile: (07) 3832 1386

Canberra (Central Office)

PO Box 967
Civic Square ACT 2608
26 Mort Street
Braddon ACT 2612
SITA CBRBACR
Facsimile: (02) 6247 1290

Canberra Field Office

24 Mort Street
Braddon ACT 2612
Facsimile: (02) 6274 6604

Melbourne

Level 9
Casseldon Place
2 Lonsdale Street
Melbourne Vic 3000
Facsimile: (03) 9285 6674

Perth

PO Box 327
Belmont WA 6104
Suite 2
Pastoral House
277-279 Great Eastern H'way
Belmont WA 6104
Facsimile: (08) 9479 1550

Sydney

PO Box Q78
Queen Victoria Bldg NSW 1230
Level 7 BT Tower
1 Market Street
Sydney NSW 2000
Facsimile: (02) 9283 1679

CAIR

Reply Paid 22
The Manager
CAIR
PO Box 600
Civic Square ACT 2608
24 Mort Street
Braddon ACT 2612
Facsimile: (02) 6247 4691

INVESTIGATION REPORT SAB/IP/95/02
ISBN 0 642 22589 3