Australian Government
Australian Transport Safety Bureau

Safe Transport

AVIATION RESEARCH INVESTIGATION REPORT
B2004/0337

Risks associated with aerial campaign management:

Lessons from a case study of aerial locust control

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Cover photograph: P. Spurgin, Australian Plague Locust Commission

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ABBREVIATIONS

AGL	Above Ground Level
APLC	Australian Plague Locust Commission
ATSB	Australian Transport Safety Bureau
CASA	Civil Aviation Safety Authority
CFIT	Controlled Flight into Terrain
DPI	New South Wales Department of Primary Industries
DPI Victoria	Department of Primary Industries, Victoria
HROs	High Reliability Organisations
NRM	Queensland Department of Natural Resources and Mines
RLPB	Rural Lands Protection Board
SARDI	South Australian Research and Development Institute

EXECUTIVE SUMMARY

In 2004, there were two wirestrike accidents in New South Wales involving helicopters undertaking locust control operations. The first accident occurred in October 2004 near Forbes and resulted in minor injuries to one occupant and extensive damage to the helicopter. The second accident occurred in November 2004 near Dunedoo and resulted in the death of two occupants. A third occupant was seriously injured and there was extensive damage to the helicopter. A third accident, near Mudgee in November 2004, involved a helicopter that was being used for locust control, although the helicopter was not involved in locust control activities at the time of the accident.

The Australian Transport Safety Bureau (ATSB) began formal investigations into all three accidents and a research investigation into the practices used by Government organisations to contract aerial operators for locust control in order to identify issues that may enhance future aviation safety.

Locust control operations are presented as a case study, but it is intended that organisations managing other aerial operations with similarities to locust control, such as aerial fire control, other pest management operations, and emergency service operations, may also find the concepts presented in this analysis useful. These types of operations, collectively referred to in the report as ‘aerial campaigns’, are characterised by:

- a significant community need for the operation, possibly urgent;
- requiring the coordination of significant numbers of resources and organisations;
- a degree of irregularity or unpredictability as to when the operation will be required and the size the operation;
- requiring aerial operations with a relatively high hazard level; and
- a regularly changing operational environment throughout the course of the campaign.

These characteristics potentially increase risk to the organisation and its staff. Locust control organisations are closely involved in aerial operations and can therefore influence the level of risk of the operations.

Many complex organisations operating in a hazardous environment, such as major public air transport companies, recognise the influence they have on safety. While they may subcontract many safety-critical aspects of their operations, these organisations still maintain an interest in the safety of these operations and proactively manage safety beyond what is required by regulation. Similar methods can be effective for mitigating risk in aerial campaigns.

Locust control organisations and other organisations involved in aerial operations with similar characteristics may benefit from developing some of the characteristics identified in High Reliability Organisations (HROs). HROs work in complex high-hazard environments but with relatively low numbers of accidents and incidents. These organisations have been identified as having an ‘organisational mindfulness’ which is defined by:

- an attitude that recognises failures, no matter how small, are symptoms of a problem in a system and that failures provide learning opportunities for the organisation;

- encouraging diverse views and approaches to operations to assist to identify a diverse range of risks and solutions;

- ensuring there are people within the organisation who have a clear understanding of the 'big picture' at all times;

- a commitment to resilience, in that the organisation can cope with unexpected dangers by being able to organise itself appropriately at times of increased risk;

- a deference to expertise at times of increased risk, rather than relying on traditional management structures.

After the two helicopters accidents involved in locust control in NSW in October and November 2004, the organisation overseeing these operations has advised the ATSB that it has taken considerable steps towards safer operations by developing more comprehensive safety management systems. The organisation has consulted widely with aviation industry bodies, aerial operators and other government departments and has developed risk controls based on a risk management approach to the entire locust control campaign.

1 INTRODUCTION

In 2004, there were two wirestrike accidents in New South Wales involving helicopters undertaking locust control operations. The first accident occurred in October 2004 near Forbes and resulted in minor injuries to one occupant and extensive damage to the helicopter. The second accident occurred in November 2004 near Dunedoo and resulted in the death of two occupants. A third occupant was seriously injured and there was extensive damage to the helicopter. A third accident, near Mudgee in November 2004, involved a helicopter that was being used for locust control, although the helicopter was not involved in locust control activities at the time of the accident[1].

The Australian Transport Safety Bureau (ATSB) began formal investigations into all three accidents and a research investigation into the practices used by Government organisations to contract aerial operators for locust control in order to identify issues that may enhance future aviation safety.

This report analyses how organisations that contract aerial operators for locust control can potentially influence the safety of these operations. Further information regarding the specific accidents associated with locust control operations in October and November 2004 is available in the ATSB *Accident and Incident reports* 200404285, 200404286 and 200404590[2].

[1] Appendix 1 contains summaries of these three accidents and four other accidents the ATSB has on record as involving locust control.

[2] This accident is still under investigation at the time of publication of this report. Some preliminary information is available.

2 METHODLOGY

2.1 Scope of the analysis

The focus of the report is on the management of aerial operators by Government organisations that contract aerial operators for locust control. While there are numerous hazards associated with locust control operations, including those associated with chemical application and ground control, the primary concern of this analysis is aviation safety.

2.2 Information sources

The information for this report comes from two ATSB investigation reports into helicopter accidents which occurred during the NSW 2004/2005 locust campaign[3], and extensive interviews with locust control organisations throughout Australia and aerial operators involved in locust control.

2.3 Application of the analysis

Locust control operations have been presented as a case study, but it is intended that organisations managing other aerial operations with similarities to locust control, such as aerial fire control, other pest management operations, and emergency service operations, may also find the concepts presented in this analysis useful. These kinds of operations, collectively referred to in this report as 'aerial campaigns', are characterised by:

- a significant community need for the operation;
- a requirement for the coordination of significant numbers of resources and organisations;
- a degree of irregularity or unpredictability as to when the operation will be required and the size the operation;
- a requirement for aerial operations with a relatively high hazard level; and
- a regularly changing operational environment throughout the course of the campaign.

[3] *Accident and Incident reports* BO/200404285 and BO/200404286.

3 AERIAL LOCUST CONTROL IN AUSTRALIA

Locust plagues are a significant problem for agriculture in Australia. Crop damage from locusts can be significant[4]. Aerial control is a significant component of locust control programmes once locust populations reach a high enough level.

Locusts are insects belonging to the same order as grasshoppers and crickets (the Orthoptera). There are a number of species of pest locusts in Australia which occur in different areas and have different behaviour (Australian Plague Locust Commission, 2005a).

All locust species develop in three stages: egg, nymph and adult. The time at which they develop into each stage is dependent on the species. Locust eggs are laid by adult locusts in soil. Locust nymphs hatch from the eggs wingless, but they are able to move along the ground eating vegetation. When the nymph population is high enough, certain plague locust species aggregate into large bands. These bands may extend over several kilometres and can move significant distances each day consuming large numbers of crops and damaging pastures (Australian Plague Locust Commission, 2005a).

The nymph locust develops wings over successive shedding of the skin until it reaches the final adult stage. If the population is large enough, adult locusts form large mobile swarms. A single swarm can extend over a considerable area of land (up to 50 km^2) depending on the environmental and ecological conditions (Australian Plague Locust Commission, 2005a). Swarms usually only move short distances (10 to 15 km) during the day and generally swarm fly at about 10 to 25 metres above ground level. However, adult locusts are capable of migrating long distances overnight with recorded displacements of 500 to 600 kilometres not uncommon. It is this ability to band, swarm and travel large distances which allows locusts to consume large amounts of crops and pasture, and makes them a significant pest for agriculture when the populations are large.

The development of locusts into plague-size populations is dependent on sufficient amounts of rainfall in inland Australia over successive seasons which allows the locust to breed rapidly (Australian Plague Locust Commission, 2005b).

3.1 Organisations conducting aerial locust control in Australia

A number of government-funded organisations are involved in locust control activity in Australia.

The Australian Plague Locust Commission (APLC) is tasked to manage locust populations which are considered a significant interstate threat, to assist the States to manage locust outbreaks in their area of responsibility and to seek to improve the effectiveness and safety of locust field operations (Australian Plague Locust Commission, 2005c). The APLC is funded by

[4] A plague in 1984 has been estimated to have cost $5 million with the control measures in place. Without the control measures, the costs would have been $103 million. See Australian Plague Locust Commission (2005) for more information.

funds administered by the Australian, New South Wales, Victorian, South Australian and Queensland governments.

Locust control in NSW is undertaken by the New South Wales Department of Primary Industries (DPI), the Rural Lands Protection Boards (RLPBs), APLC and landholders. The DPI is responsible for coordinating ground control state-wide and coordinating aerial control in its area of responsibility (East of the Newell Highway). The APLC is responsible for coordinating aerial control generally west of the Newell Highway. The RLPB's responsibilities for locust control include monitoring and reporting locust outbreaks, organising landholder control of locusts and assisting DPI and APLC with aerial control activities.

Aerial locust control in Queensland is conducted by the APLC and the Queensland Department of Natural Resources and Mines (NRM). The majority of locust control conducted by the NRM is carried out within the boundaries of the Central Highlands. The NRM conducts aerial locust control, but not every year.

Aerial Locust control in South Australia is conducted by the APLC and the South Australian Research and Development Institute (SARDI). SARDI conducts aerial locust control, but not every year, and it is generally limited to between two and four aircraft.

Aerial locust control in Western Australia is conducted by Department of Agriculture; however, locust plagues in Western Australia are relatively infrequent (Australian Plague Locust Commission, 2005a).

Locust control in Victoria is conducted by the APLC and Department of Primary Industries, Victoria (DPI Victoria). DPI Victoria does not conduct aerial mitigation.

Certain locusts species do exist in the Northern Territory; however, the Northern Territory Government do not undertake State-wide aerial control programmes. The APLC is not funded by the Northern Territory Government.

For the purpose of this report, these organisations will be referred to collectively as locust control organisations, although the majority of them have responsibilities in other areas relating to agriculture and natural resources. Locust control – and more particularly, aerial locust control – is only a small component of their business. The exception to this is the APLC, which only works on locust management.

Landholders may apply chemicals on the ground or use privately contracted aerial operators. However, aerial control of locusts by landholders is not considered in this paper.

3.2 Aerial control of locusts

The requirement for aerial locust control is determined by the locust control organisations based on criteria such as the population level of the locusts and the potential impact on agriculture. The APLC is the only locust control organisation which normally conducts aerial locust control on an annual basis.

There are two types of aerial operations carried out around Australia as part of locust control programmes: surveying and spraying. Each of these aerial operation types can be conducted using fixed-wing or rotary-wing aircraft or a combination of the types.

Surveying is conducted to establish the numbers of locusts in the area, to identify suitable target areas for spraying, to delimit target boundaries and to identify known hazards for the spray pilot within the target area.

Surveying using fixed-wing or rotary wing aircraft is conducted by most government agencies responsible for locust control in Australia. The aircraft is flown systematically over an altitude generally in the order of 1,500 feet above ground level (AGL) while a dedicated locust spotter in the aircraft searches for locust bands and locust crop and pasture damage. The location of locust bands and damage are recorded for control using spray aircraft and/or for further surveying.

Adult locusts are unlikely to be detected from such altitudes. The procedure followed by many locust control organisations is to fly at lower altitudes, sometimes as low as 10 feet AGL. Helicopters are the more appropriate aircraft for this kind of work. In order to gauge the density of a locust swarm or band and to delimit the infestation boundaries, the survey helicopter may be flown so that the locusts are forced upwards by the downwash from the helicopter rotor, so that they can be seen.

Survey helicopters may be required to land on properties to gain the land owner's permission to spray and to request additional information regarding chemical and aviation hazards. This may include information regarding the location of areas sensitive to spray (eg housing or dams), utility wires (such as power or telecommunications) and other hazards to low-flying aircraft.

When it is determined by the occupants of the survey aircraft that an area requires spraying, a spray aircraft will be called in. The survey aircraft is responsible for providing the spray pilots with the location of the spray area. This information is generally relayed to the spray pilot via radio communications. The survey aircraft may conduct a flight around the perimeter of the spray area to visually indicate the target area boundaries and any hazards to the pilot of the spray aircraft. The spray aircraft may conduct a flight around the perimeter of the spray area while the survey pilot observes to ensure the spray pilot has understood the instructions.

Spraying is generally conducted using fixed-wing aircraft, although rotary-wing aircraft have been employed in NSW by the DPI, and experimentally by the APLC.

Hazard identification is undertaken by the survey aircraft and relayed to the spray pilot by radio. It was unclear from interviews that the ATSB conducted with the locust control organisations and the aerial operators as to whether spray pilots routinely conduct their own independent hazard assessment, although the spray pilot retains responsibility for the safe application of the spray chemicals.

4 POTENTIAL RISKS ASSOCIATED WITH AERIAL CAMPAIGNS

The current Australian/New Zealand Standard on risk management, AS/NZS 4360:2004 (page 4), defines risk as:

> 'the chance of something happening that will have an impact on objectives.'

Risk is composed of hazards, events, consequences and conditions which cause the presence of the hazard, moderate the likelihood of an event occurring or moderate the consequences of the event.

Risk is measured in terms of the consequences of an event and its likelihood. In terms of the safety of aerial locust control and other aerial campaigns, risk may be measured in terms of the likelihood of an accident occurring and the consequences which result from an accident for people and property.

A hazard is a source of risk (Standards Australia, 2004). Hazards will always exist in any activity involving aircraft; however, with appropriate controls, a high-hazard environment can be managed to be a low-risk environment. Utility wires such as power and telecommunication wires are a major hazard for aerial agricultural operations and other operations involving low-level operations, including aerial locust control. A search of the ATSB aviation accident database returned seven accidents involving locust control activity since 1985[5], six of which were accidents involving a helicopter striking a wire[6].

The characteristics of aerial campaigns, such as aerial locust control, have the potential to increase the risk to aerial operations.

4.1 A significant community need for the operation

There is considerable public pressure on government agencies to control locusts due to the potential for damage to crops and pastures. The costs of locust damage are a significant concern for farming communities. This pressure can intensify during certain months when locusts are in their highest numbers.

Significant community pressure on organisations to conduct operations may have the potential to increase risk as organisations focus their energy and resources on completing the tasks without appropriate planning or resources allocated to controlling the hazards.

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[5] Appendix 1 contains a summary of these accidents. The appendix includes an accident near Mudgee in which a pilot was repositioning a helicopter in preparation for locust control activities but was not involved in locust control activities at the time of the accident.

[6] These six accidents include the three helicopter accidents that occurred in NSW in 2004 already referred to in the text.

4.2 The coordination of resources and organisations

4.2.1 Organisational complexity

The organisational complexity of aerial campaigns and the subsequent coordination effort required may lead to a diffusion of responsibility among the parties involved. The ATSB has in the past identified a diffusion of responsibility among parties involved in similarly complex operations, such as the manufacture of aviation fuel[7] and the management of helicopter emergency medical service operations[8]. The complexity is further increased when staff from different organisations are working together towards a joint outcome.

In a large locust control operation, the spraying of one infested area may involve the locust control organisation, a rotary-wing aerial operator, a fixed-wing aerial operator, the property owner, and other government organisations (rangers and other agricultural organisations frequently provide staff and other assistance in the event of a large locust infestation). The process is normally cooperative and effective, however the lines of management and responsibility for ensuring that the work is being done satisfactorily are often complex. The responsibility for safety may become diffuse and elements of safety management may be lost as no single organisation is cognisant of the whole operation.

4.2.2 Regulatory complexity

The regulation and contractual arrangements involved in campaigns and locust control are relatively complex and may also lead to a diffusion of responsibility for safety.

CASA’s task as the aviation regulator is to set and maintain a minimum standard for commercial aviation operations. It can regulate organisations that conduct commercial aviation activities; however, it cannot influence the customer and contractual relationships that may affect the behaviour of an aviation operator. CASA’s role can be seen as but one part of a cooperative safety management system for aviation operations.

Under State, Territory and Federal Occupational Health and Safety (OHS) legislation, contracting organisations have ‘duty of care’ responsibilities to their employees working with contractors. Contracting organisations also have a duty of care to the contractor’s employees working within the contracting organisation’s workplaces. This duty of care requires these organisations to do everything reasonably practicable to remove or minimise any possible causes of injury and illness to their employees. Similarly, the

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[7] In January 2000, a large number of piston-engine aircraft were grounded as a consequence of contaminated aviation gasoline. The ATSB investigation revealed that one of the factors which allowed the contamination to occur was that there was a diffusion of responsibility among the various regulatory bodies that oversee the manufacture, quality assurance, supply and use of aviation fuel. It was possible for each one of these bodies to influence the quality of the fuel, but there was no clear delineation of roles and responsibility of the respective regulatory organisations. For further information see (ATSB, 2001).

[8] On 17 October 2003, a Bell 407 helicopter crashed into the sea near Mackay, Queensland while en-route to pick up a patient at Hamilton Island. There were a number of organisations involved in the provision of the emergency medical helicopter service. The investigation found there was a diffusion of responsibility for ensuring safe operations of the emergency medical service helicopter among these organisations. For further information see (ATSB, 2005).

operator has a duty of care to its employees and the staff of the contracting organisation, and all employees have a similar duty of care to cooperate and participate in safety-related activities.

Under State, Territory and Federal regulation, organisations cannot contract out their duty of care. Compliance with the regulatory requirements of CASA by itself does not meet all the requirements associated with Australian OHS legislation.

4.3 Irregularity of operations

There is some degree of irregularity in aerial campaigns. The control organisation may be aware that the operation may be required soon, but the exact time of this requirement may not be known.

In the case of locust control operations, the size of the locust population in a season is dependent on a number of environmental factors such as sufficient rainfall in successive seasons (Australian Plague Locust Commission, 2005b). Locust plagues are relatively uncommon. There have been 12 locusts plagues and five major outbreaks of locusts in eastern Australia since 1933 (Australian Plague Locust Commission, 2005b). There may be a significant period between even small-scale aerial operations and they are rarely conducted on such a large scale as the campaign that was conducted in NSW during 2004 and 2005. While the locust population can be forecast, there are time limitations on these forecasts. The irregular nature of campaigns has a number of potential influences on the risks associated with the operation. It reduces the amount of time available for organisations to plan and coordinate control activities.

The opportunities for staff and aerial operators to be involved in these kinds of campaigns are limited. This in turn limits the experience of staff within the control organisations and the aerial operators.

If there is a significant locust population in a season, considerable resources may be required to control the problem. Aerial operators and pilots may be called in from other unaffected areas of Australia, and these operators and pilots will be required to conduct operations outside their immediate area of familiarity. Pilots working in unfamiliar areas have a higher workload, as they need to pay more attention to navigation, the terrain and infrastructure such as utility wires.

4.4 Aerial operations with a relatively high hazard level

Aerial campaigns usually require relatively hazardous aerial operations often involving low-level flying. Locust spotting has routinely involved low-level flying in order to see the locust swarms and to record their location and density. In circumstances where the spotters believe there are adult locusts in vegetation, helicopter rotor wash may be used to ‘flush’ the locusts into the air to provide some indication of density. Low-level operations are inherently more hazardous than higher-level flying as:

- there are a greater number of obstacles, including vegetation, the terrain, utility wires, and other man made structures, for the helicopter to avoid;

- in the event of an emergency situation, such as loss of aircraft control, the pilot has significantly less time to regain control of the situation before contacting the ground; and
- pilots have a higher workload at low levels, as they must negotiate the hazardous environment in addition to their normal workload.

Low-level flying is normally prohibited by regulation except for times when it is necessary, such as take-off and landing[9]. Where there is an operational need for low-level flying, operators may apply to CASA for an exception from the regulations, and alternative risk controls are required to decrease risk. The controls include formal pilot training in the extra skills required to operate safely at low level, and extra procedures required to identify and avoid the hazards.

Rotary-wing survey aircraft are required to land on agricultural properties on unsurveyed landing sites to obtain the permission of the land holder to spray the locusts and to discuss any aviation or chemical hazards on the property. Although helicopters can land at unprepared sites, there are potentially a greater number of hazards to avoid than at a designated landing site, and regular operations of this nature increase the risk of collision without appropriate mitigating procedures.

4.5 Changing environment

Aerial campaigns are characterised by an environment that can change rapidly. Unlike airline operations with set operations conducted on a regular basis and planned well in advance, each flight in a campaign operation is likely to be unique as the problem changes in magnitude or position. Pilots and control organisation staff face novel situations on a regular basis. These kinds of operations reduce the time available for pre-flight planning and in-flight hazard assessment and reduce the effectiveness of generic risk management systems.

The ability of locusts to increase in population rapidly and travel large distances may result in a constantly changing campaign environment. Control activities must be carried out in a number of environments with varying terrain and human population as locusts move through different areas. An area with higher human population levels will tend to have more infrastructure and subsequently a greater number of wires in the flying area, while terrain with a greater variation in elevation increases the risk of controlled flight into terrain (CFIT) accidents.

[9] Civil Aviation Regulations 1988, Regulation 157.

5 ORGANISATIONAL INFLUENCES ON AVIATION SAFETY

Modern theories of accident causation recognise that accidents have many causes involving people at different levels within an organisation (Reason, 1990) (Reason, 1997). James Reason's model of organisational accidents[10] proposes that this accident type has its origins in the strategic decisions and organisational processes of the organisation, such as budgeting, auditing, planning, scheduling and managing[11]. These processes, combined with a natural tendency for human error and human violations to be committed by individuals at the operational end of an organisation, may result in an accident (Reason, 1997).

Organisations are protected from hazards by a series of controls or defences. Defences reduce risk in a number of different ways, including by containing or limiting hazards, by providing alarms and warnings of imminent danger, by providing guidance on how to operate safely and by creating and understanding an awareness of the local hazards (Reason, 1990, 1997). Defences exist at multiple levels in complex systems within an organisation (Reason, 1990, 1997). They reduce the risk that an error by one or two people may result in the failure of a system, as other system defences capture the error before it creates an unacceptable situation. The effectiveness of defences in preventing hazards from being realised is influenced by organisational factors.

There are numerous examples of investigations into accidents or incidents in aviation and other industries which have led to identification of systemic problems within an organisation that may have contributed to the incident or accident[12].

It is likely that the immediate precursor to many wirestrike accidents involving low-level operations has been that the pilot did not see the utility wire, or had seen the wire but had forgotten about it. The pilot provides one level of defence against wirestrike accidents. However, it is unrealistic to expect a single pilot to see every wire or keep every wire in their memory at all times while at the same time control an aircraft at low-level, and conduct other tasks associated with the operation. Other defences may be provided by the organisations supporting the pilot such as:

- the pilot's employer, providing operating procedures, training, equipment;
- the contracting organisation, providing task allocation based on risk assessments by suitably knowledgeable staff;
- CASA, providing appropriate regulatory requirements for low level aircraft operations; and

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[10] More information on Reason's model of organisational accidents is contained in (Reason, 1990, 1997).

[11] While organisations themselves are influenced by other organisations, regulation and society in general, for practicability, Reason's model is confined to the boundaries of the organisation.

[12] Appendix 2 contains examples of accidents identified by the ATSB as involving organisational elements.

- and the landowner, providing information about the local area and hazards.

5.1 How can an organisation contracting an aerial operator potentially influence the safety of aerial operations?

Locust control organisations:

- are responsible for selecting and obtaining the services of the aerial operator;
- are responsible for tasking the operator;
- are responsible for briefing the pilot and operator at the beginning of the day and throughout the operation;
- are responsible for components of ground support; and
- may often have staff on board the contracting aircraft.

Locust control organisations are involved in the management of significant parts of the aerial campaign. Decisions made in the management processes therefore have the capacity to influence the campaign's safety. If safety is to be maintained, that capacity must be monitored and managed: leaving responsibility for safety to another party that is not managing the overall campaign will not be effective.

5.1.1 Contract selection and management

5.1.1.1 Tendering documentation and contract specification

The criteria for the selection of operators have the potential to influence aviation safety by defining:

- flight crew and operator experience;
- the nature of the performance measures that will drive the contract;
- the nature and quality of any safety management system or occupational health and safety systems required of the contractor; and
- the types of equipment used.

The effective development of appropriate selection criteria may be difficult if there is limited aviation knowledge within an organisation. The aviation industry is relatively complex in that it is has components that are highly regulated and highly technical. In addition, aerial agriculture and rotary-wing aircraft industries have a relatively large range of operators, ranging from small businesses to large organisations. All these businesses have different areas of expertise and use different safety management systems and aircraft, making it difficult for the controlling organisation to compare them.

If an organisation uses the same selection criteria when contracting aerial operators for different task types, such as fire fighting or mammal pest management, then there is a risk that the criteria may be inappropriate for the task.

5.1.1.2 Evaluation of the selection criteria

Risk can be introduced if the selection criteria are not checked throughout the campaign. As the campaign progresses, possibly with increasing intensity, new operators and pilots may be brought in. In the case of an accident involving a locust spotting helicopter striking a wire near Forbes in October 2004, the pilot provided by the operator did not have the experience required by the contractor in the original tendering documentation. The locust control organisation did not ensure the pilot complied with the requirements of the original tendering document. There were no formal audits of contracted aerial operators conducted by the locust control organisation prior to the accident. While the investigation could not determine the direct influence of this factor on the accident, it did result in the placing of employees in potentially higher-risk environments. Without proper evaluation and audit of the aerial operators against the criteria specified in the tendering and contract documentation, the criteria are not effectively mitigating any risk.

Selection criteria need to be set to balance the needs for suitably competent staff with the need to be able to employ sufficient pilots and to enable pilots to become experienced in this kind of work. When pilots do not have the required skills additional risk controls must be considered to mitigate the increased risk.

5.1.2 The management of operations throughout the campaign period

5.1.2.1 Briefing and tasking

The controlling organisation is involved in briefing and tasking of the aerial operators and is therefore directly involved in placing the aircraft in a particular work environment. This is a potential area of risk as the contracting organisation has an element of financial control over the operator. However, locust control organisations did state that the final decision for conducting an operation was always the pilot’s. This was generally written into locust control organisation operating procedures, and many operators stated there was no undue pressure placed on them by the contracting organisation to complete a task.

Pre-flight planning and general briefing is an opportunity for pilots and staff to set the objectives of a flight, share ideas on how the operation is going, identify any problems, plan operations and discuss any common hazards.

5.1.2.2 Operating procedures

The absence, deficiency or inappropriateness of operating procedures for operators may increase the risk to aviation safety.

The absence of standardised procedures means there may be considerable differences in the techniques used by different operators and contracting organisation staff to conduct tasks. Processes that are used to accomplish a particular task will evolve through a process of experience and passing on this information, often by word of mouth. There will be inconsistencies in how the task is accomplished, as different staff and operators will have differing levels of competence and experience, and different solutions to the same problem will have naturally evolved. The organisation that is managing the operation in such an uncontrolled environment will not be in full control or fully aware of how its tasks are being accomplished and therefore will have less control over the safety of the operation.

On the other hand, while operating procedures encourage consistency and control of a process, this does not guarantee that they reflect the safest way to conduct that activity. For example, in the recent NSW locust management campaign, the procedures used by aerial operators with limited experience of locust management operations were provided by the contracting locust control organisation. One helicopter company manager informed the ATSB that the company's pilots learnt the technique of flushing the locusts directly from locust control staff and the contracting organisation's operating procedures. The text contained in the operating procedures read:

> 'When looking for adults, the helicopter should fly along tree and creek lines and in localised areas of green vegetation approximately 12 ft (3 m) above ground level and at 30 knots (60 km/h). Locusts adults will flush-up ahead, to the side or behind the helicopter. If the weather is cool or very windy, adult locusts will be difficult to see. Warm, sunny days with wind of less than 3 m/s are ideal for survey work.'

There was no mention in the operating procedures for planning the task, for assessing risk, for assigning tasks among crew to minimise risk or of operational limitations to manage the risks associated with this task. This text has since been removed from the operating procedures and the locust control organisation no longer uses this procedure.

Procedures can also introduce risk by being inappropriate for the task at hand. Overly restrictive procedures may prevent the task being completed and are more likely to result in the rules being broken.

Procedures that are not constantly reviewed and re-evaluated by their controlling organisation may not prove to be an effective risk control in a dynamic operating environment. In the case described above, the locust control organisation did conduct a substantial evaluation and modification of their risk mitigation strategies.

5.1.3 The contracting organisation staff

5.1.3.1 Management staff

Management staff are responsible for making the high level decisions which set the context of the operation. If management prioritise safety and ensure this is reflected in the processes of the organisation, then this will influence staff throughout the organisation as well as contractors and staff of other involved organisations.

5.1.3.2 Operational staff

Operational contracting organisation staff can influence the safety of an aerial operation as they are normally directly involved. In the case of locust control, operational locust control staff are responsible for tasking the operators, providing ground support and often fly in the survey aircraft for spotting purposes.

The risk to aviation safety may be increased by inappropriate management of staff who fly on aircraft. Exposing greater numbers of staff to aerial hazards increases the risk to the organisation; therefore risk may be reduced by only allowing essential staff on the helicopters. Some operators suggested to the ATSB that during the recent NSW locust control programme, the excitement of working in a helicopter, in addition to a financial incentive, caused many staff in the locust control organisations to be eager to be involved in helicopter work. There were four locust control staff on board the helicopter which crashed near Forbes in 2004. According to the locust control organisations standard operating procedures, all staff were required to have written approval and appropriate training and experience in detecting bands and directing spray aircraft. In the case of the Forbes accident, no written records were produced to indicate that this was the case. There was no indication of a consistent risk-based procedure for determining flight crew tasking.

There was an inconsistent perception by the helicopter operators of the roles of the occupants in the Forbes NSW helicopter crash in November 2004. Prior to the accident, the pilot had requested all occupants of the helicopter (a ranger in the front and two locust spotters in the back) to look out for power cables and other potential hazards around the landing site. One spotter reported understanding that a cable should not be reported unless it was felt the pilot had not seen the cable. It is not clear what the understanding of the other spotter was with regard to hazard spotting. Neither spotter reported the presence of any power cables. One spotter had some limited experience in survey flights and some brief training courses, but no on-the-job or practical training. The other spotter had been in a helicopter on one occasion prior to the accident flight and had no training in regard to the campaign or helicopter operations. The potentially different perceptions of roles by individuals in the helicopter increased the risk that a pilot might not be made aware of a wire threat by another crew member.

Management staff within most locust control organisations appeared to be aware of an informal hazard spotting role among their spotters; however, the extent of this role varied. This could lead to an inconsistent understanding among spotters and pilots regarding the spotters’ role. Operators were also unclear about the extent to which locust control organisation staff had a locust spotting role. Many stated they had variable experiences with spotting staff and most stated their pilots would not rely on the spotters for hazard spotting.

6 CONCEPTS FOR ENHANCING THE SAFETY OF CAMPAIGNS

There are a number of safety management concepts that have been developed from accident investigations and from studying high reliability organisations (HROs)[13] that may assist agencies involved in aerial campaigns to further reduce the risk to the organisation and their staff.

6.1 Integrated and flexible risk management practices

Major aviation accident and incident investigations in Australia have frequently identified organisational deficiencies in the aviation system surrounding an accident. These deficiencies are usually incorporated during a change, often years before the accident and are difficult to identify (Reason, 1997). Examples of these kinds of accidents and incidents can be found in Appendix 2.

Many aviation organisations use documented procedures as a tool to manage risk. Documented procedures can reduce risk by making operations more consistent, thereby reducing the opportunity for unplanned changes in the procedures associated with an activity. However, aerial campaigns are more dynamic than many other types of aerial operations. Reliance on a standard set of risk controls is likely to incorporate irrelevant requirements which are likely to be ignored or subverted, or unnecessarily reduce the effectiveness of the operation. They may also give an inappropriate sense of security to those involved and lead to a false perception of safety. Campaign risks may be better managed by a system that actively seeks and manages risk throughout all design, management and implementation processes. A risk management system that is integrated into all processes also signals to operators and staff involved in the campaign that there is an ongoing commitment to safety by the contracting organisation.

An important component of the risk management process is to monitor and review the process on an ongoing basis[14]. The organisational culture necessary to maintain a high degree of reliability in complex technical and organisational operations was described in the ATSB investigation report BS/20010005, which examined the management of maintenance at Ansett Airlines leading up to the grounding of its Boeing 767 fleet. It describes the need for an organisation to constantly review how its activities are measuring up against the achievement of its objectives.

6.2 Clearly defined responsibilities for safety

Aerial campaigns are potentially high risk, and technically and organisationally complex. A significant potential exists for the requirements of one aspect of the operation to adversely affect another aspect of the operation. Each part of the operation (such as aircraft operation, chemical

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[13] High Reliability Organisations operate in difficult environments with relatively few accidents (Weick & Sutcliffe, 2001).

[14] The *Australian/New Zealand Standard Risk Management* AS/NZS 4360:2004 and the corresponding guidelines (HB 436:2004) provide an overview of the risk management process.

management and ground support for obtaining permission to spray) can manage its own tasks. For example, in the case of aerial operations, a safety management system is required by the Civil Aviation Safety Authority (CASA) for the aircraft operator. However, this system only encompasses the operation of the aircraft by that operator and does not include other elements that have the potential to affect the safety of the operation such as the tasking of the operator. An effective overall management system can ensure that no one aspect of the operation compromises another aspect.

The relative infrequency of some campaigns and the occasional requirement for large numbers of operators means that operational experience of the campaign will normally reside within the contracting organisations. The effectiveness of this process will be enhanced by good information sharing among operators and the locust control organisations. Campaign control organisations are in the best position to facilitate this by seeking external expertise, by monitoring the effectiveness of procedures and modifying them if necessary, by encouraging information sharing through regular operator briefings and by encouraging and formalising feedback processes from operators and their staff on the operations.

Confidence in the safety of the entire operation can be enhanced by a system which manages all the influences that can affect the outcome of the operation and this function can normally be best accomplished by the organisation that is responsible for initiating the operation.

6.3 Organisational mindfulness

Organisational mindfulness is a concept proposed by Weick and Sutcliffe (Weick & Sutcliffe, 2001) to help understand the success of HROs. HROs rarely fail to achieve their objectives despite encountering numerous unexpected events. These organisations ‘organise themselves in such a way they are better able to notice the unexpected in the making and halt its development.’ (Weick & Sutcliffe, 2001). Weick, Sutcliffe, and Obstfeld (1999) outline five processes that characterise organisational mindfulness[15]:

- ‘a preoccupation with failure’;
- reluctance to simplify interpretations;
- sensitivity to operations;
- commitment to resilience; and
- deference to expertise.

‘A preoccupation with failure’ describes a mindset in which an organisation recognises that failures, no matter how minor, provide the opportunity to learn about potential disasters. The organisation treats every failure as a symptom of something wrong with the system. It requires an organisation to encourage the reporting of safety-related incidents, consider their potential impact and modify procedures accordingly.

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[15] A similar concept to organizational mindfulness has been described as ‘chronic unease’ (Reason, 1997).

HROs are reluctant to simplify interpretations in that they use complex systems to manage a complex environment and encourage diverse views and approaches to operations. An application of this is to encourage the sharing of information among all involved, from managers to operational staff, and involve these parties in the risk management processes. This may assist in developing a diverse range of opinions and in identifying potential risks that may not be identified by only one area of an organisation.

HROs are sensitive to operations in that they ensure that someone in the organisation has a clear understanding of the 'big picture' of operations at all times. For example, organisations that are sensitive to operations will have managers who have a clear understanding of the functioning of line operations at all times. Managers may gain greater sensitivity to operations by encouraging operational staff to report to management on the progress of the operations towards meeting their objectives.

HROs have resilience in that they recognise that no system is perfect and are committed to ensuring that the organisation can cope with unexpected dangers. These organisations are not derailed by errors and are able to organise themselves in ways that enable them to deal with errors (Hopkins, 2005). In particular, HROs do not rely on hierarchical structures, particularly in problem solving, when experience and expertise become more important than rank in the management hierarchy. At critical times these organisations consult widely and hunt out the required expert. This type of approach requires open communication among all staff and operators involved in an operation.

7 CONCLUSIONS

Aerial campaigns such as aerial locust control operations are conducted in relatively hazardous environments that also have the potential to be high-risk environments. Campaign control organisations are directly involved in numerous aspects of the aerial component of these campaigns and can increase or decrease the risk of these operations.

While the aerial component of the operation is provided by an aerial contractor, the campaign control organisation is in a central position to understand the big picture. The adoption of good systems for managing risk by the contracting organisation can provide an effective additional layer of defences over and above that provided by each operator to protect against an incident or accident.

Many complex organisations operating in a hazardous environment, such as major public air transport companies, recognise the influence they have on safety. While they may subcontract many safety-critical aspects of their operations these organisations still maintain an interest in the safety of these operations and proactively manage safety beyond what is required by regulation. Similar methods can be effective for mitigating risk in aerial campaigns.

The focus of this paper is on aviation safety, but it is recognised that there are hazards in other components of a campaign. For example, in the case of locust, there are hazards associated with ground vehicles and chemical application. However, risk management processes can guide the organisation towards the lowest risk solution to a problem if they are integrated into all aspects of an operation.

After the two helicopters accidents involved in locust control in NSW in October and November 2004, the organisation overseeing these operations has advised the ATSB that it has taken considerable steps towards safer operations by developing more comprehensive safety management systems. The organisation has consulted widely with aviation industry bodies, aerial operators and other government departments and has developed risk controls based on a risk management approach to the entire locust control campaign.

At the time of publication of this research paper, the ATSB has released investigation reports for the Mudgee (BO/200404285) and Forbes (BO/200404286) accidents. The fatal accident in Dunedoo (BO/200404590) is still under investigation. The ATSB is also conducting further research into wire strike accidents. The results of this research will be released in the second half of 2005.

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9 APPENDIX 1- ACCIDENTS INVOLVING LOCUST CONTROL

The following accidents have been recorded by the ATSB as involving locust control activity.

ATSB Occurrence number: 198700756
Date of incident: 10/12/1987
Location: Near JAMESTOWN, SA
Accident summary: A helicopter crashed after striking a wire while engaged in low level locust survey operation. Two occupants were fatally injured.

ATSB Occurrence number: 199300124
Date of incident: 27/01/1993
Location: 5km E Menindee, NSW
Accident summary: A helicopter crashed after engine power loss due to fuel exhaustion while engaged in a locust survey operation. The accident did not result in any injuries.

ATSB Occurrence number: 199703877
Date of incident: 27/11/1997
Location: 7.5km SW Orroroo, SA
Accident summary: A helicopter crashed after striking a wire while engaged in locust control operations. The two occupants were fatally injured.

ATSB Occurrence number: 200005357
Date of incident: 16/11/2000
Location: Jerramungup, WA
Summary: A helicopter crashed after striking a wire while engaged in locust control operations. The pilot was fatally injured.

ATSB Occurrence number: 200404285
Date of incident: 30/10/2004
Location: Forbes, NSW
Summary: A helicopter crashed after striking a wire while engaged in locust control operations. One occupant sustained minor injuries.

ATSB Occurrence number: 200404286
Date of incident: 1/11/2004
Location: Mudgee, Aerodrome, NSW
Summary: A helicopter crashed after striking a wire while re-positioning in preparation for locust control operations. The helicopter was not engaged in locust control activities at the time. The pilot sustained minor injuries.

ATSB Occurrence number: 200404590
Date of incident: 22/11/2004
Location: 12km SW Dunedoo, NSW
Summary: A helicopter crashed after striking a wire while engaged in locust survey operations. The pilot and one passenger were fatally injured and one passenger sustained serious injuries. The investigation is continuing at the time of publication of this report.

APPENDIX 2- AUSTRALIAN ACCIDENTS AND INCIDENTS INVOLVING ORGANISATIONAL FACTORS

Examples of Australian accidents and incidents involving organisational factors investigated by the ATSB include:

Report number: BO/199403038

Boeing 747 landing with nose wheel not locked down, Sydney, NSW.

On 19 October 1994, Boeing 747 VH-INH landed at Sydney without its nose landing gear locked down. The operating company had recently introduced this aircraft type. While the processes for training staff and developing operating procedures had been conducted, the actual process had been rushed, and delays had been absorbed by compressing the change programme. Workarounds were used when parts of the process were not working properly, so that although all the induction and change procedures had been completed, no one was reviewing the whole change procedure to ensure that it was achieving its desired objective. The organisation was not monitoring the change process to ensure that it was effectively achieving all the necessary tasks to ensure consistent and safe operations when the aircraft type was introduced to service.

Report number: B98/166

G airspace demonstration implementation.

In October 1998, a trial of a new airspace structure was developed in one area of Australia. A Bureau of Air Safety Investigation (BASI) report found that the purpose of the airspace change was not clearly defined, so there was no common understanding against which the effectiveness of the change could be measured. There were inadequate established processes for managing such a complex change, and the change agent did not have appropriate resources to monitor and control its activities during the change process. The review mechanisms that were incorporated into the change process were not appropriate to the review needs during the design and implementation of the airspace changes, and the review mechanisms were not independent from the process they were reviewing.

Report number: Not available

Aviation Gasoline contamination

Just before Christmas 1999, the supply of aviation gasoline (Avgas) from a major refinery was inadvertently contaminated with a chemical that made aircraft engines unreliable. The change to the use of this chemical in the refining process was initiated some eight years earlier to increase the efficiency of the process. The undesired outcomes from an inadvertent contamination with this chemical were not investigated, nor were the circumstances when a contamination would be likely. The change process examined the desired outcomes thoroughly, but missed the risks associated with some of the undesired outcomes.

Report number: BO/199904538

Boeing 747 over ran the end of a runway, Bangkok, Thailand.

On 23 September 1999, a Boeing 747 overran the end of the runway at Bangkok International Airport at some speed. A number of factors combined to increase the probability of the overrun event. One factor was a change to the normal landing configuration for this aircraft type that had been implemented in 1996. The change increased the efficiency of the operation in a number of ways, and reduced the cost of the operation. A proper risk assessment of the new procedure was not undertaken. There were also significant deficiencies in the manner in which the company implemented and evaluated the new procedures associated with this change in landing configuration.

Report number: BS/20010005

Ansett's maintenance of continuing airworthiness in Class A aircraft

In December 2000 and April 2001, Ansett Australia elected to ground its fleet of Boeing 767 aircraft, because it was not confident that it knew that all necessary maintenance had been done. It had lost control of the information systems necessary to ensure that all necessary maintenance was being done at the right time. The organisation had become very complex with many different aircraft types, and frequent partial changes of ownership changing the commercial focus of the airline. The information management support that was necessary to control the information needed to design the maintenance systems was not changed to reflect the needs associated with the increasing complexity. In this case the supporting infrastructure was not given the same budgetary priorities as the visible front of the organisational changes. The organisation finally became aware that it did not know what it did not know, and therefore lost confidence in its own systems

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