Uncovering the Origins of Latent Failures: The Evaluation of an Organisation's Training Systems Design in Relation to Operational Performance.

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Models of organisational risk management often describe various layers of defences and interpret incident or accident causation as the successive penetration of these defences by either active failures or latent conditions. For any organisation within high-risk industries such as aviation and medicine, training is as an essential component in an organisation's efforts to maintain high levels of operational performance and safety. However, it is possible to construe deficiencies in training as resident pathogens within an organisation's defences. This paper presents a detailed example of the use of a new methodology developed to assist an organisation in the process of uncovering latent failures through the evaluation of training systems design in response to operational performance. The paper describes the types of latent failures which were uncovered through the use of this integrated approach to organisational safety within the airline concerned and highlights the benefits available to an organisation which adopts such a pro-active approach to safety.

Latent Conditions and the Organisational Approach to Safety

Recent research examining organisational safety has emphasised the need to examine the performance of organisational systems and systemic failures rather than merely the errors committed by individuals. This approach to safety involves a focus on larger operational units and organisational systems as the primary drivers of effective operational performance and recognises the role of latent organisational conditions as important contributing factors to incidents and accidents. (Reason, 1990, 1997). This expanded focus of risk management, quality assurance, and performance evaluation has been termed the *organisational approach* to aviation safety (Maurino, 1995) or the *system approach* to human error (Reason, 2000).

Reason (1990) describes a model of organisational risk management which involves various layers of defences. According to this model, incident or accident causation is characterised by the successive penetration of these defences by either *active failures* or *latent conditions*. *Active failures* are defined as "unsafe acts" committed by people in the form of slips, lapses, mistakes and violations. These have typically been the traditional focus of investigations of human error. In contrast, *latent conditions,* or *latent failures,* are described as "resident pathogens" which arise from factors such as organisational culture, management decisions, the design of procedures, or deficiencies in training. These resident pathogens are described as having two forms of adverse effect: 1) they can translate into error provoking conditions; and 2) they can create weaknesses in the organisation's defences which may lie dormant within the system, until when combined with active failures, they contribute to the occurrence of an incident or accident (Reason, 2000). Accordingly, the organisational approach to safety is seen to focus on not only the minimisation of active failures, but also on the elimination of latent conditions which act as resident pathogens acting against the overall safety system. Within this framework, one of the most difficult tasks for an organisation is the process of *uncovering* these latent conditions.

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Training as an Incubator for Resident Pathogens

Training within high-risk industries such as aviation and medicine is seen as an essential component in an organisation's efforts to maintain high levels of operational performance and safety. However, deficiencies in training can lie dormant within an organisation and act as latent failures which form important elements of the chain of accident causation. Indeed, as MacLeod (2001) suggests, incident and accident reports frequently highlight the fact that not all training in the aviation industry is of a high standard, nor do all those in need of training participate in training activities that are adequate for knowledge and skill development. It is therefore possible to construe deficiencies in training as resident pathogens within an organisation's defences.

As Bent and Fry (1997) suggest, poor aspects of training such as lack of relevance to the operational environment, de-compartmentalisation of technical knowledge and skill development, inappropriate information and lack of standardisation are all possible elements of accident causation. Similarly, a number of recent accident reports have highlighted that deficiencies in training, such as a lack of emphasis on particular types of operations, as significant latent factors in accident causation. Accordingly, there is a demonstrable need to investigate new mechanisms to uncover latent failures in training and build more responsive training systems design.

The Development of Responsive Training Systems

A process involving the systematic evaluation of training has been suggested as the only way to ensure that training programmes are an effective and worthwhile investment for an organisation. However, the collection of constructive evaluation data, which demonstrates that training is having a significant effect on operational performance is often not undertaken by an organisation (Salas, Burke, Bowers, & Wilson, 2001). Organisational processes such as confidential reporting systems are a common tool used to evaluate operational performance. However, such reactive tools are unable to uncover resident pathogens until such a time as they have resulted in the failure of the system through an incident or safety-related event. Furthermore, these tools do little to uncover the primary origins of deficiencies in the safety system, and often do not collect data which specifically evaluates the effectiveness of training systems (Thomas, 2003).

The task therefore is to develop organisational systems and an organisational culture which proactively seeks to uncover the origins of latent failures. Westrum (1993) describes the notion of a *generative organisation* as one which possesses an advanced safety culture characterised by high levels of employee empowerment and an established culture of organisational learning. To this end, generative organisations engage in constant processes of reflective analysis and seek mechanisms by which improvements can be iteratively employed and evaluated.

With reference to the notion of a generative organisation, it is possible to develop the concept of *responsive training systems* which utilise the multiple data-sources available within a generative organisation in order to enhance the quality and relevance of training. Accordingly, *responsive training systems* can be defined as training systems which constantly adapt to the changing and unique requirements of an organisation. They are systems in which the training curriculum is relevant to, and sufficiently meets, the specific operational needs of an organisation, in a manner which reflects the unique operational context and organisational culture in which they are embedded.

In order to achieve responsive training systems, an organisation must develop effective feedback loops between the current status of its normal operations, and the design of its training systems. To be effective, these feedback mechanisms must be designed to achieve two important goals:

1. they must identify weaknesses in normal operations which require the development of training interventions; and
2. they must identify the weaknesses in training which give rise to resident pathogens within normal operations.

A number of recent advances in the evaluation of an organisation's normal operational performance have enabled at least the first of these goals. In particular, the Line Operations

Safety Audit (LOSA) methodology enables the systematic evaluation of operational performance, highlighting both the systematic strengths and resident weaknesses of normal operations (Helmreich, 2000; Klinect, 2002). Using the conceptual framework of *Threat and Error Management* as the primary frame of reference, LOSA provides an organisation with a diagnostic and proactive evaluation of the "health" of normal operations.

While the LOSA process enables the systematic evaluation of operational performance, there remains a significant need to build an additional mechanism that is able to identify the weaknesses in training which give rise to resident pathogens. This paper presents a detailed example of the use of a new tool for the systematic evaluation of training as an addition to the traditional LOSA methodology. This combination of tools has been developed to assist an organisation in the process of uncovering latent failures through the evaluation of training systems design in response to operational performance. The paper describes the types of latent failures which were uncovered through the use of this integrated approach to organisational safety within the airline concerned and highlights the benefits available to an organisation that adopts such a proactive approach to safety.

Method

Participants

The study was undertaken in a single-aisle twin-engine jet fleet of an airline flying largely short-haul operations. Participants were volunteer flight crew who were recruited at random from the total pool of the fleet's pilots. While the study collected data through the observational evaluation of individual crew performance, the broad focus of data analysis was explicitly organisational performance rather than the individual crews observed. Accordingly, crews participated in the study in full understanding of the non-jeopardy nature of the study and with assurance that their anonymity would be maintained without exception.

Design and Procedure

The study focussed on the evaluation of training systems through the comparison of data collected during training with baseline data from normal line operations. Baseline data were collected from a total of 102 sectors of normal line operations in order to establish the relative strengths and weaknesses of normal operations and identify areas in which latent organisational failures may be evident. In addition, 25 sectors of line training flights were observed in order to gather data as to the possible origins of latent failures observed within the flight operations system. Of these training sectors, all were revenue flights, with 17 involving Initial Line Training and eight involving Command Upgrade Training.

Data were collected by a team of five observers who collected data from the jump-seat during normal operations and line training. The observers were nominated by the project team with approval from the pilot's union representative group from the airline. The observer team included a representative from Flight Operations within the organisation who was also type-rated on the aircraft type, a current First Officer from the fleet being observed, a Captain from a similar aircraft type from another airline, and a retired Check and Training Captain from another organisation. The observers were chosen in order to provide a range of perspectives, both in relation to experience and to achieve balance between internal and external perspectives.

Observers received detailed training in the use of the observational methodologies employed in this study. Training involved a two day workshop which focussed on ensuring inter-rater reliability. To further enhance reliability, a series of data cleaning round-tables were used in order to clarify questions and eliminate inconsistencies. Once data cleaning processes had been completed, the data were subjected to a range of descriptive and comparative statistical analyses.

Observational Methodologies

The analysis of normal line operations utilised the Line Operations Safety Audit (LOSA) methodology as designed and developed by the Human Factors Research Project at the University of Texas (Klinect, Wilhelm, & Helmreich, 1999). Three major areas of focus form the foundation of the LOSA methodology: 1) the analysis of crew's non-technical skills; 2) the occurrence of external threats to safety and their management by crews; and 3) the occurrence of error committed by the crews and their management of these errors. The procedures for the observational analysis of normal line operations adhered to the ten operating characteristics of LOSA which specify the broad parameters under which a LOSA should take place (Klinect, 2002).

The analysis of line training utilised a new methodology designed to develop tangible feedback-loops between operational performance evaluation and training systems design (Thomas, 2003). The Operational Analysis of Training Systems (OATS) methodology was conceived as an optional "plug-in" to the LOSA methodology which could be used by an organisation to simultaneously evaluate their training systems while undertaking a LOSA. The OATS methodology includes the analysis of non-technical skills alongside threat and error management in the training environment. Further elements of the methodology include the broad analysis of training systems design, and instructional performance.

The types of data collected through the observational methodologies were designed to facilitate a structured analysis of both operational and training performance. While the LOSA methodology is primarily concerned with the evaluation of normal flight operations, the OATS analysis is structured around two major focal points as described in the table below.

Table One: Data Analysis Framework of the Operational Analysis of Training Systems (OATS)

1) Analysis of Training Systems Design	2) Threat and Error Management During Training
- Training Syllabus and Curriculum Structure	- Threat Representation
- Instructor and Trainee Performance	- Threat Management During Training
	- Error Occurrence and Typology
	- Error Management During Training

Results

The comparative analysis of operational performance and training provided the organisation with clear empirical data as to the origins of a number of systemic strengths and weaknesses which could be described as latent conditions which had the potential to threaten the overall safety of the operation. While the data from the LOSA methodology provided the organisation a clear understanding of the systemic strengths and possible weaknesses in normal operations, the addition of the OATS methodology for the analysis of training provided insights into the origins of a number of these strengths and weaknesses.

Analysis of Training Systems Design

The first task in the OATS methodology involves the overall evaluation of the training syllabus and curriculum structure employed within the training program. For instance, the focus for this study involved the analysis of initial line training and command upgrade training programs. Accordingly, through the interrogation of syllabus documentation and soliciting feedback from flight crew, the efficacy and efficiency of the training program is evaluated.

The second task in the OATS methodology involves the analysis of instructor and trainee performance against a set of behavioural markers identifying ten key instructor and ten key crew performances found to be essential for facilitating learning (Thomas, 2001). One of the critical factors in minimising the transfer of latent failures from the training environment into normal operations is the standardisation of instructor performance and ensuring that the organisation's Standard Operating Procedures are trained consistently.

The Training Syllabus and Curriculum Structure. For the organisation involved in this study, the overall training systems design was found to be strong, and served well the operational requirements of the organisation. However, through the detailed analysis of training, two areas of possible latent systemic failure were highlighted for further investigation.

First, a common suggestion from crews was that pilots needed more experience than they were currently obtaining before being selected as candidates for upgrade. For many pilots, the transition to aircraft command was seen to occur too quickly, resulting in a possible deficit of experience on the flight deck. Although this was identified through the analysis only as a perceived weakness, it was an area that warranted further investigation.

Secondly, the concision and compressed structure of line training was highlighted as a possible area of weakness in the overall training systems design. By far the most frequent comment pilots made in relation to training was that the current length of initial line training was inadequate. As a direct result of the structure of training, fatigue was seen to play a large part in reducing the performance of trainees, especially during initial line training. On a number of occasions the observers made note that trainees were visibly suffering from the effects of fatigue, which then mitigated against the instructional value of the training flight. Pilots themselves also commented that the structure of initial line training was such that often the First Officers found it difficult to keep up, especially when the first few days of training involved a number of short sectors with short turn-around times. In these circumstances it could be argued that the only real training benefit is the indoctrination of pilots into the organisational imperatives of on-time performance and the high workload demands of the operation in general. While such a "Baptism of Fire" certainly is beneficial in this regard, any detailed instruction from the Training Captains was very difficult to achieve, and could only occur during a post-duty debrief when it would be even more likely that the trainee was exhausted.

Instructor and Trainee Performance. For the organisation involved in this study, there was a high level of variability in instructor performance observed during training flights, with examples of both highly effective and unproductive instructional process demonstrated by Training Captains. Observers rated instructor performance against a range of key markers of effective performance in the training environment. Ratings were made of a four point scale including: 1) poor; 2) marginal; 3) standard and 4); outstanding.

Table Two: Observer ratings of instructor and trainee performance

Instructor Performance Behavioural Marker	Mean	S.D.	Trainee Performance Behavioural Marker	Mean	S.D.
Communication			**Communication**		
Briefing	3.00	.392	Inquiry	2.84	.375
Performance Feedback	3.05	.510	Receiving Feedback	3.10	.436
Clear Explanation	3.00	.535	Participation in Debriefing	3.13	.516
Debriefing	3.15	.555	**Situation Awareness**		
Situation Awareness			Vigilance	2.64	.658
Vigilance	2.91	.684	Monitor and Cross Check	2.50	.598
Monitor and Cross Check	2.82	.733	**Task Management**		
Task Management			Workload Management	2.57	.590
Adaptability	2.95	.590	Management of Fatigue and Stress	2.56	.629
Management of Fatigue and Stress	2.71	.611	**Instructional Processes**		
Instructional Processes			Preparation	2.83	.389
Receptive to Trainee' Characteristics	3.14	.710	Attention	2.95	.224
Promotion of Learning	3.04	.638	Self-evaluation and Critique	2.80	.422
Overall Performance Rating	2.80	.577	Overall Performance Rating	2.76	.523

Scales range from a minimum rating of 1 (poor) to a maximum rating of 4 (outstanding).

This element of the OATS methodology enabled the organisation to investigate a range of the performance drivers which underpinned the quality and outcomes of their training systems. From the above table it is evident that the strengths of the organisation's Training Captains were in relation to the processes of debriefing, being receptive to the trainee's characteristics and performance feedback. Areas of relative weakness included management of fatigue and stress during training, monitoring and cross checking and vigilance. The strengths of trainee performance were their participation in the debriefing, remaining receptive to feedback and their high levels of attention to the training task. Relative weaknesses were identified as monitoring and cross checking, management of fatigue and stress, and workload management within the training environment.

Analysis of Threat and Error Management in the Training Environment
The second major focus of the OATS methodology involves the analysis of threat and error management in the training environment. This process aims to uncover latent failures in relation to the specific design of the training activities and the use of normal operational events in the training environment.

Threat Representation. An important objective of any type of training is that it adequately prepares personnel for a wide variety of conditions in the normal operating environment. To this end, it is important that trainees are exposed to a range of threats that are representative of an airline's normal operations. During line training a total of 39 threats were observed, giving an average of 1.56 threats per flight. This average is slightly less than, though not statistically different from, the average of 2.06 threats observed during normal line operations. The table below illustrates the frequency with which threats were encountered in the line training environment when compared to the environment of normal line operations.

Table Three: Threat Representation in the Training Environment compared to Line Operations

Threat Type	**Training Frequency**	Managed	Not Managed	**Line Operations Frequency**	Managed	Not Managed
ATC Events or Errors	38.5	80.0	20.0	26.7	82.1	17.9
Adverse Weather	25.6	70.0	30.0	25.7	85.2	14.8
Ground / Dispatch Events	2.6	100.0	00.0	13.9	100.0	00.0
Airport Conditions	10.3	75.0	25.0	11.4	87.5	12.5
Aircraft System Malfunctions	10.3	100.0	00.0	7.6	87.5	12.5
Operational Pressure	2.6	100.0	00.0	7.3	73.3	26.7
Traffic	7.7	100.0	00.0	5.7	75.0	25.0
Other	2.6	100.0	00.0	1.9	75.0	25.0

Frequency expressed as a percentage of threats observed (Line Operations n = 210, Training n=39).

In general, the design of training activities was seen as a significant strength of this organisation's training systems design, as threat representation in the line training environment was not significantly different from that in normal line operations. One of the benefits of both initial line training and command upgrade training being shaped around normal everyday operations is that crews are exposed to a wide variety of conditions in a manner which is nearly identical to that experienced in everyday line operations. While there were proportionately less Ground / Dispatch events and threats during training flights the other major threat types were well represented.

Threat Management During Training. The ways in which external safety threats are managed during training has significant ramifications for subsequent threat management during normal operations. In general, threat management during training was found to be a significant strength of this organisation's training, and can be seen to predict high levels of threat management during normal line operations.

The first aspect of effective threat management involves the detection of threats. Before any action can be taken by crews in relation to a threat, the crew must obviously be aware of the existence of that threat. In total, 97.4% of all threats were detected by crews during training operations. This highlights an overall higher level of threat detection when compared to normal line operations and again highlights a strength of the organisation's training. It is interesting to note that First Officers detected more threats during training flights, and Training Captains proportionately less. This does not reflect a lower level of operational performance on behalf of the Training Captains. Rather, it reflects an effective use of threat events by Training Captains from an instructional perspective. Through the increased focus on the First Officer's performance whilst under training, Training Captains did not step in until such a time as the First Officer had become aware of the presence of a threat.

Table Four: Frequency of threat management actions, expressed as the percentage of all threats.

		Training (n = 39 Mean = 1.56)	Line Operations (n = 210 Mean = 2.06)
Threat Detection			
	Captain	38.5	45.2
	First Officer	15.4	14.8
	Both Crew	43.6	31.9
	Other	0.0	4.3
	Nobody	2.6	3.8
Threat Response			
	Detect + Manage	82.1	85.2
	Detect + Mismanage	15.4	10.0
	Detect + Ignore	0.0	1.0
	Fail to Detect	2.6	3.8
Threat Outcome			
	Inconsequential	82.1	88.1
	Undesired Aircraft State	0.0	0.0
	Additional Error	17.9	11.9

The second aspect of effective threat management relates to the response to the threat. Obviously, if the threat is not detected by the flight crew nor brought to the attention of the flight-crew by another party, then the crew do not have the opportunity to respond to the threat. However, even if the crew is aware of the presence of a threat that has the possibility to impact negatively on the safety of the flight, they are able to respond in a number of ways. Ideally, crews will Detect and Manage the threat, which means that they take undertake observable action to prevent the threat becoming operationally significant. However, they might Detect and Mismanage the threat, which means that the actions they take result in an error and the threat is therefore not effectively managed. It is also possible that crews become aware of a threat, but chose to take no action. This response is termed Detect and Ignore and is also classified as ineffective threat management.

This study found that crews' response to threats was not as effective in line training as it was during normal line operations. When compared to normal operations, the threats encountered in line training led to more consequential outcomes. However, this finding is to be expected given the nature of the training environment and the inexperience of the trainee's. In general, there was a higher occurrence of error resulting from poor threat management in the training environment.

Error Occurrence and Typology. Within the line training sectors observed during this study, a total of 93 errors were observed. This represents an average of 3.72 errors per training flight. This figure is significantly higher than the error rate per flight observed during normal line operations, which is an expected finding due to the nature of the training environment ($t(33) = -2.206$, $p < 0.05$).

Table Five: Error Type and Origin in the Training Environment compared to Line Operations

Error Type	**Training Frequency**	CA	FO	**Line Operations Frequency**	CA	FO
Violations	6.5	7.7	4.0	8.1	6.9	8.1
Procedural	75.3	73.1	72.2	68.7	69.3	66.1
Communication	5.4	19.2	0.0	7.7	7.9	8.0
Proficiency	11.8	0.0	22.0	11.0	7.9	15.2
Decision-Making	1.1	0.0	2.0	4.5	7.9	2.7

Frequency as a percentage of errors observed (Line Operations n=246 Mean=2.41, Training n=93 Mean=3.72).

During training there were fewer violations and more proficiency and procedural errors observed. This finding is intuitive, and clearly reflects the nature of the training environment. However, the overall distribution of errors according to error category was not operationally different to that observed during normal line operations. It was found that First Officers were responsible for more errors during line training, committing 53.8% of the errors compared to 28.0% being committed by Captains. Further, of the 93 errors observed during training, 22.0% of the errors committed by First-Officers were proficiency errors. These findings are in line with what would be expected during training.

However, while increased levels of proficiency and procedural errors are an intuitive finding, the number of violations committed during training was identified as an area for concern. Violations in relation to checklist use were observed during training, and in all instances were not effectively managed by the Training Captains. Within the scope of this organisation's operations, it was evident that this particular failure in error detection and management represented a significant resident pathogen which originated from within the training systems of the organisation.

Error Management. The distribution of errors by error type and error origin clearly reflect the nature of the line training environment. However, the distribution of error detection during line training indicates that still only a relatively small proportion of errors were effectively detected and managed by crews. While Training Captains detected more errors during training than Line Captains had during normal line operations, Training Captains still only detected 34.4% of all errors that occurred. Overall, during training 43.0% of all errors remained undetected. This finding suggests a weakness in this organisation's training operations and a possible link between poor error detection during training and a continuation of poor error detection on the line.

At a higher level of resolution, it is possible to examine differing rates of error detection according to the categories of error that were observed during line training. The most frequently detected errors were those relating to *proficiency*, with 63.6% of these errors detected by the crew. The second most frequently detected errors were those relating to unintentional deviations from procedures, with 44.3% of these errors being detected by the crew, and 17.1% of these being brought to the attention of the crew by the observer. Only 16.7% of *violations*, were detected by the crew and the crew detected none of their communication or decision-making errors during training.

The relatively high proportion of errors that were detected by the observer and brought to the attention of the crew during line training is an area of concern. However, it does highlight the value of having a third flight crew member in the jumpseat during line training. A number of pilots commented on the value of having a safety First-Officer in the jumpseat during the initial sectors of line training and suggested that this safety mechanism should be in place for a larger number of sectors. The findings presented here reinforce these suggestions and provide evidence to support the position that a safety-pilot should be included on the flight-deck for a longer period of line training.

As a higher proportion of errors were detected during training, the overall proportion of errors that were effectively detected and managed was higher in line training than during normal operations. In parallel with the findings from line operations, errors that were committed by the First-Officer were more likely to be detected and managed than those committed by the Captain.

Table Six: Frequency of error management behaviours, expressed as the percentage of all errors.

		Training (n = 93 Mean=3.72)	**Line Operations** (n = 246 Mean=2.41)
Error Detection			
	Captain	34.4	26.0
	First Officer	6.5	10.2
	Both Crew	1.1	0.4
	Other	15.1	6.1
	Nobody	43.0	57.3
Error Response			
	Detect + Manage	53.8	38.2
	Detect + Mismanage	1.1	2.4
	Detect + Ignore	2.2	2.0
	Fail to Detect	43.0	57.3
Error Outcome			
	Inconsequential	95.7	94.7
	Undesired Aircraft State	3.2	2.0
	Additional Error	1.1	3.3

Crews' response to errors which occurred during line training was also found to vary markedly in relation to the type of error. None of the violations or decision-making errors were effectively managed by the crews during line training. This finding firstly demonstrates that adherence to SOPs during line training was on occasion quite poor. Pilots made comments about the need for standardisation amongst Check and Training Captains, and the observed training flights provide some evidence to reinforce these suggestions. Of particular concern were that 50.0% of the violations involved improper checklist procedures which were not commented upon by Training Captains.

The most common error type during training, which involved unintentional deviations from procedures, was also the most effectively managed during line training. Of these procedural errors, 61.4% were effectively managed and none were mismanaged. The category of proficiency errors was the next most frequently managed error type, with 45.5% of these errors effectively managed during training. However, 9.1% of these errors were actively mismanaged by crews and 9.1% of these errors were ignored.

Discussion

The design of responsive training systems is an essential characteristic of an organisation with an advanced safety culture. However, in order to effectively build responsive training systems, first it is essential to build effective feedback mechanisms between an organisation's real operational needs and their training systems design. To be effective, these feedback mechanisms must employ data collection and analysis techniques which: 1) identify weaknesses in normal operations which require the development of training interventions; and 2) identify the weaknesses in training which give rise to resident pathogens within normal operations.

This study has provided a detailed example of the combined use of two new methodologies designed to provide a mechanism through which an organisation can uncover the origins of possible resident pathogens within their training systems. By using the Line Operations Safety Audit (LOSA) methodology to examine normal operations, and the Operational Analysis of Training Systems (OATS) methodology for the analysis of training, the organisation involved in this study was able to develop effective feedback mechanisms as described above.

Uncovering Latent Conditions and Resident Pathogens

For the organisation involved in this study, a number of relationships between performance within the training environment, and subsequent performance during the normal line operations of an airline were demonstrated. Through the systematic analysis of the training operations within an organisation, the strengths of the organisation's training system design were identified. These included:

- The similarities between threat representation during training and threat occurrence during normal operations; and
- The high levels of threat detection during training.

Moreover, through the systematic analysis of the training operations within an organisation, a series of possible resident pathogens were also uncovered. For the organisation involved in this study, these possible resident pathogens included:

- The experience requirements prior to commencement of Command Upgrade Training;
- The compressed structure and concise nature of Initial Line Training;
- Standardisation of Training Captain practices;
- The frequency of violations during training; and
- The low levels of error detection during training.

The occurrence of poor training practices within an organisation were shown to represent the origins of certain latent conditions present within the organisation. In turn, these latent conditions have the potential to impact negatively on the safety of normal operations. Accordingly, this study has clearly demonstrated that deficiencies in training practices do form an incubator for resident pathogens within an organisation. Once these possible resident pathogens have been uncovered, the organisation is then able to investigate each of these areas in more detail, and determine the level of operational risk associated with each possible pathogen identified through the OATS methodology.

OATS as an addition to the traditional LOSA methodology

This study has demonstrated how using the OATS methodology, as an addition to the LOSA methodology, facilitated the systematic evaluation of an organisation's training systems design in relation to performance in normal operations. This process is critical in developing responsive training systems that enable an organisation to proactively uncover resident pathogens and engage in generative processes for organisational development and risk management.

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