Safety Regulation Group

CAA PAPER 2004/12

Final Report on the Follow-on Activities to the HOMP Trial

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Foreword

The research reported in this paper was commissioned and funded by the Safety Regulation Group of the UK Civil Aviation Authority (CAA) at Smiths Aerospace Electronic Systems - Southampton, and the trials were performed by Bristow Helicopters Ltd (BHL) and CHC Scotia Helicopters Ltd (Scotia). This work formed a follow-on exercise to the main HOMP trial reported in CAA Paper 2002/02, and investigated the transfer of HOMP from the BHL Super Puma to a second operator (Scotia Super Puma) and to a second helicopter type (BHL Sikorsky S76).

CAA considers that both trials have demonstrated the successful transfer of the safety benefits of HOMP, and have usefully identified significant differences between operators and between helicopter types. The results have also served to broaden the general HOMP knowledge base which, it is hoped, will assist and encourage the wider implementation of HOMP. In March 2004, the ICAO Helicopter Tiltrotor Study Group (HTSG) unanimously agreed to propose to add HOMP to ICAO Annex 6 Part III as a Recommended Practice for flight data recorder-equipped helicopters.

CAA is continuing to progress technical developments to further increase the benefits of HOMP:

- A programme of work is underway to implement in HOMP the control movement-based pilot workload algorithms developed during a separate project aimed at establishing a turbulence criterion for offshore helidecks (see CAA Paper 2004/03). If successful, this will enable HOMP to be used for mapping the turbulence environment around helidecks to provide something similar to the military Ship/Helicopter Operating Limits (SHOL) diagram, and monitor for changes in the environment (e.g. due to modifications to the platform topsides).
- Work on providing a measure of low airspeed for use within the HOMP analysis is to be progressed. Crucial to this work is the generation of a suitable data set to enable the neural network algorithm to be 'trained', and the practical difficulties of performing the necessary flight trials need to be addressed.

Safety Regulation Group

26 April 2004

Glossary

AGL	Above Ground Level
AVAD	Automatic Voice Alerting Device
BA	British Airways
BALPA	British Airline Pilots Association
BASIS	British Airways Safety Information System
BHL	Bristow Helicopters Limited
CAA	UK Civil Aviation Authority
CQAR	Card Quick Access Recorder
CRM	Cockpit Resource Management
CSV	Comma Separated Variable
DAPU	Data Acquisition and Processing Unit
ES-S	Smiths Aerospace Electronic Systems - Southampton
FBS	Flight Business System
FDE	Flight Data Events module
FDH	Flight Data at Home
FDM	Flight Data Monitoring
FDM (BA)	Flight Data Measurements module
FDR	Flight Data Recorder
FDS	Flight Data Simulation
FDT	Flight Data Trace module
FDV	Flight Data Viewer
FSO	Flight Safety Officer
GPS	Global Positioning System
HLL	Helideck Limitations List
HOMP	Helicopter Operations Monitoring Programme
HUMS	Health and Usage Monitoring System
IAS	Indicated Airspeed
IHUMS	Integrated HUMS (i.e. HUMS+FDR)
INTOPS	INTegrated OPerations System
LAN	Local Area Network
MDR	Maintenance Data Recorder
MOR	Mandatory Occurrence Report
NR	Main Rotor Speed
ODBC	Open Database Connectivity
OLE DB	Microsoft component data access specification
PC	Personal Computer
PCMCIA	Personal Computer Memory Card Interface Architecture
SMS	Safety Management System
SQL	Structured Query Language
UKOOA	UK Offshore Operators Association
VNE	Maximum Speed (Never to be Exceeded)
VNO	Maximum Speed Normal Operation
WAN	Wide Area Network

Executive Summary

This report presents the results of the CAA-funded follow-on activities to the Helicopter Operations Monitoring Programme (HOMP) trial that completed in late 2001. The CAA published the final report on this work (CAA Paper 2002/02) in September 2002. As a result of the success of the trial, UKOOA committed its members to fund the implementation of HOMP on all FDR-equipped UK public transport helicopters operating over the UK Continental Shelf. With UKOOA's help, Bristow Helicopters Limited (BHL) has now fully implemented HOMP on the whole of its North Sea helicopter fleet, located at four different operating bases.

To help to facilitate this wider implementation of HOMP, the CAA funded a follow-on programme of work with the two primary objectives of:

a) transferring the HOMP to a second UK operator, CHC Scotia Limited (Scotia); and

b) developing the HOMP for a second helicopter type, BHL's S76.

A secondary objective was to continue to develop and refine HOMP data analysis capabilities using the new experience gained. This report presents the results of the CAA-funded work and also contains additional experience from BHL's on-going AS332L programme, as this provides useful complementary information.

The follow-on programme resulted in a successful trial of HOMP within Scotia on two AS332Ls and also a successful HOMP implementation on BHL's S76s. The results obtained provide further evidence of the safety benefits of HOMP. Both BHL and Scotia identified significant safety issues as a result of their programmes and were able to take corrective measures to address them. A range of feedback mechanisms were successfully used to address identified risks and both operators obtained widespread aircrew acceptance of HOMP, and a positive aircrew response to HOMP findings. In both cases, the operators have been able to demonstrate a reduction in operational risk as a result of the actions taken.

BHL and Scotia identified several common operational risks on their AS332L helicopters but, as a reflection of the differences in their operations, the operators sometimes took a different view on the levels of risk associated with different HOMP events. The BHL S76 programme identified some different operational issues on the S76 to those found on the AS332L, and the HOMP events generated on the S76 were generally less significant than those triggered on the AS332L. The S76 experience illustrated the importance of key parameters such as GPS data for HOMP and, although the data was initially missing, BHL were readily able to add this to the FDR data frame.

The HOMP events continued to be developed, with two new types of event being implemented as a result of pilot-reported occurrences. In addition, the event severity allocation guidelines developed by BHL in the main HOMP trial were evaluated by both BHL and Scotia in the follow-on work. The results showed that the guidelines provide a good basis for severity allocation, but there is a need for guidance material to achieve greater standardisation of the process. The flight data measurements continued to be refined and were used to demonstrate a capability to 'map the helideck environment', to characterise problems of both structure-induced turbulence and hot turbine exhaust plumes on offshore platforms.

Section 1 Introduction

1 General

The Helicopter Operations Monitoring Programme (HOMP) is a helicopter version of fixed wing Flight Data Monitoring (FDM) programmes. CAA publication CAP 739 (Reference [1]) defines FDM as "the systematic, pro-active and non-punitive use of digital flight data from routine operations to improve aviation safety". CAP 739 further states that:

> "Flight Data Monitoring (FDM) programmes assist an operator to identify, quantify, assess and address operational risks. Since the 1970's the CAA's Safety Regulation Group (SRG) has helped develop and support such systems and used FDM information to support a range of airworthiness and operational safety tasks. Through this co-operative development work many farsighted operators have demonstrated the safety benefits of FDM such that the International Civil Aviation Organisation (ICAO) have recommended their use for all Air Transport operations in aircraft of over 20 tonnes maximum weight. Further, they are making FDM a standard for all such operations of aircraft over 27 tonnes with effect 1st January 2005. The UK, in continuing its policy of applying ICAO standards, will make this a requirement under UK law and other European regulators are also expected to comply."

In 1999 the CAA instigated trials of an FDM programme for North Sea helicopters, known as the Helicopter Operations Monitoring Programme (HOMP), which represented the first application of FDM to helicopters. The HOMP trial was jointly funded by the CAA and Shell Aircraft Limited. Smiths Aerospace Electronic Systems – Southampton (ES-S) was prime contractor to the CAA for the trial. The HOMP was operated by Bristow Helicopters Limited (BHL) and involved five Super Puma helicopters based at Aberdeen and Scatsta (in the Shetland Islands). The helicopters were equipped with Meggitt Avionics Ltd PCMCIA Card Quick Access Recorders (CQARs) to extract and download the flight data. British Airways (BA) provided the helicopter flight data replay and analysis software, comprising three BA flight data modules. The HOMP trial consisted of an 8 month development phase followed by a 2 year operational phase, completing in late 2001. The results of the HOMP trial were published in CAA Paper 2002/02 (Reference [2]).

The HOMP trial achieved excellent results. Significant safety issues were identified and the operator was able to take action to address them. The results obtained clearly demonstrated that the HOMP can bring about improvements in flying practice, training, operating procedures and the operational environment. As a result of the success of the trial and the promulgation of the findings by the project team, the United Kingdom Offshore Operators Association (UKOOA) committed its members to providing funds to support the implementation of HOMP on all FDR-equipped UK public transport helicopters operating over the UK Continental Shelf.

To help to facilitate the wider implementation of HOMP, the CAA funded a follow-on programme of work with the two primary objectives of:

a) transferring the HOMP to a second UK operator, CHC Scotia Limited (Scotia); and

b) developing the HOMP for a second helicopter type, BHL's Sikorsky S76.

A secondary objective was to continue the development of the HOMP data analysis, both for the CAA-funded HOMP activities and also for BHL's on-going AS332L HOMP programme.

This report presents the results of the CAA-funded work, and also contains additional experience gained from BHL's AS332L programme as this provides further evidence of the HOMP benefits that are being achieved, and the lessons that are being learned. Section 2 of the report describes the CAA funded follow-on activities and BHL's wider HOMP implementation. Section 3 summarises the operational experience gained by Scotia and BHL during the programme. Sections 4 and 5 present the results obtained from the programme, focussing on the HOMP flight data events and measurements respectively. Section 6 describes a brief exercise comprising the application of data mining techniques to a database of events. Finally, Sections 7 and 8 present the conclusions and recommendations resulting from the work.

2 Background Information on HOMP

The HOMP system is shown in Figure 1. Aircraft flight data acquired by the HUMS/FDR data acquisition unit is stored on a PCMCIA card Quick Access Recorder (CQAR), and then transferred to a ground-based analysis system. The HOMP software consists of three integrated modules, which are briefly described below:

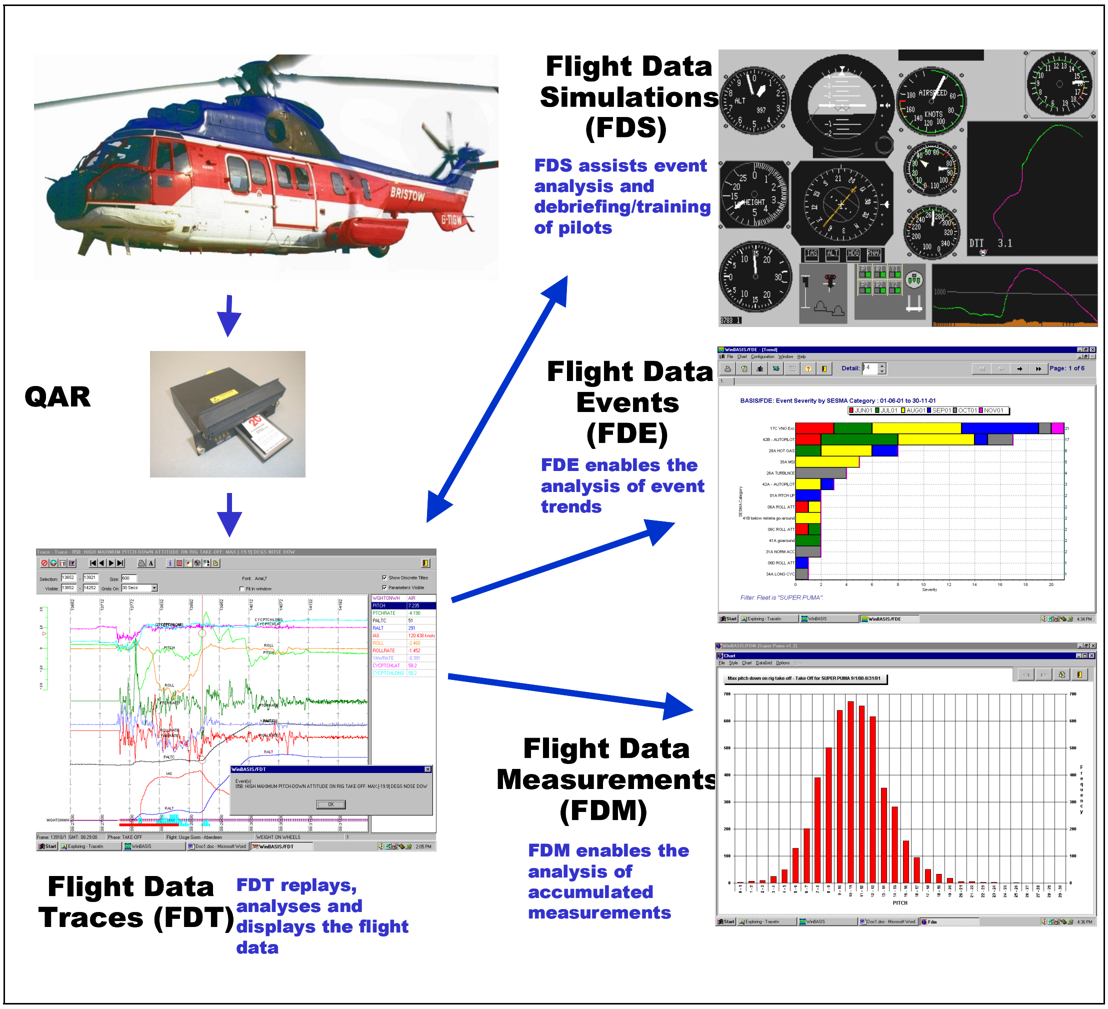


Figure 1 HOMP System

The **Flight Data Traces (FDT)** module reads in flight data from the CQAR, detects pre-defined events and extracts a set of flight data measurements. The events are stored together with their associated flight data and can be analysed by viewing event traces and flight data simulations (FDS) from within the module. Validated events and flight data measurements are exported to the other two modules. FDT has been designed to be user-configurable to allow events and measurements to be modified or added without the involvement of the software provider. This is important for filtering out any regular nuisance events.

The **Flight Data Events (FDE)** module stores the validated events generated by FDT which can be collectively analysed to determine trends in their frequency of occurrence or severity by location, operating base, pilot code, flight phase etc. Event severity values are allocated in FDT or FDE and, by performing a trend analysis of cumulative event severities, FDE provides an effective risk management tool. FDE has an optional link to the BASIS ASR module which allows any air safety report information associated with a flight data event to be viewed. This enhances the tracking and management of overall safety performance. Also, individual events stored within FDE can be further analysed using a facility known as FDV (Flight Data Visualisation). This enables event traces to be analysed and flight data simulations to be run from within the FDE module itself.

The **Flight Data Measurements (FDM)** module also stores information generated by FDT but is not event based. This information is the collection of many flight data measurements for every single flight; e.g. maximum roll angle, height at gear retraction, estimated wind speed and direction at landing. Once in FDM this data can be usefully analysed in many different ways (by location, time period, aircraft registration etc.) to make comparisons and help to better understand normal operation in relation to problems identified in FDE. The module is also useful for determining realistic and effective event limits for FDT.

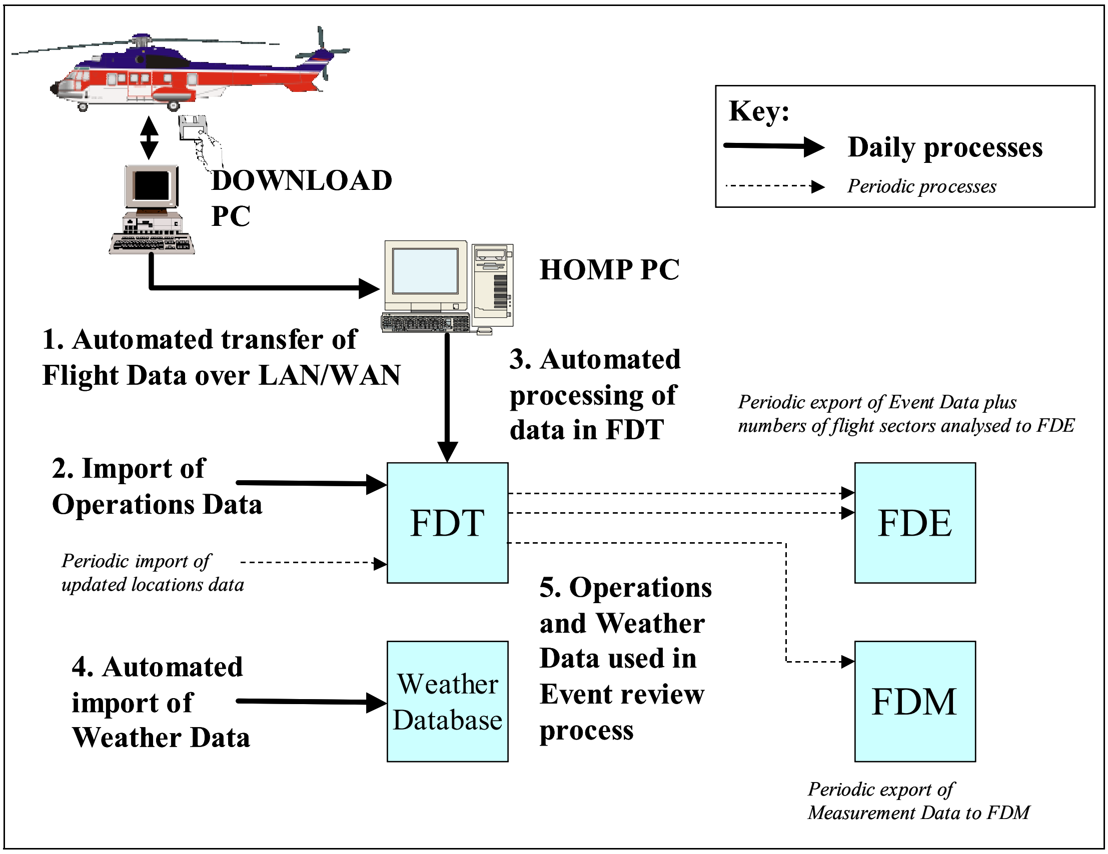


Figure 2 HOMP Information Flow

In addition to the downloaded flight data, other types of data are used in the HOMP analysis process. Figure 2 shows all the data flows for the HOMP system implemented within BHL.

Prior to processing the previous day's flight data, an operations data file is imported into FDT. This is automatically extracted from BHL's flight operations (INTOPS) database and contains useful information that is not available from the helicopter's FDR (for example take-off weight, type of flight, number of passengers, de-identified aircrew codes). Offshore and onshore weather information is also collected for use in the event assessment process. As mobile offshore platforms can be re-positioned, BHL also periodically import an automatically generated file of offshore platform locations into FDT, which is used by the program to identify take-off and landing locations from GPS data.

Events and associated cut sections of flight data are periodically exported from FDT to FDE. FDT also outputs a record of the number of flight sectors analysed to enable FDE to factor the number of events generated by the number of sectors flown for event trend analysis. Measurements are also similarly periodically exported from FDT to FDM.

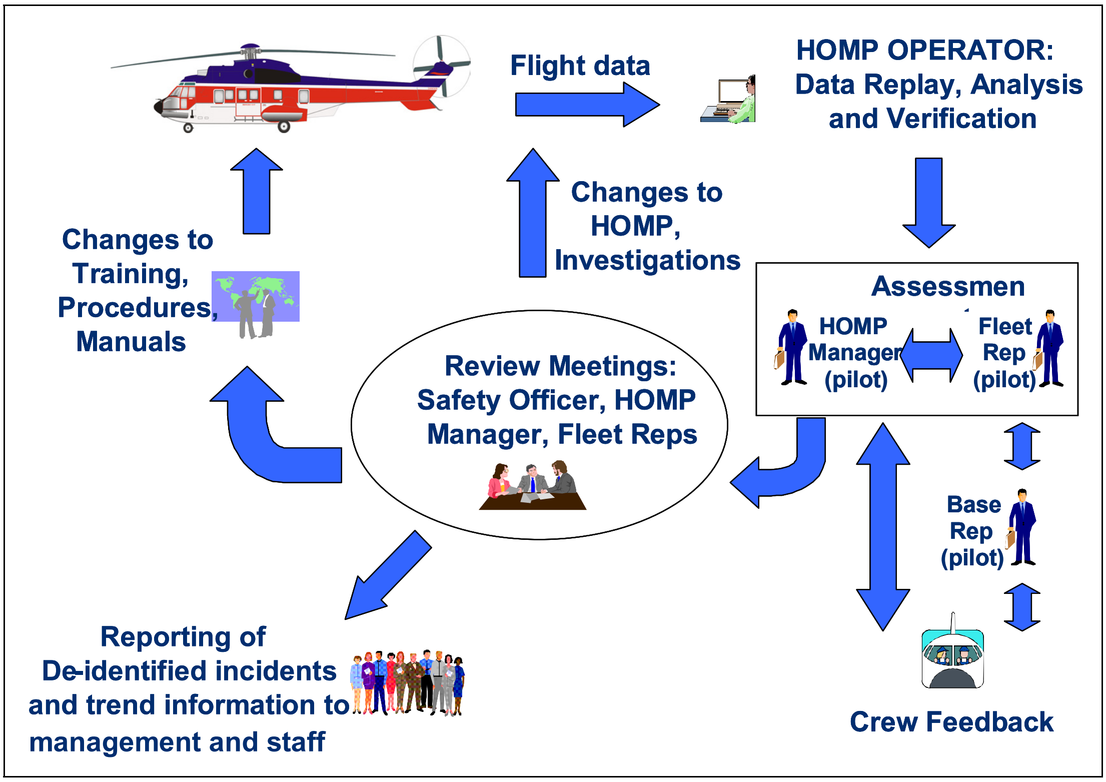


Figure 3 HOMP Operation and Management Processes

The processes implemented by BHL for operating and managing HOMP are similar to those shown in Figure 3. The downloaded flight data is processed and any events generated are verified. These events are then assessed by the HOMP Manager (who is a senior current pilot, and ideally a training captain) or a Fleet Representative (another senior pilot) if the event is on an aircraft type the HOMP Manager is not familiar with. If necessary, aircrew feedback is obtained via a confidential debrief, which may be performed by a local Base Representative if the crew are located at a remote base. Significant events and event trends are reviewed at periodic meetings involving the HOMP Manager, any Fleet Representatives, and the Flight Safety Officer (FSO) who provides the link to the operator's existing safety management system. Any further appropriate investigative or corrective actions are initiated at these meetings. Feedback on HOMP findings is provided through confidential aircrew debriefs, via the training department, or via de-identified bulletins to all staff.

3 Further Reading

Detailed background information on the HOMP can be obtained from the following two CAA documents:

3.1 CAA paper 2002/02, "Final Report on the Helicopter Operations Monitoring Programme (HOMP) Trial"

This paper (Reference [2]), published on 25 September 2002, presents detailed descriptions of the airborne and ground-based components of the HOMP system, and the flight data analysis performed by the system. It describes how the trial programme was implemented within BHL, the management processes and agreements that were put in place, and the follow-up and feedback procedures that were utilised. The paper presents a range of results to illustrate the capabilities and benefits of a HOMP, and summarises all the valuable lessons that were learned during the trial.

3.2 CAP 739 "Flight Data Monitoring: A Guide to Good Practice"

CAP 739 (Reference [1]), first issued on 29 August 2003, outlines good practice relating to first establishing and then obtaining worthwhile safety benefits from an operator's Flight Data Monitoring (FDM) programme. Most of the information in this publication is very relevant to HOMP.

The objectives of the document are to:

a) give guidance on the policy, preparation and introduction of FDM within an operator;

b) outline the CAA's view on how FDM may be embodied within an operator's Safety Management System; and

c) describe the principles that should underpin a FDM system acceptable to the CAA.

The document includes chapters on the following useful topics:

- Objectives of an operator's FDM system.
- Description of a typical FDM system.
- FDM within a Safety Management System.
- Planning and introduction of FDM.
- Organisation and control of FDM information.
- Interpretation and use of FDM information.

The flight data analysis performed for a FDM programme includes event detection and the taking of routine flight data measurements. These are described in CAP 739 as follows:

Event (or Exceedance) Detection

Event detection is the traditional approach to FDM that looks for deviations from flight manual limits, standard operating procedures and good airmanship. There are normally a set of core events that cover the main areas of interest that are fairly standard across operators.

Routine Data Measurements

Increasingly, data is retained from all flights and not just the significant ones producing events. The reason for this is to monitor the more subtle trends and tendencies before the trigger levels are reached. A selection of measures are retained that are sufficient to characterise each flight and allow comparative analysis of a wide range of aspects of operational variability.

Section 2 HOMP Trial Follow-on Activities

This Section describes the activities carried out during the CAA funded follow-on programme to the main HOMP trial. Although not part of the CAA work, it also briefly discusses the wider HOMP implementation within BHL, as the experience gained complemented the CAA-funded activities, and some of the data generated has been used in the CAA work.

1 Objectives

The overall objective was to perform activities identified as being necessary to ensure a successful fleetwide HOMP implementation on the UK offshore helicopter fleet, using the results of the HOMP trial to provide a good foundation for this implementation.

There were two primary objectives for the follow-on activities:

a) To transfer HOMP to a second UK operator. At the time of commencing the follow-on work the UK offshore oil industry was largely supported by two helicopter operators – Bristow Helicopters Limited (BHL) and CHC Scotia Limited (Scotia). Only BHL had had any involvement in the HOMP trial at that time. Scotia had no experience of setting up, operating or managing a HOMP and therefore lacked first hand knowledge of the issues which must be addressed and the procedures which must be put in place. There was therefore a perceived need to provide Scotia with assistance in these areas prior to any wider HOMP implementation. In addition, it would be informative to compare the HOMP experiences of two different operators on the same aircraft type (the AS332L).

b) To develop a HOMP for a second helicopter type. All the initial HOMP experience was on a single helicopter type – the AS332L. Prior to a fleetwide implementation there was a need to gain experience applying the existing HOMP system to a new helicopter type such as the S76, and to identify and address the issues which this might create. The BHL S76s were located at Norwich, and this would also provide further experience of supporting a HOMP at a remote base.

A secondary objective of the work was to continue to develop and refine the HOMP flight data analysis. This was to include continued development of the flight data event and measurement analysis, further investigation of methods for allocating severity values to events and further work to 'map' the offshore helideck environment for both structure-induced turbulence and hot exhaust gas plumes from turbines. The follow-on activities are described in more detail in the following sections.

2 Transferring the HOMP to a Second UK Operator

A trial HOMP programme was implemented on two Scotia AS332Ls (aircraft G-PUMD and G-PUME), operating from Scotia's main base at Aberdeen.

Scotia's Flight Operations Quality Manager (FOQM) and the HUMS co-ordinator were tasked with implementing the HOMP trial within the company. Their initial responsibilities were as follows.

The FOQM addressed the organisational aspects of HOMP:

- Initiating a HOMP awareness programme with briefings to pilots.

- Working with BALPA to agree a “Statement of Understanding”.
- Arranging coordination meetings and liaison with BHL and ES-S.
- Acting as the focal point for the trial.

The HUMS co-ordinator addressed the hardware requirements:

- Identification of suitable airframes for the trial.
- Sourcing of HOMP equipment.
- Installation of HOMP equipment in aircraft.
- Installation of HOMP equipment in the engineering department and headquarters building.

During the trial preparation period in June and July 2002, Scotia relocated its entire operation from the Eastern side of Aberdeen Airport to a new terminal on the West side of the airfield.

2.1 Equipment and Data Analysis

The two aircraft were equipped with Meggitt Avionics Ltd PCMCIA Card Quick Access Recorders (CQARs, see Reference [2] for details). Scotia utilised the aircraft modification design that had been produced by BHL for the main trial, with the CQAR again being mounted in the cockpit centre console. It was necessary, however, for Scotia to make a minor amendment to allow for differences in the layout of the centre console on Scotia's aircraft. The installation of the CQAR unit and the associated wiring from the IHUMS DAPU required 8 to 10 man hours of work, which had to fit in with scheduled maintenance on the aircraft. The two trials aircraft were equipped with CQARs and data gathering commenced on the first aircraft in August 2002, and on the second aircraft in September 2002.

Scotia's HOMP analysis PC was delivered in August 2002 and initial training was provided on the system during the same month. Scotia had generated test files containing the location data and flight operations data required by the HOMP system and the import of this data into the system was successfully tested. The configuration of the flight data events and measurements was identical to that used by BHL. The only change made to the configuration was to a derived parameter to allow for the fact that Scotia's flight operations database recorded aircraft take-off weight in kilograms, whereas BHL's recorded weight in pounds.

Working closely with the IT department, a suitable location was identified for the HOMP analysis PC in the CHC Headquarters building, located approximately half a mile from the terminal building. This provided a place of privacy away from the normal workplace so that the HOMP Manager could have private meetings with crews. Scotia installed a PCMCIA card reader and ES-S's CQAR download program on a PC in their engineering department. Data files were downloaded from the two trials aircraft to this PC on a daily basis. The HOMP analysis PC retrieved the data from the download PC over a Local Area Network (LAN) the following morning and then processed the data.

2.2 Organisation

The key to a successful HOMP lies not only in the acquisition and interpretation of data, but in having an effective system for debriefing crews, and providing feedback to flight operations, company management and clients.

It was appreciated that implementing HOMP would attract a range of responses from the pilot workforce. It was therefore important to address any issues raised by the pilots before the flying trial began. These primarily related to confidentiality of data.

For example, who would have access to the data, and how would the data be stored, used and disseminated? A dialogue with the Company Council was established at an early stage and a HOMP agreement was developed in collaboration with the Council. This was based on existing agreements in place with other operators, including British Airways. Once this agreement had been finalised it was accepted that sufficient protective mechanisms had been put in place to protect the individual from inappropriate company or customer enquiries. A copy of the agreement is presented in Appendix 1.

Prior to the flying trial commencing, the company appointed a HOMP Manager and a HOMP System Administrator, who was also the FOQM and trial coordinator. The HOMP Manager needed to be someone that had sufficient 'Authority Gradient' to make the feedback to crews credible. A Training Captain was the ideal person for this role, being fully familiar with the aircraft type and its operating characteristics, and also familiar with the company operations manual and any operational limitations that it may contain.

During the trial the HOMP System Administrator was responsible for the daily downloading and processing of the HOMP data. Any events generated were validated and the System Administrator would meet with the HOMP Manager on a weekly basis to review the previous week's events. It was then up to the HOMP Manager to determine any further action concerning a HOMP event.

If the HOMP Manager believed that a HOMP event (or series of events) merited follow-up to debrief the crew and gain further information, he would make a mutually agreed arrangement to view the HOMP data. The pilot or crew could attend by themselves, or with an associate of their choice. Typically this could be another pilot from the workforce or a BALPA representative, but the decision for accompaniment lay entirely with the pilot.

To monitor the functioning of the HOMP programme, a “HOMP Working Group” was formed, which comprised the HOMP Manager, the System Administrator, the FSO and a representative from the Company Council or BALPA. Additionally, when it was felt necessary, further technical experts could be invited. The group met on a monthly basis and discussed the previous months events, and any follow up with aircrew.

2.3 Operational Trial

The month of September 2002 was considered to be a commissioning phase, so the six month operational phase of the trial commenced on 1st October. However, significant events detected during the commissioning phase were retained and have been reported as part of the overall HOMP trial experience. The six month trial period was officially completed on 31st March 2003, however data gathering continued beyond that date and, again, the additional experience has been included in this report.

3 Develop the HOMP for a Second Helicopter Type

The Sikorsky S76A+ was chosen as the second helicopter type to be added to the HOMP as it is the second largest BHL North Sea fleet after the AS332L. BHL have two bases operating the S76, Norwich (UK) and Den Helder (Netherlands). Norwich was selected for the trial as it is the larger of the two and is geographically less remote from Aberdeen. It is also where the Chief Training Captain for the fleet is based. The two aircraft selected for the HOMP modification were G-BISZ and G-BIEJ.

3.1 **Equipment and Data Analysis**

The aircraft were again fitted with Meggitt Avionics Ltd PCMCIA card CQARs, located in the cockpit centre console. Data gathering commenced in August 2002.

Although not initially appreciated due to a lack of clarity of the HUMS/FDR documentation, it was discovered that some parameters that had proved useful in the AS332L programme were not recorded on the S76. EUROCAE Minimum Operational Performance Specification (MOPS) ED-55 defines different sets of mandatory parameters to be recorded on helicopters over 7000kg MTWA (i.e. the AS332L) and on helicopters over 2730kg and up to 7000kg MTWA (i.e. the S76). As a result, parameters such as lateral acceleration, longitudinal acceleration and yaw rate were recorded on the AS332L but not on the S76. In addition, ED-55 includes navigation data in the set of additional recommended parameters to be considered and it was found that whilst GPS data was recorded on the AS332L, it was not on the S76. This was because the area navigation equipment fitted to the S76 at the time of IHUMS installation did not output position data. The experience highlighted the importance of good documentation on the recorded flight parameters, and also of carefully checking this documentation prior to embarking on a flight data monitoring programme.

Although the objective of the trial was to develop a HOMP for the S76 using the available FDR parameters, it was recognised that some of the missing parameters (primarily GPS data, but also lateral and longitudinal accelerations) had proved very useful in the AS332L programme. Since installation of IHUMS, the S76 fleet had been fitted with an upgraded area navigation system, and it was confirmed that a simple wiring modification to connect it to the IHUMS DAPU was all that was needed to provide GPS data. It was also established that simply replacing the single axis accelerometer with the tri-axial version having the same form and fit would enable the provision of all three axes of acceleration data. BHL's S76s were operating on a Shell Expro contract at the time and they generously agreed to pay for the tri-axial accelerometers.

Unfortunately, owing to the very heavy loading on BHL's Design Office, the GPS wiring modification could not be completed until the beginning of May 2003. The tri-axial accelerometer modification was completed in June 2003.

BHL's Aberdeen-based HOMP system was updated to include the S76 fleet in September 2002. The update included the initial configuration of the S76 flight parameter decode equations, derived parameters, events and measurements. The configuration was based on the AS332L analysis, but with changes to reflect the differences between the AS332L and S76 flight manuals, the disabling of events and measurements utilising GPS and lateral/longitudinal acceleration data, and the deletion of events and measurements utilising other parameters not available on the S76 (e.g. fuel tank contents and yaw rate). In the absence of fuel tank contents data, the aircraft current weight was calculated using an assumed fuel burn rate.

A new data download PC was installed at Norwich for collection of the S76 HOMP data, and this data was transferred to Aberdeen via the company Wide Area Network (WAN). A connection was also established to BHL's INTOPS system (i.e. flight operations database) at Norwich to extract the relevant S76 flight operations data for importing into the HOMP system. All the S76 HOMP data was analysed at Aberdeen, with the data being transferred from Norwich in a batch process overnight. The HOMP system included a FDH (Flight Data at Home) facility, which enabled events to be emailed to Norwich together with cut sections of flight data for review by the local Base Representative; alternatively event-related data could be sent on floppy disk or emailed for viewing using the FDS replay program.

As part of BHL's Europe-wide implementation of HOMP, following the introduction of the IHUMS Windows NT ground station all remaining S76s were fitted with the CQARs by May 2003. This meant that five S76s were then HOMP-equipped, four being based at Norwich and one at Den Helder in the Netherlands.

3.2 Organisation

When previously managing the HOMP operation in Scatsta remotely from Aberdeen, it was felt that there was no need for an on-site HOMP representative. This was because Scatsta was really a satellite base of Aberdeen, operating the same aircraft type as Aberdeen, and with all the crews being known to the HOMP Manager or his assistant.

However, the relationship between Aberdeen and Norwich was more distant, with many of the Norwich crews never having operated from Aberdeen. There were also no S76s based at Aberdeen, and neither the HOMP Manager nor his assistant had any experience of the S76. It was therefore apparent that a Fleet Representative would be required to supply technical and operational knowledge to the programme, and a Base Representative would also be needed to provide a known face to the crews at Norwich.

The Chief Training Captain on the S76 was selected to be both the S76 Fleet Representative, and Norwich Base Representative. He was responsible for giving advice on the type's operation and for any follow-up with crews. He was assisted by a former Chief Training Captain on the S76, who provided additional technical expertise. The Norwich representatives would be contacted by the HOMP Manager or his assistant when there was a need for either advice on fleet-specific issues during initial event validation and investigation, or for information about a specific event.

The Norwich representatives were normally empowered to decide on the best course of action following an event - for example whether to simply note an event and monitor for a recurrence or trend, or whether to contact the crew with a view to further investigation. If appropriate, they would request access to data relating to the event. They would report back to the HOMP Manager with the outcome of any crew contact, suggestions for the severity value to be allocated to the event and, possibly, suggestions for adjustments to the event thresholds.

The Norwich representatives could ask for data from specific flights to investigate events not detected by HOMP. However, this would only be granted if all members of the crew concerned had given their consent, or if the crew had identified themselves by raising an Air Safety Report, in which case the HOMP data could become a useful part of the investigation.

A HOMP agreement between the company and BALPA existed in draft form. Due to the occurrence of more pressing issues, progress on its completion was slow, and the agreement had still not been completed at the end of the trial. However, BALPA had accepted the spirit of the agreement.

3.3 Operational Trial

The S76 HOMP data analysis commenced at the beginning of October 2002. Although the duration of the operational phase of the trial was intended to be six months, this was extended to include at least three months of operations after the GPS and tri-axial accelerometer modifications had been completed. This enabled an assessment of the added benefit of GPS and tri-axial accelerometer data to be made, which is useful information for the wider application of HOMP. This report includes information from S76 HOMP operations up to the end of October 2003.

4 Fleetwide HOMP Implementation on BHL AS332Ls

4.1 Equipment and Data Analysis

Five AS332Ls had been equipped with CQARs for the main HOMP trial. BHL commenced installing CQARs in additional AS332Ls and including them in the programme at the beginning of September 2002. BHL also started claiming the UKOOA-agreed premium per flight hour for the HOMP implementation when the first additional aircraft was modified. All twelve of BHL's Aberdeen-based AS332Ls were included in the HOMP by early January 2003 and the additional five aircraft at Scatsta in the Shetland Isles had all been added to the programme by February 2003.

The HOMP implementation coincided with an upgrade of the BHL IHUMS, which included the introduction of an updated IHUMS ground station with a Windows NT operating system and a replacement of the on-aircraft Maintenance Data Recorder (MDR) by the CQAR. In addition to storing the HOMP data files, the CQAR also stored HUMS data files, so that both HUMS and HOMP data files were downloaded on the same PCMCIA card. The HOMP data was therefore initially downloaded to the IHUMS ground station and then transferred to the HOMP analysis PC via a LAN (for Aberdeen data) or a WAN (for Scatsta data).

A second data analysis PC was obtained for the HOMP office at Aberdeen and the HOMP software became a client-server application on the two PCs.

4.2 Organisation

As part of the wider programme implementation, BHL's HOMP Manager was joined by an Assistant HOMP Manager. With this addition, the HOMP personnel and organisation were generally adequate to cater for the increased number of aircraft included in the programme at Aberdeen, Scatsta and Norwich.

As part of the UKOOA agreement, BHL's base in Den Helder, Netherlands was added to the programme. This small operation had one or two S76s permanently based there, with an AS332L on contract from time to time. A number of pilots at this base were Dutch nationals who had had little contact with Aberdeen. It was therefore considered necessary to appoint a Base Representative for Den Helder, partly because the operation was subject to Dutch national rules but also because of the local pilots' lack of familiarity with the Aberdeen personnel. A well-regarded S76 Training Captain, who had also flown the AS332L, was selected as the obvious choice.

A similar process to that used at Norwich was set up, whereby the Aberdeen HOMP office would send any events worthy of note or further investigation to the Den Helder representative. This was generally achieved by e-mailing a CSV file to be replayed on the FDS program. A PC was provided to ensure that the HOMP representative had a secure means to store and view the data. The representative would decide the best course of action, taking advice from the Aberdeen office where necessary. Following any crew contact, he would then report back relevant findings to Aberdeen and assist with the assignment of an event severity value.

5 Continued Development of HOMP Software and Data Analysis

5.1 HOMP Software Developments

An updated version of the HOMP software was installed at BHL in early June 2002, this also became the baseline software version for Scotia's HOMP system. New features introduced in the update included:

- A Flight Data at Home (FDH) facility, which can easily be installed on any PC. Event data together with the associated cut sections of flight data can be emailed to FDH from the HOMP system and the flight data can be viewed as a trace, listing or FDS flight simulation just as in FDE using the Flight Data Viewer. This enables the pilot assessment of events to be performed at any location where there is a PC connected to the Internet. Keywords and comments can be added to the event in FDH and emailed back to the HOMP office.
- Inclusion of an 'Aircraft Usage' window in FDT, which shows data recovery information and errors in the recovered data in graphical form. This provides a clear calendar-based picture of data recovery rates, allowing periods of missing data to be quickly identified.
- A new 'Data Request' window in FDT, which allows flight data to be viewed as a trace, listing or FDS flight simulation, and also extracted into an appropriate file format, without having to be scanned for events and measurements.
- Several improvements to the facilities in FDT for displaying and navigating around flight data traces.

BHL's and Scotia's HOMP systems received a second software update at the beginning of April 2003. No major functional enhancements were introduced, but new features included:

- An ability to allocate a 'development' status to new events, so that these can be run separately from the main event analysis.
- Further encryption of sensitive information, such as aircraft registration and flight date, to enhance data security and aircrew confidentially.
- The ability to support multiple configurations of a basic aircraft type as different fleets within FDT, but merge the resulting event information into one fleet within FDE.
- Enhanced features for coping with events triggered by incorrect data. For example, the system can halt the replay if the total number of events triggered exceeds a configurable limit or, if too many events of one type trigger (e.g. due to a faulty sensor), these can be marked as false and highlighted.

5.2 Development of HOMP Event Analysis

5.2.1 AS332L Event Analysis

A new event was introduced following an occurrence on a BHL AS332L shuttling between two platforms at night, where the Automatic Voice Alerting Device (AVAD) was suspended without the captain's knowledge. This resulted in the captain being unaware that the aircraft was descending towards the sea until the 100 ft warning sounded (see Section 4 sub-section 3.1). The new event (45A/B/C) detects that an aircraft is at low height and speed when more than 500m away from the take-off and landing point at night. It was found that the event as initially configured was inappropriately triggering on approaches to Aberdeen, because of the relatively long air-taxiing distances. The event was therefore modified so that, when in the take-off and landing flight phases, it applied to offshore operations only.

Scotia requested a new HOMP event to detect inadvertent application of collective instead of the parking brake, as there had been two recent occurrences of this on the S76 and one on the AS332L. Attempts were made to configure an event based on raising and lowering of the collective. However, due to the existing bad data trapping and problems with spurious events, this proved to be unfeasible. Therefore an “inadvertent lift-off” event (46A) was created instead to detect very short flights.

Following a BHL AS332L offshore landing during which turbulence that created a significant yaw motion was encountered, it was decided to develop a new HOMP event to detect 'yaw turbulence'. A new event (47A/B) was implemented based on yaw acceleration in one direction and rate of movement of the tail rotor pedal in the opposite direction.

5.2.2 S76 Event Analysis

The starting point for the S76 HOMP event set was the set of events that had been developed for the AS332L (Reference [2]). Table 1 lists the AS332L events that were deleted as they were either not relevant to the S76, or the required FDR parameters were not available (some of the events were deleted during the event review described below). The table also lists new events that were created specifically for the S76, which were all based on S76 Flight Manual limitations.

Table 1 Adaptation of the AS332L Event Set for the S76

AS332L events (initial set) deleted		
Event No	**Event Name**	**Reason for deletion**
06A	Roll Attitude Above 30 deg Below 300 ft AGL	Not relevant to S76 (no Flight Manual roll limits)
06C	Roll Attitude Above 30 deg Above 300 ft AGL	Not relevant to S76 (no Flight Manual roll limits)
12A	Excessive Collective Pitch Control in Level Flight	Not relevant to S76 (no Flight Manual limits)
12B	Excessive Collective Pitch Control	Not relevant to S76 (no Flight Manual limits)
14A	IAS Mode Engaged Below 60 knots IAS	No parameter available
14B	ALT Mode Engaged Below 60 knots IAS	No parameter available
14C	HDG Mode Engaged Below 60 knots IAS	No parameter available
17A	Vno Exceedance (<= 8,750lbs)	S76 Vno exceedances not considered significant
17C	Vno Exceedance (> 8,750lbs)	S76 Vno exceedances not considered significant
18A	No. 1 (LH) Fuel Contents Low	No parameter available
18B	No. 2 (RH) Fuel Contents Low	No parameter available
19A	Heater On During Take-Off	No parameter available
19B	Heater On During Landing	No parameter available
38A	Taxi Limit (left gear lifts)	Not relevant to S76
38B	Taxi Limit (right gear lifts)	Not relevant to S76
New S76 events added		
Event No	**Event Name**	**Reason for addition**
22C	IAS Above 130 kt and Gear Down	S76 Flight Manual Limitation
25C/D	Maximum Continuous Torque – Engine 1/2	S76 Flight Manual Limitation
25E/F	Maximum Contingency Torque - Engine 1/2	S76 Flight Manual Limitation
25G	Maximum Combined Torque over 200%	S76 Flight Manual Limitation
43A/B	Maximum Continuous N1 - Engine 1/2	S76 Flight Manual Limitation
43C/D	Maximum Contingency N1 - Engine 1/2	S76 Flight Manual Limitation
44A/B	Maximum Continuous T5 - Engine 1/2	S76 Flight Manual Limitation
44C/D	Maximum Contingency T5 - Engine 1/2	S76 Flight Manual Limitation

The two new AS332L events, 45A/B/C "low height and speed at night" and 46A "inadvertent lift-off", described in the previous section, were also added to the S76 event set.

The S76 Fleet Representative, who was also the HOMP Base Representative at Norwich, reviewed the S76 event set in February 2003 after an initial period of HOMP operations. He recommended adjusting several event limits and deleting some events (included in the table above), but could not identify a need for any S76-specific additions to the event set.

Because of the different autopilot types, events 14A/B/C were not relevant to all BHL S76s and were omitted. In the early days of the AS332L HOMP, BHL's training management decided that the 14A/B/C events did not represent any particular safety issue. As they were never actioned on the AS332L there was no justification for adding them to the S76.

The S76 normally cruises near Vno, therefore it is inevitable that Vno will be exceeded (the limit is not included in the FAA version of the flight manual). Vno exceedances are seen as a fleet policy issue – BHL do not expect pilots to exceed Vno on the AS332L, but accept that this occurs on the S76. The resulting high frequency of S76 Vno events was considered to be a nuisance and the events were therefore deleted (see Section 4 sub-section 2.1 for a full explanation of this action).

5.2.3 Summary of AS332L and S76 Events

A summary table of all the AS332L and S76 events at the end of the follow-on programme is presented in Appendix 2.

5.2.4 Event Severity Assessment

As part of the main HOMP trial, BHL developed the 0-10 scale shown in Table 2 for the allocation of severity values to events, with the numbers being defined in terms of the potential erosion of helicopter operational safety margins. Severity values were manually allocated to events using this scale.

Table 2 BHL's Event Severity Guide

Severity	Significance of Event
0	No significance
1	Contrary to operational or flight manual procedures or limits but no actual safety risk
2	Slight risk of problem if combined with several other factors
3	Risk of problem if combined with other factors
4	Slight risk of problem as a stand-alone event
5	Significant risk of problem as a stand-alone event
6	Serious risk of incident
7	Minor incident occurred
8	Moderate incident occurred
9	Major incident occurred
10	Accident occurred

With the manual approach to event severity assessment described above, it was recognised that there might be inconsistencies between operators in the allocation of severity values, which could make it difficult to share experience. To investigate this issue, the same manual approach was adopted by both BHL and Scotia in the follow-on work. The severity values that had been manually applied to events were then reviewed to compare the assessments being made by the two operators. The review also determined whether there were any identifiable patterns in the event severity values that would indicate the feasibility of a semi-automated severity allocation process, starting with the calculation of some initial default severity values.

5.2.5 The Application of Data Mining Techniques to Event Data

Although FDE provides a good set of easy-to-use event trend analysis functions, it was recognised in the main HOMP trial that simple trend analysis can miss some hidden patterns or trends in the event data. Therefore one of the recommendations from the main trial was to develop data mining tools for the efficient analysis of HOMP event and measurement databases. Although it was not part of the statement of work for the immediate follow-on activity, ES-S performed a limited investigation of the application of data mining to a suitably de-identified copy of BHL's FDE event database. The mining was performed using ES-S's state-of-the-art data mining tool, which had been developed in accordance with Microsoft's OLE DB for Data Mining specification (i.e. an open standard). This allowed the tool to be used not only as a stand-alone application, but also as an extension to Microsoft Analysis Services provided with SQL Server. The tool can therefore utilise the many management and visualisation tools Microsoft offer and also use algorithms supplied by Microsoft in addition to those developed by ES-S. The data mining algorithms used in the investigation were primarily decision trees and clustering (see Section 6 for details).

5.3 Development of HOMP Measurement Analysis

5.3.1 AS332L Measurement Analysis

At the end of the main HOMP trial, additional offshore take-off and landing profile measurements were implemented in the HOMP system maintained by ES-S for development and support purposes, and one year of archived flight data was reprocessed using the extended set of 300 AS332L measurements. Prior to implementing these in the HOMP systems at BHL and Scotia, it was decided that the total number of measurements should be reduced to less than the 256 column/field limits in Microsoft Excel and Access. In addition to the user-defined measurements, a measurement record contains 13 items of fixed information, therefore this gives a maximum number of user-defined measurements of 243. The total number of measurements was reduced to 230, which provided some future growth capacity before the Excel and Access limits would be reached.

To prevent occasional spurious data points when mapping the turbulence environment around offshore platforms, control of the GPS-derived wind speed and direction measurements was improved with checks on aircraft regime being made before and after the measurement was taken. In addition, to enable mapping of the turbine hot exhaust gas environment around offshore platforms, separate measurements of maximum OAT increase on take-off and landing were introduced.

The AS332L measurement set was updated with all of the above changes in November 2002, giving a final total of 234 measurements.

5.3.2 S76 Measurement Analysis

As for the events, the starting point for the S76 measurement set was the set of measurements that had been developed for the AS332L (Reference [2]). This included all the items described in the previous section. Again, all the measurements for which the required FDR parameters were not available were deleted.

Owing to the performance limitations of the S76A+, it was decided to implement new measurements to give an estimate of twin engine torque in the hover during an offshore take-off and landing. Two new measurements were configured, however it was noted that these only provided approximations of twin engine torque in the hover as aircraft could execute a progressive take-off manoeuvre without a clearly identifiable stable hover condition. The new S76 hover torque measurements were added in June 2003, giving a final total of 225 S76 measurements.

5.3.3 Summary of AS332L and S76 Measurements

A summary table of all the AS332L and S76 measurements at the end of the follow-on programme is presented in Appendix 2.

6 Dissemination of Information on HOMP

Activities to disseminate information on the HOMP continued throughout the follow-on programme. A brief summary of key activities is presented below.

The final HOMP trial report produced by ES-S was published as CAA Paper 2002/02 and made available in pdf format for downloading from CAA's website. In addition, a pdf format HOMP presentation was placed in the FDM focus area of the CAA's website.

Articles on HOMP were published in the January 2003 edition of Rotor & Wing and the December 2002/January 2003 edition of Defence & Public Service Helicopter. An article on FDM and HOMP was also published in the March 2003 edition of the Business & Commercial Aviation magazine.

HOMP presentations were given at a number of different conferences and events. These included the meeting of the JAA Helicopter Offshore Safety and Survivability (HOSS) working group in October 2002, the European Helicopter Operators Committee meeting in May 2003, and the American Helicopter Society's Forum 59 also in May 2003. HOMP updates were also given at committee meetings of the International Association of Oil and Gas Producers (OGP).

Section 3 HOMP Operational Experience

This section describes the operator's experiences with the HOMP programme, but not the results obtained, which are covered in the following sections of the report.

1 CHC Scotia AS332L HOMP Trial

1.1 HOMP Equipment

All HOMP related hardware installed in the aircraft, and at the engineering and headquarters buildings, operated reliably with no failures occurring.

The PCMCIA cards were removed from the two trials aircraft by an engineer at the end of each day's flying. One CQAR PCMCIA card was damaged early in the trial, which was found to be slightly bent indicating that it may have been sat on. During the trial period there were only one or two days for which no data had been available following a flight; the reason(s) for the missing data was not identified.

The only aircraft sensor problem that occurred was a faulty tri-axial accelerometer, which caused a large number of acceleration events. Due to inexperience in data interpretation, these were initially accepted as nuisance events, but after a few days it was obvious there was a trend on one aircraft and an engineering investigation quickly revealed the problem. Should it have occurred again, the accelerometer fault would have been immediately identified. Without HOMP, aircraft sensor problems would not be detected until the annual FDR check.

An IHUMS DAPU clock error occurred on one of the trials aircraft. This resulted in the incorrect recording of GMT, which prevented the HOMP system from being able to match the imported flight operations data files with the CQAR data for a period of time. Once the problem had been identified it was promptly fixed.

No problems were experienced with the HOMP analysis PC during the trial. Software support was provided by ES-S and any updates were received electronically with supporting instructions. There were no notable problems with the updates and any minor difficulties that did occur were promptly dealt with by telephone.

1.2 HOMP Analysis

The System Administrator (and trial coordinator) batch processed the HOMP data on a daily basis using the FDT module, which was also used for initial interpretation of data. This was either viewed as a trace, or as a FDS display. Being an ex-pilot, the System Administrator initially viewed events via the FDS display which was very easy to assimilate and was very effective at providing 'instant' feedback. However, as the trial progressed and competency increased in interpreting the graphical trace output from HOMP, then this also became a useful tool for initial data interpretation.

Use of the graphical trace to view selected data in different ways, or to view different data selections, was found to be quite intuitive. The ability to 'zoom' in and out of traces was also useful, enabling the user to look at data in very fine detail. The additional facility to read the data in a numerical form was also quite easy to assimilate. For future HOMP implementations, training in the interpretation of data presented as trace displays would be beneficial.

The first action after the daily batch processing of the data was to purge all non-events (i.e. false or repeat events). All the data files that then had zero events were marked for archive, and finally the files that contained events were reviewed. Given the scope of the trial (two aircraft) and the flying rates for the aircraft (approximately 20 days per month), this was not considered to be an onerous duty. However, if HOMP activity is scaled up to beyond, perhaps, five aircraft then the initial processing, archiving and reviewing would become a more time consuming task.

During the HOMP trial Scotia were in the process of introducing their new Flight Business System (FBS) to manage the organisation, planning and execution of all the company's flight operations. The FBS introduction involved a considerable amount of system development and the FBS was not fully operational until after the conclusion of the HOMP trial. This had a negative impact on Scotia's ability to automatically extract the flight operations information required for HOMP.

The HOMP system is designed to import a “locations” data file to enable it to automatically identify airports and offshore platforms from the GPS latitude and longitude recorded at take-off and landing. Although Scotia generated a locations file from their old flight operations system (i.e. pre FBS), it was found that the data was not specified to a high enough resolution to enable the HOMP system to automatically detect the majority of the take-off and landing locations based on GPS data (there was no decimal minutes information). Although it would have more accurate locations data, the new FBS introduced some different location codes and could not provide the new data before the end of the trial. Although this caused some problems with location identification during the trial period, outputs from the FBS will be available for any future analysis.

The introduction of the FBS also delayed the implementation of a capability to automatically generate daily operational data files containing information such as the type of flight, flight times and destinations, number of passengers on board, and de-identified crew codes, for importing into the HOMP system. Once the importing of this operational information commenced, the flight data analysis process was greatly improved. Until then it was possible to manually obtain the information when investigating particular events but, for pure efficiency and effectiveness, the automated electronic overlay of operational information was considered to be an important facility.

To enable meaningful trending of the events generated during the trial, ES-S retrospectively populated Scotia's HOMP system database tables with missing flight operations information at the end of the trial period. Once this update had been completed, Scotia's HOMP System Administrator reviewed all the valid HOMP events generated during the six month trial and allocated severity values to the events. Although this activity can be carried out retrospectively, it would have been better to keep the activity coincidental with the day-to-day analysis of the HOMP data. Severity level allocation was based on the 1-10 severity scale developed by BHL in the main HOMP trial (Section 2 sub-section 5.2.4). Whilst the scale was easily understood, the personal perception of an event and its relevance to a particular company's operations was expected to result in variations between operations and operators. However, it was important that as much 'subjective consistency' as possible be applied, as these severity values were central to the presentation and analysis of event trends within the FDE module.

BHL had created an ability to import meteorological information into a database on their HOMP PC for use during the event review process. It was not possible to implement this during the course of the relatively short Scotia trial. For the future use of HOMP this was considered to be an important facility that should be integrated in some way, as the weather on any given day could have a marked effect on how an aircraft is handled. For example, handling that triggers a HOMP event during ground taxiing might in fact be no cause for concern given the particular wind and weather conditions.

1.3 HOMP Operational and Management Experience

The workload during the first couple of months of the flying trial was quite high due to the learning process, and it typically took an hour or more of time to process and interpret data from the previous day's flying from the two aircraft. However, by the end of the trial the time was down to 10 minutes or less. This was due to the increasing HOMP experience and also a reduction in the number and severity of events that were being generated, which reduced the amount of investigative work required.

Internal resourcing issues had some impact on the trial. Scotia's HOMP Manager took early retirement shortly before the end of the trial period. In the absence of a HOMP Manager, the HOMP System Administrator consulted the BALPA representative if he believed that there was a need to contact aircrew about a HOMP event. The HOMP System Administrator, who was the Flight Operations Quality Manager, also became Scotia's FSO during the trial, which reduced the amount of time he had available for HOMP activities.

During the course of the trial the location of the HOMP PC had to be moved within the headquarters building as the room in which it was originally located became more frequently used by others. This started to impinge on the 'confidentiality' of the system, which requires unhindered and free access at any time, a point which needs to be considered in any future implementation.

The HOMP agreement with BALPA was a key device to aid 'buy in' from the pilot workforce. Once in place, it was considered that this contained sufficient mechanisms to protect the individual from inappropriate company or customer enquiries. There were no problems with BALPA or the pilots' acceptance of HOMP during the trial period.

1.4 'Closed Loop' Feedback Processes

If the HOMP Manager believed that a HOMP event merited a de-brief with the crew, he would arrange a meeting to review the HOMP data. These meetings were always met with a positive attitude by crews, who all seemed to be impressed with what HOMP could do. The information provided by the pilot or crew gave a much more 'balanced' view of a HOMP event and this enabled a better assessment of possible corrective actions. Direct feedback to crew was considered to be an important element of the HOMP process.

During the trial the HOMP System Administrator provided a monthly 'Synopsis' of the events to both the workforce and to management. This contained a cumulative event trend graph and a 'Hit List' of the most frequent events. It was displayed in flight operations and in the course of the trial it was possible to track the marked reduction in 'potential right wheel lifts' during taxiing as a result of the feedback provided. The information on this event was supported by background material such as a 'rollover' graph which showed the BHL AS332L that rolled over whilst taxiing and the position of the flight controls that led to the incident.

Through regular meetings of the HOMP Working Group, the FSO was also made aware of various trends throughout the trial and he took the opportunity to produce notices to raise general awareness of safety-related issues. During the course of any investigation that he was conducting, the company FSO could also ask if there was any associated HOMP information. His enquiries would be made via the HOMP Manager only and any HOMP information viewed would be specific to the investigation and not of a general nature.

As the HOMP Manager was part of the company's flight training department, he took the opportunity to provide direct (de-identified) feedback on HOMP trends related to handling skills. Any handling issues identified from HOMP trends could be addressed during scheduled proficiency checks, which provided the opportunity for both the evaluation of a particular pilot skill, and for the demonstration of correct handling actions.

Careful consideration was given to the type of information that should be given to clients. As the clients would be paying for a future HOMP implementation, they were quite rightly interested to see how it was working and if it was producing results. During client audits a general demonstration of the HOMP system was given, and it was important to show that Scotia had the competence to operate the HOMP system and that if any trends were identified then the company had the ability to take corrective action. However, the system was not made directly accessible to clients or management, either for enquiries about specific flights or for any general queries. Feedback to management and clients was limited to the identification of event trends, and a statement on what corrective action had been carried out.

2 BHL S76 HOMP Trial

2.1 HOMP Equipment

The CQARs fitted to the S76s were to a modified standard compared to those initially available on the AS332L during the main HOMP trial. The modification improved the PCMCIA card guide to make it impossible to insert the card at an angle, which could cause it to miss the card guide altogether and fall into the CQAR. This modification proved to be entirely successful, with no reported cases of the card being 'lost' inside the CQAR.

The CQARs and PCMCIA cards performed reliably throughout the trial, with no reported defects. However, it was suspected that an occasional data file was lost due to a failure of the CQAR processor to survive a low voltage 'brown-out' occurring when the aircraft started up on its internal battery. It was impossible to categorically prove or disprove whether this actually occurred.

At the start of the trial the CQARs only recorded HOMP data. IHUMS data was stored on a separate Maintenance Data Recorder (MDR), which was routinely downloaded by pilots post flight. It was decided that the engineering department would be responsible for downloading the HOMP data from the CQAR. This was because only engineering personnel would be present in the evenings and thus be able to guarantee that the download was carried out after the last flight of the day. A simple MSDOS batch file was written to move any new HOMP files to the Aberdeen HOMP computer over the Bristow WAN. As the files were quite large and WAN bandwidth was limited, this was scheduled to run in the early hours of the morning when other network traffic was light.

Although a simple download programme was provided on the dedicated HOMP PC at Norwich, some of the engineering staff had problems understanding how to carry out the download process. With hindsight it would have been better to provide the staff with some formal training. The data collection rate at the start of the trial was therefore not very good, with some files missing and multiple copies of other files because the PCMCIA card had not been cleared after downloading the data. This was quite difficult to resolve at a distance because of the difficulty in contacting engineering staff by telephone, as the staff were carrying out tasks in the hangar, despatching aircraft etc.

In December 2002, a new Windows NT version of the IHUMS ground station software was installed at Norwich, enabling the CQAR to be used to record both the IHUMS data and the HOMP data. During download of the HUMS files into the IHUMS ground station, the HOMP data files were also copied to the ground station server. Because each download was stored in a separate folder on the computer, all the HOMP files had the same name. It was therefore necessary to write a slightly more complex transfer program, this time using Visual Basic for Applications in MS Access, which searched the IHUMS ground station server for the previous day's files, renamed them using a unique number, and copied them to the Aberdeen HOMP computer. Again, this was scheduled to run overnight to minimise impact on the WAN.

The HUMS data was downloaded on each return to base and in BHL this task has always been carried out by the pilots. Thus the aircrew were already in the habit of downloading a card post-flight, so the additional downloading of the HOMP data was transparent to them. Following this change of download method, data collection rates improved dramatically, with only a small number of files missing. These files were believed to be lost due to the very occasional failure of the CQAR to survive the power fluctuations during start-up.

Generally the HOMP software worked well and was intuitive to use. A few minor problems were encountered, for example the system maintained two separate tables of heliport locations (in the FDT and FDE modules) and there were some problems with these two tables getting out of synchronisation with each other. Generally, the structure of the HOMP system's databases reflects the way in which the different modules have evolved. Rationalising and centralising the data into a modern database would improve reliability and maintainability and make extraction of data in ways not covered by the front-end modules much easier.

There is scope for improving the method of handling bad data error correction within the FDT module. The techniques used appear to be based on a tape-based data storage medium, which suffers from data dropout over multiple parameters as a section of bad tape passes the reading head. The general approach taken is that if one parameter is detected as being 'bad', all the other parameters are also effectively considered 'bad' over the same time period. However, with modern solid-state recorders any parameter faults are likely to occur in isolation. A better technique would be to detect any bad parameters using the existing rules, but then only suppress events that used that parameter, and not suppress all other events as well.

It was initially thought that the AS332L FDS (cockpit view display) would be adequate for use with the S76. However, it rapidly became apparent that this was not the case due to the different appearance of the panel and also differences in the parameters available to drive the display. Therefore a new FDS module was commissioned to reflect more accurately the S76 instrument panel and the final version was delivered in May 2003.

2.2 HOMP Analysis

The S76 configuration for the FDT module supplied by ES-S was based on the AS332L's event and derived parameter set, with some adjustments for type-specific variations. These variations were decided upon following consultation with the S76 Fleet Representative. Unfortunately some of the non-mandatory parameters that were believed to be present on the S76 FDR were found to be missing. These included all the GPS data (position, groundspeed and drift angle) and lateral and longitudinal accelerations.

The lack of GPS position had quite a fundamental effect on the usefulness of the system, as it was impossible to record the takeoff and landing locations and whether it was onshore or offshore. Other information lost included takeoff and landing wind speed and direction and the day/night calculation. This meant that 12 events (4A, 4B, 5A, 5B, 20A, 21A, 21B, 23A, 23B, 37A, 41C, 45A) had to be switched off as there was insufficient data for them to work. For the same reason, a significant number of measurements were rendered inoperative. Lack of lateral and longitudinal acceleration data resulted in 8 events being switched off (10C, 10D, 10E, 10F, 35A, 35B, 36A, 36B) and also a number of measurements being inoperative.

The combined effect of this lack of data was that approximately 20% of all the AS332L events had to be switched off. It was therefore decided to try to add the missing parameters to the data set. Fortunately this could be achieved quite easily by additional wiring for GPS and by replacing the uni-axial accelerometer with the tri-axial equivalent, so these modifications were implemented.

Day-to-day analysis of S76 flights followed a similar pattern to the AS332L. However, the initial absence of GPS data made the task substantially more difficult and less effective as there was no information on the type or location of heliport used for takeoff or landing.

Some minor adjustments were made to event thresholds shortly after introduction to reduce nuisance events. All the events were subsequently reviewed by the S76 Fleet Representative, but no significant changes or additions were proposed other than to switch off the events that detected Vno exceedances (see Section 2 sub-section 5.2.2).

Based on experience gained with the AS332L, it was considered essential to merge operations data into the analysis process so that information such as the flight type (e.g. revenue, training) and whether passengers were carried, could be considered in the event review process. In particular it has proven essential to include encrypted ID numbers for the crew, so as to allow the detection of any adverse trends relating to a particular crewmember. Fortunately this was relatively easy to achieve using an MS Access ODBC connection to BHL's INTOPS database at Norwich. The base at Den Helder uses the same INTOPS database as Norwich, having remote access to the Norwich server. There was therefore no additional IT requirement to include operations data from Den Helder. During the course of the programme, the Norwich INTOPS server was physically moved to Aberdeen, which was of benefit to the Aberdeen HOMP office as it meant access speed was much improved.

The S76 measurement set configured in FDT closely matched the AS332L's set with only minor variations for type-specific reasons. Initially, the measurement set was significantly affected by the missing parameters, but restoring the GPS and lateral and longitudinal acceleration parameters resulted in a near-complete set of measurements. Only a few measurements, such as fuel tank contents, remained unavailable due to the lack of relevant FDR parameters. Towards the end of the trial, there was a request from the CAA-led HOMP trial steering committee to gather data relating to hover power required on lift off from offshore. ES-S added this to the measurement set, although there was some difficulty in creating a reliable and accurate measurement as the aircraft often did not properly stabilise in the hover before commencing the takeoff profile.

BHL continued to manually allocate severity values to events in accordance with the simple scale established for the AS332L (Section 2 sub-section 5.2.4). By the start of the trial, the Assistant HOMP Manager was carrying out much of the day-to-day analysis work on the AS332L and he continued to do this on the S76. There was some discussion from time to time between the HOMP Manager and his assistant as to exactly what severity value to assign to an event, with the result that the Assistant HOMP Manager adopted the HOMP Manager's approach. It would have been useful to have written guidance material on the setting of severity, but in this case the interactive approach was easier.

2.3 HOMP Operational and Management Experience

At the same time as the S76 trial, the HOMP programme was also moving to all the company's North Sea aircraft. However, the provision of the full time Assistant HOMP Manager meant that workload remained reasonable. The HOMP Manager spent about one third of his time on HOMP, with his assistant being full time.

Workload was inevitably high at the start of the S76 project as there were a number of infrastructure and personnel issues to be resolved, as well as the inevitable fine adjustments to be made to the data analysis. Neither the HOMP Manager nor his assistant were familiar with the S76, so some time had to be spent liaising with the S76 Fleet Representative to gain familiarity with S76-specific issues. However, the workload soon reduced with increasing familiarity and the setting up of the IT infrastructure.

Prior to introduction of the programme, the HOMP Manager made a visit to Norwich to demonstrate the benefits of HOMP to the pilot workforce and attempt to allay any fears they might have about it being a possible punitive tool. A meeting was also held with the BALPA company council chairman designate who was based at Norwich. His initial view was that the preferred operating method for HOMP was one modelled on British Airways, who use BALPA representatives as an intermediary between aircrew and the HOMP Manager. However, the BHL HOMP Manager believed that this would obstruct communication and was not necessary given the previous good record of maintaining confidentiality during the AS332L trial. It was therefore agreed that the BALPA representatives did not need to be routinely involved in HOMP.

Negotiations on the HOMP Manager's proposed aircrew-management agreement, conducted between the Head of Flight Operations and BALPA, proceeded slowly as a result of the need to address more pressing issues. By the end of the follow-on work, outstanding items were of a minor nature and concerned a desire by the HOMP Manager to close some possible loopholes allowing misuse of data. Although the agreement has still to be formally concluded, BALPA broadly accept the current version.

As a result of the IHUMS ground station update and the common download of both HUMS and HOMP (i.e. FDR) data, the HOMP Manager discovered that the downloaded FDR data was available for all engineers to browse within the HUMS ground station. Whilst the purpose of this facility was solely to assist with engineering diagnoses etc, the HOMP Manager believed that there was the potential for misuse of the data and therefore, by association, the potential to bring the HOMP programme into disrepute. At one of BHL's foreign bases there had previously been a case of FDR data being misused and misinterpreted by engineering, resulting in some conflict between engineering and pilots.

To maintain the integrity of the programme, the HOMP Manager discussed the potential for data misuse with BHL's Engineering Director and representatives from Engineering and Flight Operations. This resulted in the introduction of a procedure whereby access to the FDR data was normally inhibited and could only be activated by nominated engineering personnel from the Shift Supervisor upwards. An amendment to the engineers' operating manual was issued which indicated the processes and circumstances under which this data could be viewed. In essence, the data could be used solely for engineering diagnoses, but not for any investigations into pilot actions. Should Engineering or Operations management identify a need to investigate pilot actions, the data would have to be given to the Flight Safety department who would conduct an impartial investigation. This agreement also covered the direct downloading of the Flight Data Recorder itself. Previously the company had strict guidelines on the downloading of the Cockpit Voice Recorder, but had few controls in place over use of the FDR data.

2.4 'Closed Loop' Feedback Processes

Crew debriefs on the S76 fleet were invariably carried out by the S76 Base Representative at Norwich. Relevant event data would be passed to him and generally it was left to his discretion as to whether to contact the crew or not. He would then report back to the HOMP office in Aberdeen with his views on the event and the details of any crew debrief. The general feedback received from the Base Representative was that he had not encountered any problems with unreceptive crew members and HOMP was rapidly becoming accepted by the pilot workforce.

The Base Representative at Norwich did express a desire to have full access to the HOMP software and all S76 data. However, BHL had made a policy decision to centralise data analysis at Aberdeen, limiting the number of people who had access to the data to maximise confidentiality and minimise the possibility of misuse of data. Although the Aberdeen-based HOMP Manager and his assistant were not experts on the S76, and therefore needed advice and input from the Norwich-based S76 Fleet Representative, it was considered that this could be achieved without providing full access to HOMP data at Norwich. It was agreed, however, that if a strong case could be made, or if experience during the programme indicated a need for it, the position would be re-considered.

The Aberdeen HOMP office has responded to a number of requests from Norwich for data where this has been considered appropriate. One data request was denied – this was to investigate a complaint by a co-pilot (who was a retired captain on contract) about his captain. During a transit between two rigs without passengers, the captain had descended a little below the normal minimum transit height of 200 ft. The co-pilot had said nothing at the time, but after landing had made a formal complaint. There was clearly a CRM issue to be addressed between the two crew members, but this should be resolved using normal procedures. It would have been quite inappropriate (and contrary to the draft HOMP agreement) to provide data to support a disagreement between two pilots that was in the 'company-wide' domain. The HOMP office used the following criteria to determine the correct course of action following a data request: Would the HOMP office have taken any action on detection of the event? If 'no', nothing should be done. If 'yes', the normal HOMP processes should take place within the HOMP domain. HOMP should never provide hard data to support viewpoints outside its own domain unless all crew members concerned request it.

The first general HOMP newsletter issued following the introduction of the S76 programme was rightly criticised by Norwich crews as containing nothing of interest on the S76. All the items included related to the AS332L and it was realised that some S76 content was always required to maintain interest and to ensure that S76 crews read the newsletter.

Obtaining closure on an event is clearly a vital element of the HOMP department's responsibility. During the trial it was considered that the process could benefit from a greater degree of formality. To assist this, it would be helpful if the FDE software had a structured notes and actions area such as that contained in the BASIS ASR module. Another alternative would be to create an in-house stand-alone database, but this would be less convenient because of the difficulty of linking to the relevant event in the FDE database.

Through its line training, the training department can be of great assistance in correcting deficiencies highlighted by HOMP, because the training captains are flying regularly with a wide selection of pilots. Contact with the training department at Norwich was an intrinsic part of HOMP because the HOMP S76 Fleet and Norwich Base Representative was also the Chief Training Captain.

Communication with Norwich engineering during the trial was mainly limited to reporting faults with various FDR parameters. On one occasion engineering requested assistance in trying to track down a recurring jolt felt through the airframe of a particular aircraft, but after an extensive review nothing relevant was found. As a result of the IHUMS upgrade, engineering had direct (but controlled) access to the FDR data, with the HOMP system's only advantage for engineering investigations being its more sophisticated browsing tools.

3 BHL AS332L Fleetwide HOMP Implementation

3.1 HOMP Equipment

A limited number of AS332L aircraft were added to the programme in September 2002, but the majority of the fleet were added at the time of the IHUMS ground station upgrade because the CQAR installation had to be changed at that point. The new Windows NT IHUMS ground station was installed at Aberdeen at the end of December 2002 and the remaining aircraft were added to the programme within a few days. These had been pre-modified over the previous few months and the only requirement was to replace the old IHUMS MDR with a CQAR. The new ground station was installed at Scatsta in January 2003 and all five aircraft based there joined the programme shortly after. All BHL's North Sea AS332Ls were therefore HOMP-equipped by February 2003.

The CQAR has continued to prove very reliable with no known cases of failure. The PCMCIA cards have not proven so reliable, but problems were primarily due to mishandling, with a number of cards continuing to function despite obvious signs of external damage. The cards were relatively cheap and BHL did not see the need to provided better protection for them, such as by requiring them to be carried to and from the aircraft in a case.

With the advent of the common download process for both HUMS and HOMP data, data collection rates improved significantly. Prior to this it was noted that certain engineering shifts had a better collection record than others. Only technical failures now prevent data collection.

With the exception of the FDS programme (which is type-specific), the comments on the HOMP software in Section 3 sub-section 2.1 are also relevant here.

3.2 HOMP Analysis

Most of the improvements in the AS332L HOMP data analysis have already been described in Section 2 sub-section 5.

A minor problem was found with the identification of adjacently-located helidecks, such as can occur when an accommodation barge is alongside a platform. FDT uses the aircraft's touchdown position to scan through its list of locations until it finds one that is within the specified tolerance. This is normally set to 500 metres to allow for the resolution limitation of the FDR data which has to scale latitude or longitude into a 12 bit binary number, resulting in a resolution of approximately 200 metres. Therefore when two helidecks are in close proximity, FDT can identify the wrong location. To address this issue the location entered into BHL's INTOPS system (which should always be correct) was added to the flight operations data file imported into FDT. As FDT could only import numeric data into its User Defined Fields, the INTOPS location ID number was used.

3.3 HOMP Operational and Management Experience

With the appointment of the Assistant HOMP Manager (see Section 3 sub-section 2.3), the balance of workload versus personnel resources was satisfactory. BHL management have fully taken on board the benefits of the programme and have been helpful and supportive. After a short period of training, the Assistant HOMP Manager was left to run the programme unsupervised, with the HOMP Manager only being required to resolve IT issues and carry out management functions, rather than system operator functions.

3.4 'Closed Loop' Feedback Processes

Good feedback processes were established at Aberdeen and Scatsta during the main HOMP trial. When HOMP was extended to Den Helder (operating S76s and one AS332L), a Base Representative was appointed at Den Helder. He was an S76 Training Captain and had previously flown the AS332L, so he had a good insight into both types operated from the base. Any events worthy of further investigation occurring at Den Helder would be passed to the Base Representative, who would liaise with crews as necessary and report back to the Aberdeen office.

4 Event Severity Assessment

To enable different helicopter operators to compare event trend data and share experience from their HOMP programmes, it would be beneficial if the operators applied the same criteria when assessing event severity. This implies a need for a standardised event severity assessment process that could be adopted by multiple HOMP participants. In the HOMP trial follow-on work, both BHL and Scotia manually allocated severity values to events using the 0-10 scale described in Section 2 sub-section 5.2.4. Based on the experience gained, BHL's and Scotia's viewpoints on the event severity allocation process are given below.

4.1 BHL Viewpoint on Event Severity Assessment

Event severity allocations made by different companies will never be consistent enough to allow any direct comparison of cumulative event severities. In any event, it would be wrong to make direct comparisons such as “operator A is safer than operator B because its cumulative event severities over the last month were lower”. Only a relative comparison is relevant, for example “the event that is highlighting the greatest risk at operator A is x, what is operator B finding?”

Assessment of severity will always involve a qualitative judgement that will be influenced by current issues within a company. For example, following a serious incident, related HOMP events are likely to assume a higher profile than they had before. Even if there were some sort of automatic severity calculations, it is likely that these would be adjusted or over-ridden following such an incident on the grounds that the initial assumptions used to create the criteria were out of date.

Notwithstanding the above, there is certainly scope for improving the consistency of severity allocation within a company. The production of a document listing each event, with the reason for the event, the surrounding issues and guidance on how to set severity would be a very useful – if onerous – task. This could certainly include a default severity value for some events, with a normal range of values either side of the default value so that the severity can be adjusted up or down depending on a set of related factors.

There are a number of HOMP events that do not directly relate to an operational hazard. These events can however indicate abnormal operations and can thus point to an occurrence worthy of investigation. It is for this reason only that the events are left in the system. Where these events are triggered without there being any additional issues, the severity should be set to zero.

4.2 Scotia Viewpoint on Event Severity Assessment

Whilst a common severity scale can be utilised, the assessment of the relevance of an event to a particular company's operations will cause variations between operations and operators. However there is a good case for maintaining as much consistency as possible in the process.

For some events there is a reasonable case for having a default severity value for the event. However, the nature of helicopter flying means that occurrences do not always trigger single events, but a combination of several related events. It is in the allocation of severity values to these multiple events that personal flying and operational experience will more strongly 'colour' decisions. Also, what is a severe event to one company may be viewed with less severity by another company. This may be because the operation is different, or there is a 'cultural' difference between operators.

An agreed severity scale common to all operators would be useful, with a defined list of default severities for a small number of events. The remaining events would be left to the judgement of the individual operator, but perhaps with some greater interpretive guidance provided for the allocation of higher severity values. HOMP event severity allocation should be unique to a particular operator and its operations, being used to provide a constant measure against which the operator can assess itself. It does not matter that one operator allocates severity values to events in a different way to other operators. Operators will view their problems differently, but it is important that an operator views its own problems and trends in a way that is uniform, consistent and meaningful to its own operation.

5 Discussion

5.1 HOMP Experience

Both BHL and Scotia have been able to successfully implement, operate and manage effective HOMP programmes and, in both cases, these programmes have been well accepted by the crews. Whilst Scotia operated a trial programme on two AS332Ls, by early 2003 BHL had successfully extended HOMP operations to the whole of their North Sea AS332L and S76 fleets, located at four different bases.

All the on-aircraft and ground-based HOMP equipment operated reliably, providing an effective helicopter flight data recording and analysis capability for both the AS332L and S76 helicopters. The initial lack of GPS data on the S76 had quite a major impact on the S76 programme, highlighting the value of this data. If, on other aircraft types, it is impossible to obtain GPS data, some of the negative impact could be mitigated by modifications to the HOMP analysis system; for example by extracting take-off and landing locations from imported flight operations data.

The general acceptance of the HOMP by crews was a result of the efforts made by both Scotia and BHL to protect crew confidentiality and ensure that HOMP data was not misused, or results used for punitive purposes. Scotia made a particular effort at the start of their trial programme to develop a HOMP agreement with BALPA before any HOMP data analysis commenced.

As a result of the follow-on work and their wider HOMP implementation, BHL have gained considerable experience in HOMP operations at remote bases (i.e. at Scatsta, Norwich and Den Helder). An effective IT infrastructure has enabled efficient data transfer and the processing of all HOMP data at one centralised location in Aberdeen. The use of Base Representatives at Norwich and Den Helder has also provided effective follow-up and feedback at these bases.

BHL and Scotia have used various mechanisms for providing feedback on HOMP findings and, where necessary, taking corrective action. Both operators have found the most effective feedback mechanisms to be confidential crew debriefs and involvement of the training departments in corrective actions. Both of these mechanisms have been considerably aided by the use of Training Captains in the operation and management of the HOMP programmes.

Both operators agree with the principle of a common scale for the allocation of event severity values. However, the operators believe that there should be flexibility to allow the process to be adapted to suite the needs of a particular company. It is considered to be essential that guidance material is produced on how to determine an appropriate value for an event.

5.2 Integrating HOMP into an SMS

To avoid the danger of HOMP becoming a 'hobby' programme that is not properly proceduralised or integrated with other safety systems, it is important that the programme is properly integrated into the operator's Safety Management System (SMS). BHL's HOMP Manager's interface with the FSO provided a link between HOMP and BHL's SMS. Consideration was also given to creating a further link by enabling the SMS focal point to have de-identified access to event trend information within the HOMP FDE database. In the production of their SMS documentation, Scotia included HOMP as another safety activity that was an integral part of the SMS.

The SMS process needs to be proactive (i.e. actively looking for hazards) and, as the HOMP is a key proactive tool, it should form an essential part of the SMS. The primary function of the HOMP is to identify hazards, the SMS must then ensure that appropriate responses are made to these hazards. The HOMP information should also feed into the analysis performed for the safety case for an operation. A link should be established between HOMP information and safety cases so that HOMP information can be used to trigger the re-analysis of a safety case. This would, for example, answer questions such as “is the safety case for an operation compatible with the findings of the HOMP?”

Section 4 HOMP Results – Flight Data Events

This section presents examples of significant individual events and event trends identified by Scotia and BHL on the AS332L and S76 aircraft. These illustrate HOMP event detection capabilities and also the effects of actions taken by the operators in response to the HOMP findings. The Section also includes an analysis of the operators' approaches to the allocation of severity values to events for trending and risk assessment purposes.

1 CHC Scotia AS332L HOMP Trial

1.1 Individual Events

Overtorque on Landing - Event 25B

During the trial commissioning phase an overtorque occurred on one of the trials aircraft when landing on an offshore installation. This happened before all of the HOMP infrastructure was in place and the event was not identified by the trial team until some time after its occurrence, hence it was not possible to perform the normal HOMP follow-up. The event was captured by the IHUMS so operational integrity and safety was maintained. However the HOMP information indicated that there were some human factors issues associated with the event and a discussion with the crew by the HOMP Manager would have been beneficial to all. In addition to the overtorque event (25B), the following two events were triggered by the occurrence: 12B "Excessive collective pitch control" and 23B "Downwind flight within 60 seconds of landing". The HOMP replay showed that the aircraft had approached high on a still air day and acquired a high rate of descent which was arrested with a large amount of collective. The pilots were probably looking out of the aircraft and therefore not watching the torque gauge.

Rushed Approach - Events 08B and 14C

Two HOMP events were generated during a rushed approach in foggy conditions. The aircraft was kept high by offshore ATC, however a 'hole' in the fog appeared and the aircraft descended though it, making a very rapid descent (triggering event 08A "High rate of descent above 500 ft"), followed by a hard right turn to landing, the heading hold still being engaged when the aircraft landed (triggering event 14C "Heading mode engaged below 60 kt"). The aircrew were debriefed by the HOMP Manager following the event and during this debrief the crew were able to comment on associated human and environmental factors. The input from the crew and a review of the weather information led the HOMP Manager to conclude the crew actions were reasonable and appropriate in the circumstances. The crew were able to see via the FDS replay of what they actually did on the day which proved very helpful.

Engine Overspeed During Ground Run - Event 32A

A significant HOMP event was triggered during a ground run performed by a pilot to check engine bleed band thresholds. After a slow start the engine was hunting, resulting in a fluctuating NR and the triggering of a high NR event, with the engine eventually tripping out on overspeed. The pilot applied a large amount of collective in an attempt to control the NR, which resulted in the helicopter becoming 'light on the wheels'. The pilot then re-started the engine (after the cutout had functioned at 320 NR) and attempted to repeat the process with the result that the engine again tripped out on overspeed. The event is illustrated in Figure 1, the black markings for the "weight on wheels" discrete towards the bottom of the display shows where the helicopter was effectively airborne.

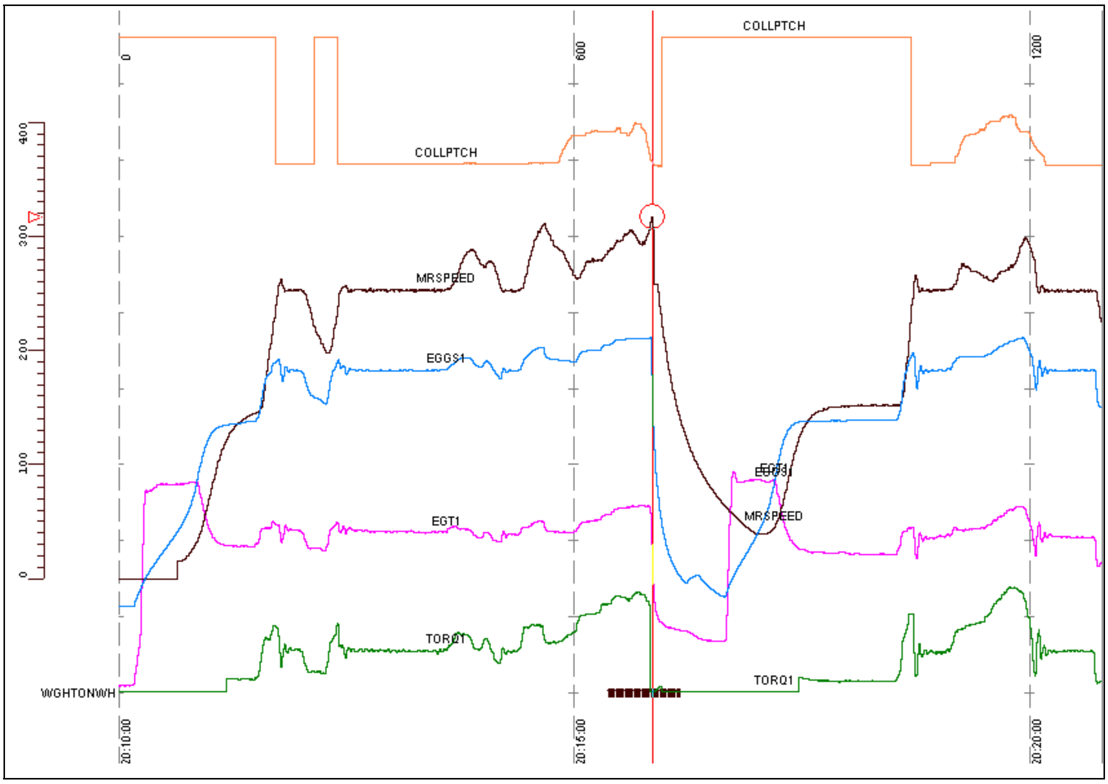


Figure 1 FDT Trace Showing Engine Overspeed Event

The engine was subsequently rejected by engineering at some considerable cost. When the event was initially detected by HOMP there was some doubt as to what had actually happened, as the 'trace' was unlike any that had been seen before. However, when the pilot was interviewed he confirmed that things had not gone according to plan during the ground run and an MOR was raised. The event raised a number of issues relating to ground tests being performed by a single pilot in a certified two-crew aircraft and at night. It also highlighted a hole in the system in that ground runs are not captured by the company Flight Business System, therefore investigating 'ground run' events involves some detective work should crew identification be required.

Below Minimum Height on Go-around at Night - Event 41C

Another event involved a go-around offshore at night following an Airborne Radar Approach, during which the aircraft descended to a height of 145 ft (the operations manual limit is 300 ft). Again, the HOMP Manager was notified and the crew debriefed on the event.

Exuberant flying - Events 02B, 02D, 03A, 04B, 05B, 06B, 07A

A series of HOMP events were triggered by some exuberant flying between two closely positioned offshore locations, which included 26 degrees nose down at take off, bank angles of greater than 60 degrees during turns and flight below 100 ft over the sea. The handling competency of the pilot was not in question, however the validity of carrying out such manoeuvres in the view of the helideck crew (i.e. the client) is questionable.

Unstable Take-off - Events 04B and 47A/B

Following the end of the six month trial period there have been other operational events where the crew have asked, or been invited by the FSO, to view HOMP data. One such event was an "unstable take off" from an offshore installation; the installation also submitted an occurrence report voicing their concerns. The HOMP data showed that the aircraft had height changes of between 1 and 11 feet above deck height, and whilst the aircraft was yawing to the left there were aircraft attitude pitch changes ranging between –6 to +7 degrees in a short period of time (i.e. two to three seconds). The event is illustrated in Figure 2.

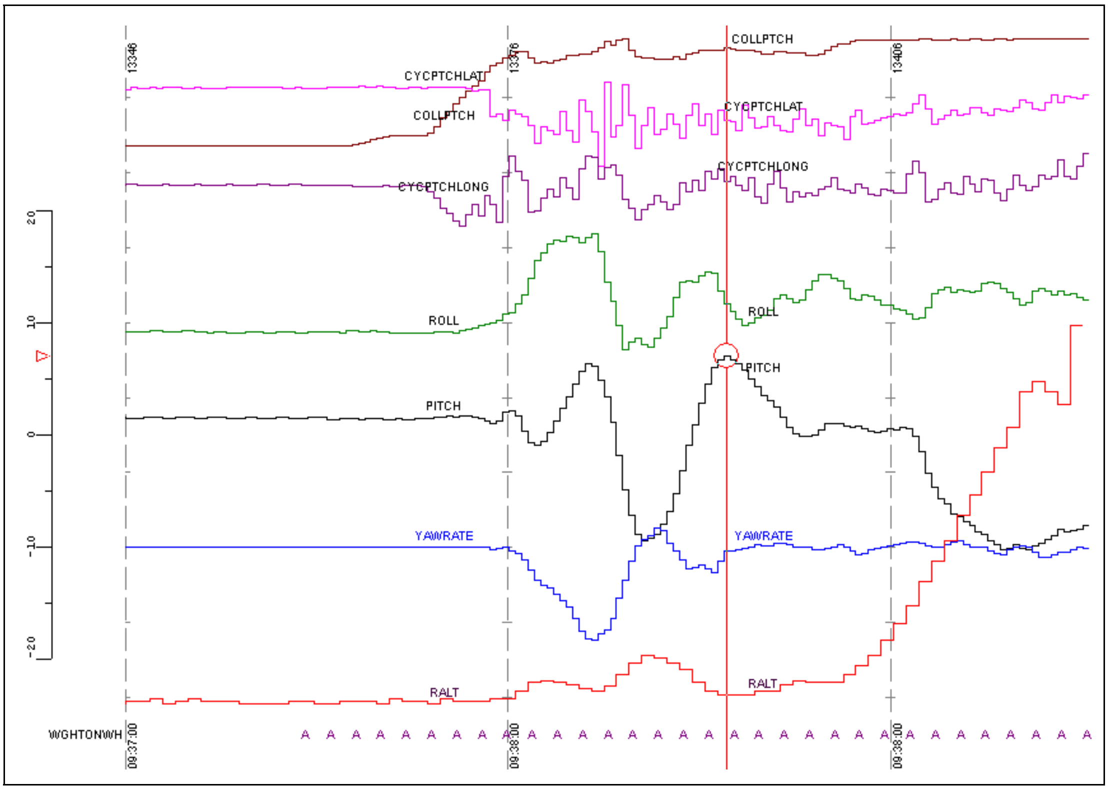


Figure 2 FDT Trace Showing Unstable Takeoff

The captain initially believed that the event could have been caused by ingestion of hot gas. The weather at the time was flat calm and the main flare on the exploration vessel was operating. He thought that this combination of environmental factors could have resulted in the aircraft manoeuvring into its own engine exhaust, causing a loss of engine power and a loss of thrust from the rotor disc. However the HOMP data did not support this hypothesis. The co-pilot (who was the non-handling pilot) commented that as the aircraft was brought to the hover the captain was looking out the right hand window and the turn to the left was initiated whilst he was still looking to the right. The more likely cause of the event may have been internal accelerations being created in the inner ear during the turn, whilst the pilot's head was turned to the right at the commencement of the turn-to-the-left manoeuvre. The Puma has a powerful tail rotor and is capable of generating very rapid movement around the yaw axis. Although the cause of the event could not be conclusively determined, both pilots found the replay of the event very constructive and useful in helping to analyse what had happened at the time of the incident.

1.2 Event Trends

During the trials the two HOMP aircraft had been flying approximately 20 days per month and 1507 sectors in total were flown during the trial period. There were no events on 89% of the sectors and, of the remaining 11% of the sectors, 75% of the events occurred on or near the ground. Figure 3 shows a plot of the cumulative event severities for the six month trial. The event with the greatest cumulative severity was 38B "Taxi limit (right gear lifts)", which indicates a potential excursion into the rollover zone when taxiing.

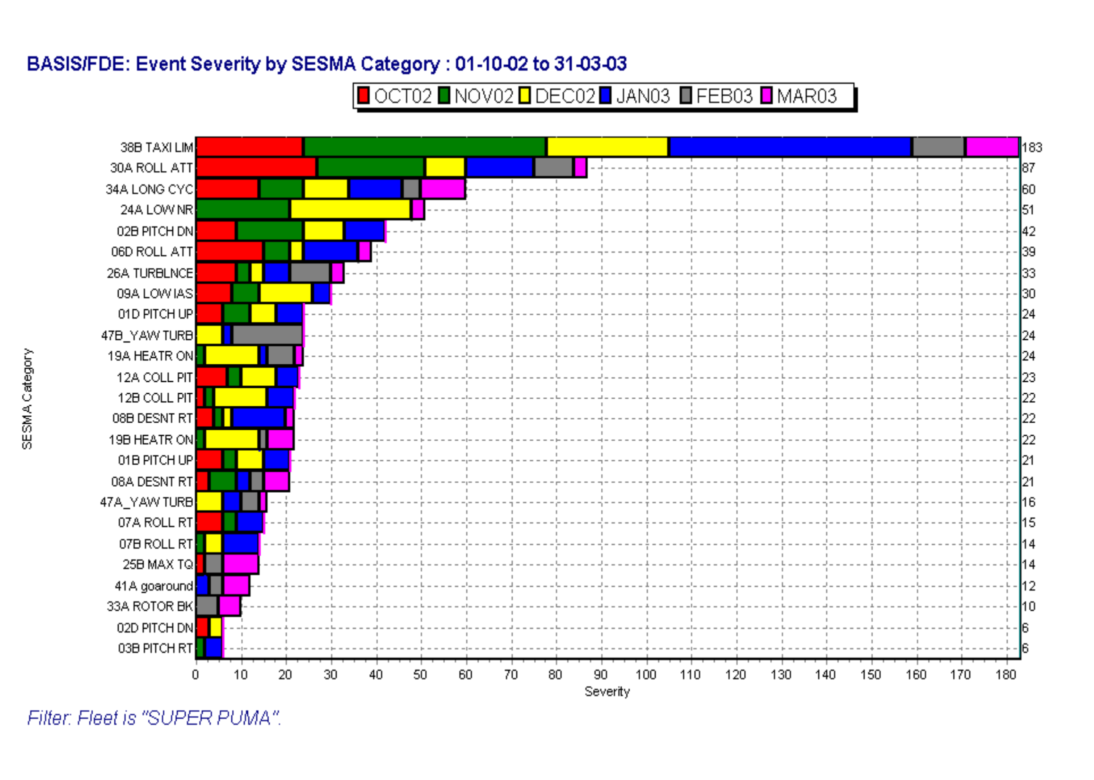


Figure 3 Scotia AS332L Cumulative Event Severity

The cumulative event severity plot shown in Figure 3 is a key trend analysis tool as it presents a picture of the relative levels of operational risk associated with the different HOMP events and enables corrective actions to be targeted at events representing the highest overall risk. For comparison, Figure 4 shows a simple count of the numbers of events generated during the six month trial, including those with a severity factor of zero. The chart only includes revenue flights and excludes any sectors flown for which there was no matching flight operations data. Again, event 38B "Taxi limit (right gear lifts)" is at the top of the chart as the most frequently occurring event. However, the order of the other events has changed and Figure 4 also includes some relatively frequently occurring events that have not had any positive severity values allocated (e.g. events 10A "Normal acceleration above 500 ft", 23B "Downwind flight" and 35A/35B "Motion Severity Index").

In the early days and weeks of the trial event 38B "Taxi limit (right gear lifts)" was the most frequently occurring event. After consultation with BHL, Scotia identified this as a flight safety issue and released a general notice on taxiing technique to aircrew via the chief pilot. Feedback on the event was also provided to the training department. It is believed that a contributing factor to the occurrence of these events was the move of operations from the East to the West side of the runway at Aberdeen at the beginning of June 2002. This increased the number of sharp turns required and Scotia's risk analysis had not identified the risks associated with the different taxiing requirements.

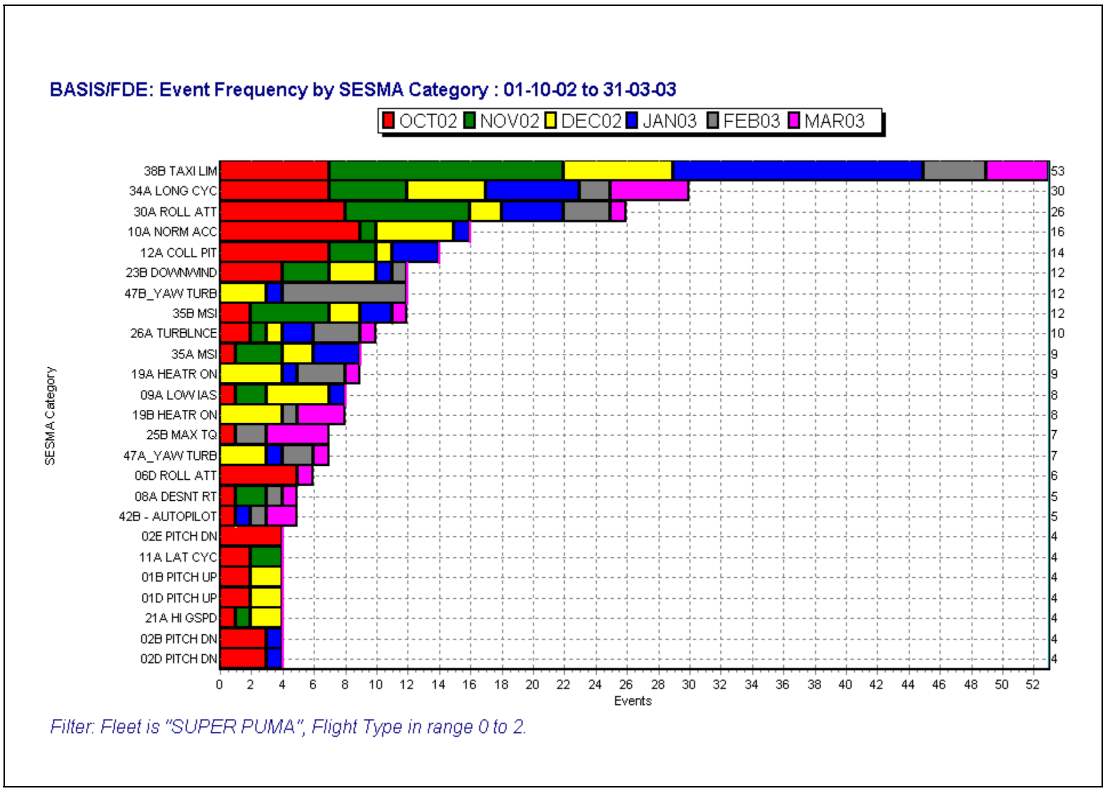


Figure 4 Scotia AS332L Event Count (including events with zero severity) on Revenue Flights

Nearly all taxiing events were in the 'right wheel lift' region, however there were two notable 'left wheel lift' events, in which full right cyclic was applied with full left pedal during a left turn. The pilots were contacted to review the HOMP events.

As a result of the actions taken, the frequency of excursions into the rollover zone during taxiing had reduced by over 70% by the end of the trial. The taxi event trend (factored by the number of sectors flown each month) is presented in Figure 5. The columns show the number of taxi events each month and the line shows the monthly cumulative severity value.

Similar to BHL's experience during the main HOMP trial, there were occurrences of the cabin heater being left on during take-off and landing and the FSO issued a safety notice. Occurrences of the autopilot being left engaged after landing and during taxiing were also detected by HOMP. Again these were noted in the monthly bulletins posted in flight operations. The HOMP proved useful for monitoring these types of check-list items.

Figure 6 shows the factored monthly trend of the total number of events given a positive severity value and the cumulative severity value for the trial period. The trend suggests that the HOMP feedback mechanisms adopted by Scotia had a positive effect that resulted in a progressive reduction in the events and their severities throughout the trial period.

For comparison, Figure 7 shows a trend of all of events generated on revenue flights during the trial period, including those with a zero severity factor. The reduction in events after the first month of operations is more noticeable and may be due in part to the rapid acquisition of experience in the event assessment process, coupled with initial publicity on the HOMP trial.

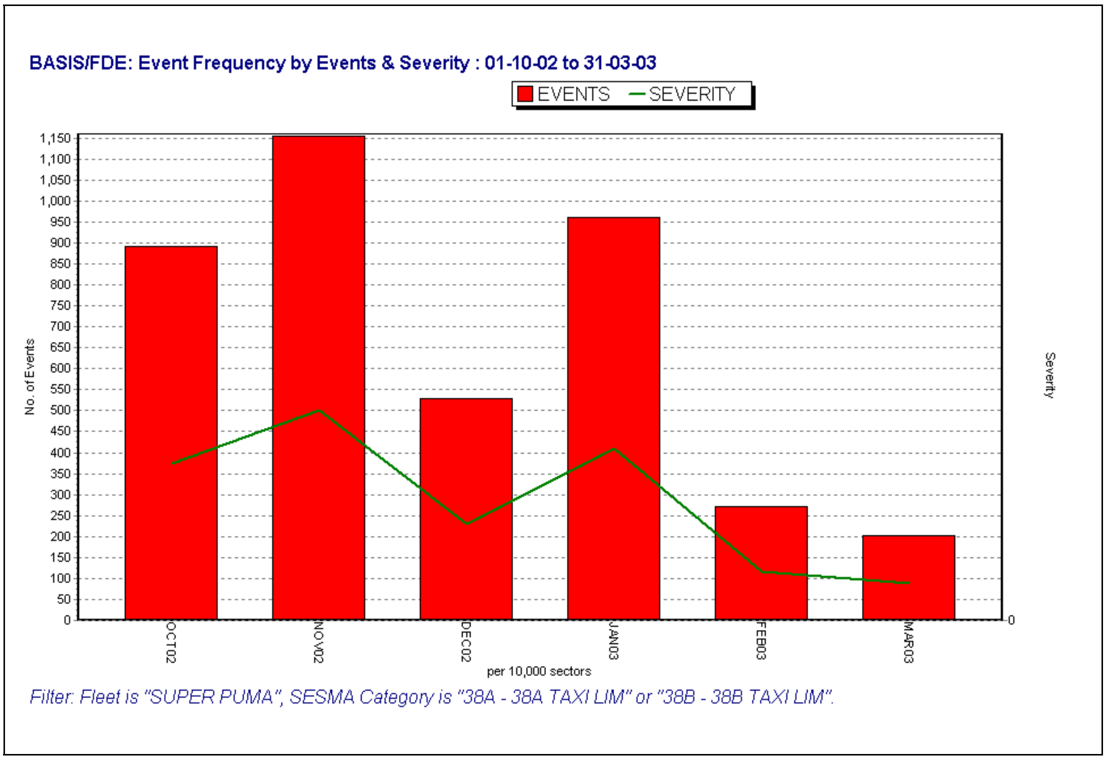


Figure 5 Trend of Scotia AS332L Taxi Limit Events 38A and 38B

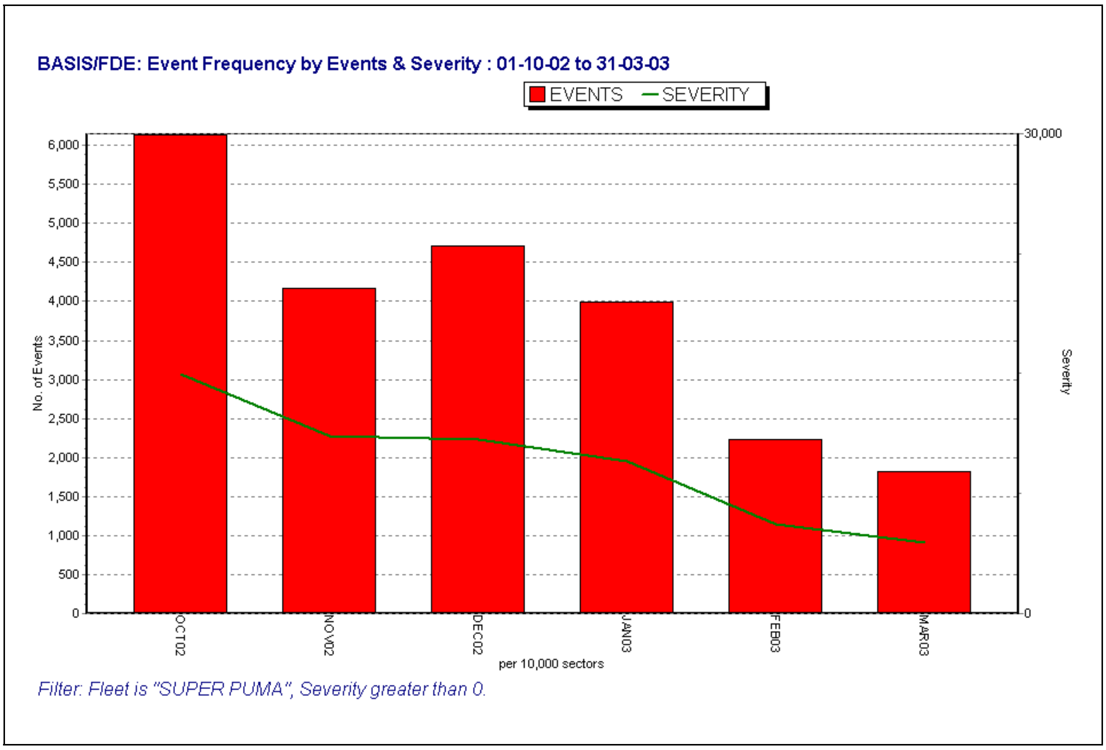


Figure 6 Trend of All Scotia AS332L Events with a Positive Severity Value

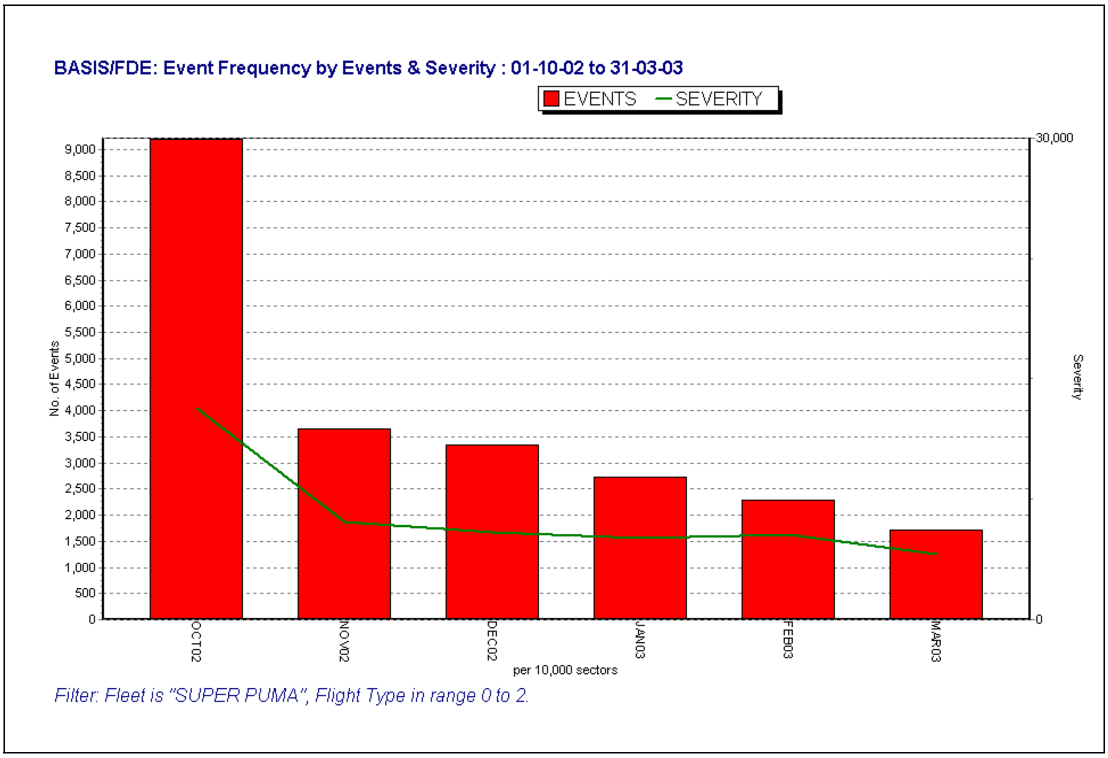


Figure 7 Trend of all Scotia AS332L Events on Revenue Flights

2 BHL S76 HOMP Trial

2.1 Individual Events

High Airspeed with Gear Down - Event 22C

The S76 has a limiting speed of 130kt for undercarriage down or in transit. This is because the undercarriage bay door struts have a weak link that is designed to break off if the flotation gear is deployed. Exceeding this speed with the gear down might cause parts to break away from the airframe.

The HOMP detected a number of exceedances of the 130kt speed limit. In some cases the excursions were minor and transitory, but in two cases the crew had clearly forgotten the state of the undercarriage. In one case this resulted in a flight of 17 minutes at 135 – 140kt with the undercarriage down and in another the aircraft was over 130kt for 3 minutes, reaching a maximum of 139kt.

The S76 Fleet Representative was both surprised by and interested in these exceedances, and instituted an awareness campaign amongst S76 crews. The issue was also covered in one of the HOMP newsletters. As a result of this action, whilst the problem did still occur occasionally, the occurrence rate fell substantially. Figure 8 shows the event rate factored by the number of sectors flown each month and the reduction in events can clearly be seen. However it can also be seen that after the campaign over the summer, the occurrence rate started to creep back up again, indicating that ongoing action was required.

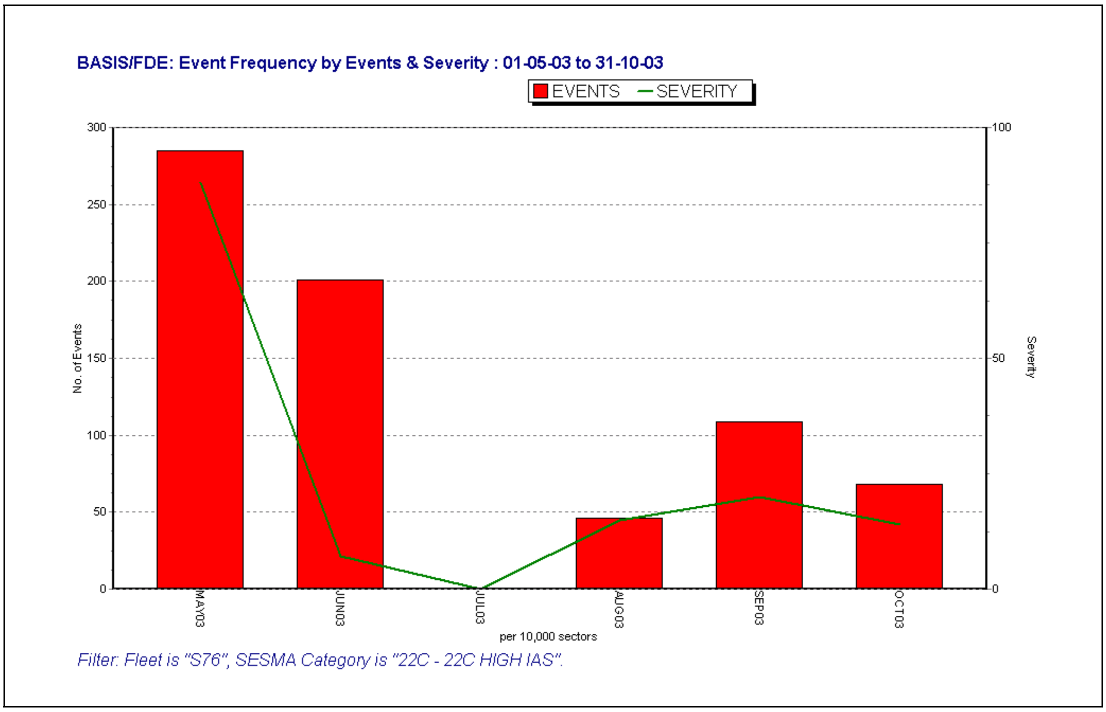


Figure 8 Trend of BHL S76 Airspeed with Gear Down Event 22C

Vno Exceedances - Event 17A/C

At the start of the trial there were a large number of Vno event exceedances (the event limit was set to Vno + 2kt). Following lengthy discussions with the S76 Fleet Representative, it was appreciated that the S76 routinely cruises near Vno and so exceedances were inevitable. Provided crews were not exceeding Vne, the S76 Fleet Representative considered that no action should be taken. He believed that the inclusion of Vno in the Flight Manual was a UK CAA requirement, and in the original certification by the FAA there was no mention of Vno. By comparison, the normal cruise speed of the AS332L is typically 20 kt below Vno, and the limit would only be reached in a high power descent. The S76 continues to cruise smoothly above Vno, whereas on the AS332L there are likely to be significantly increased vibration levels above Vno that are uncomfortable for passengers and probably damaging to the helicopter in the long term.

A higher Vno event limit could have been specified, but as the limit is increased the event becomes related less to Vno and more to Vne (which is 10kt greater than Vno). On the basis that no action would be taken following Vno event exceedances, and a separate Vne event exists to detect Vne exceedances, a decision was made to inhibit the S76 Vno event. It was considered that the flight data measurements could be used if there was a need to assess how close aircraft were operating to Vne.

There were, however, a few instances of the exceedance of Vne, which was clearly unacceptable. Crews were debriefed on these occasions by the Norwich representative.

Late Gear Down Selection on Landing - Event 15B

The S76 must slow down from its normal cruise speed before the undercarriage is lowered. On the AS332L, undercarriage-down selection is normally made during the Approach checks and checked during the Finals checks, whereas on the S76 it is normally made during the Finals checks. On the AS332L the undercarriage is normally left down for short to medium distance transits, as there is no speed limit and only a marginal drag increase, whilst on the S76 it is more likely to be selected up for transits. This can lead to an increased likelihood of late or missed undercarriage-down selection.

Two late undercarriage-down selections were detected by the HOMP. In each case the gear was not selected down until the audio warning was activated (this is triggered by low height and airspeed with the gear up). In the most significant of these, the gear was selected down at about 300 ft above the sea (150 ft above the helideck) and at about 40kt, some 17 seconds before touchdown.

In each case the Norwich representative discussed the event with the crews and problems of distraction and CRM were uncovered. However, it was believed that these were isolated events and the existing procedures, including the warning system, would make the chances of a gear-up landing very remote. Therefore, apart from reporting the issue in a HOMP newsletter, no further action was taken.

Overtorques

Event 25G: Maximum Combined Torque Over 200%

A significant operating factor on the S76 is its lack of available power during rig takeoffs and landings. The maximum permitted torque is 200% (i.e. 100% per engine) with an allowed transient up to 230%. Events were set up at both of these limits, but the time period for the 200% torque event did not represent a flight manual limitation.

After discussion with the S76 Fleet Representative, it was decided to leave the 200% event in as, even though crews could not really be faulted for using the permitted transient limit, the S76 representative wanted to have some data as to how often it was used. The event was triggered from time to time in hot calm weather and the data was passed to the S76 representative, though normally no crew intervention took place. The event set at 230% torque was never triggered.

Event 25C/D: Maximum Continuous Torque, Engine 1/2

There is also a single-engine overtorque event that can be triggered during the engine power assurance check which, on the S76, is done one engine at a time by retarding the other engine to idle. The flight manual states that maximum continuous torque should not be exceeded during this check. If it will be, crews should climb to a higher density altitude where full power on the engine will not exceed the limit. There were a few occurrences of this event, but after the S76 Base Representative circulated advisory material to the crews, these largely disappeared.

2.2 Event Trends

Figure 9 shows a plot of the cumulative event severities for the six month period of May-October 2003, after GPS data was available to enable the identification of take-off and landing locations. The period covered is subsequent to the S76 event review discussed in Section 2 sub-section 5.2.2. Event 22C “High airspeed with gear down” is the most significant event. Events 25D “Maximum continuous single engine torque” and 39A “Single engined flight” were triggered during power assurance tests.

It can be seen from Figure 9 that there was a narrower range of events with potential safety consequences on the S76 than on the AS332L, even taking into account the different amounts of flying carried out by the two types. Although the exact reason could not be established, consideration was given to possible contributory factors.

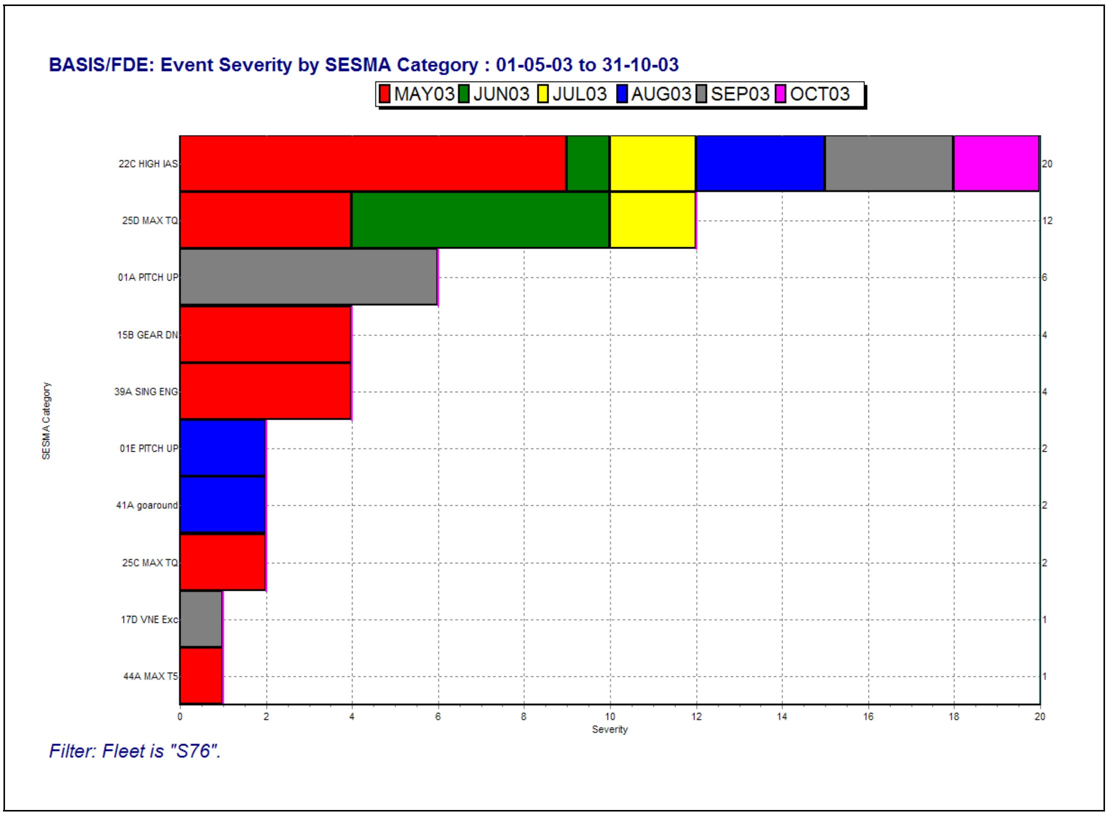


Figure 9 BHL S76 Cumulative Event Severity

It could be that the S76 fleet was operated more carefully than the AS332L fleet. This is not as contentious as it sounds as, just before the HOMP trial started, there was a fatal S76 accident at Norwich. By comparison the last fatal accident on the AS332L fleet was in 1992 and it is possible that there may have been a greater sense of invulnerability within that fleet.

The S76 event limits could have been set too wide. The limits were reviewed by the HOMP Manager and the S76 Fleet Representative, and the period for the event trends presented in the report was after any adjustments had been made as a result of this review. Furthermore, Figure 10 shows that substantial numbers of events were being triggered, suggesting that limits were not too wide. If any significant S76 occurrences were being missed it could have been due to a lack of relevant events, however, the S76 Fleet Representative had not been able to identify the need for any new events during the event review that had been performed. When considering either raising or lowering event thresholds, it is beneficial to use the FDM module to review the measurement that is associated with the event. By plotting a histogram of the measurement, a decision can be taken as to how far away (in terms of standard deviations) from the normal value the event limit should be set.

Another possible factor was that neither the HOMP Manager nor his assistant had any experience on the S76 fleet and it might have been less obvious to them when a significant event had occurred. On the AS332L fleet some of the most significant occurrences were only discovered because investigation of seemingly minor HOMP events pointed to a more serious event that was either undetectable by HOMP, or had not previously been thought of, and was therefore not programmed into HOMP. This could be an argument to support local analysis of HOMP data at Norwich. However, the HOMP Manager considered that the Norwich-based Fleet Representative was able to properly participate in event investigations using event data sent from Aberdeen, and that implementing local data analysis at Norwich could not be justified on the basis of the experience gained at that time.

Figure 10 shows a count of the numbers of events generated during the six month trial, including those with a severity factor of zero. Again, the chart only includes revenue flights, and excludes any the sectors flown for which there was no matching flight operations data. Although the top five events in Figure 9 all feature in Figure 10, the latter figure contains many other events. A comparison of the two figures highlights the impact of the event severity assessment on the operational risk 'picture' provided by the HOMP and hence the importance of having an effective assessment process.

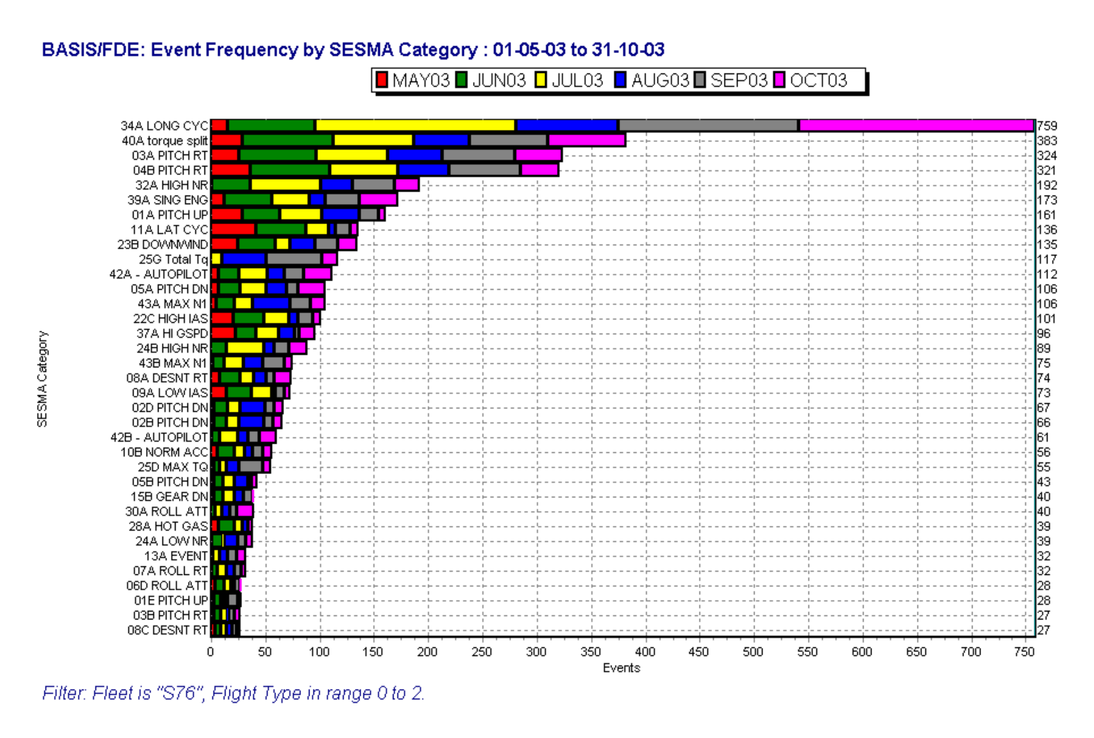


Figure 10 BHL S76 Event Count (including events with zero severity) on Revenue Flights

Figure 10 does not contain any events associated with the lateral and longitudinal acceleration data from the newly fitted triaxial accelerometer. The most useful function this provided was for the calculation of the Motion Severity Index used for event 35A/B to detect excessive movement of vessel helidecks. Unfortunately an investigation into the absence of these events at the end of the trial period revealed an error in one of the condition checks in the event definition that had prevented the event from being triggered. This had been overlooked as event 35A/B had to be disabled at the start of the trial owing to the lack of the triaxial accelerometer. The experience highlights the need for periodic checks to ensure that all events are working. The other acceleration-related events are generally triggered very infrequently but when they are, it is usually as a result of a serious occurrence which HOMP should be empowered to detect. Therefore, although not demonstrated in the trial, the triaxial accelerometer was considered to be a worthwhile addition on the S76.

Figure 11 shows the factored monthly trend of the total number of events given a positive severity value, and the cumulative severity value, for the six month period. Although there are monthly variations, the overall trend is downwards, with a large decrease after the month of May 2003. It can be seen from Figure 9 that this is primarily due to a decrease in the monthly cumulative severity for the events relating to gear down airspeed limit exceedances and power assurance checks (events 22C, 25D and 39A) after May.

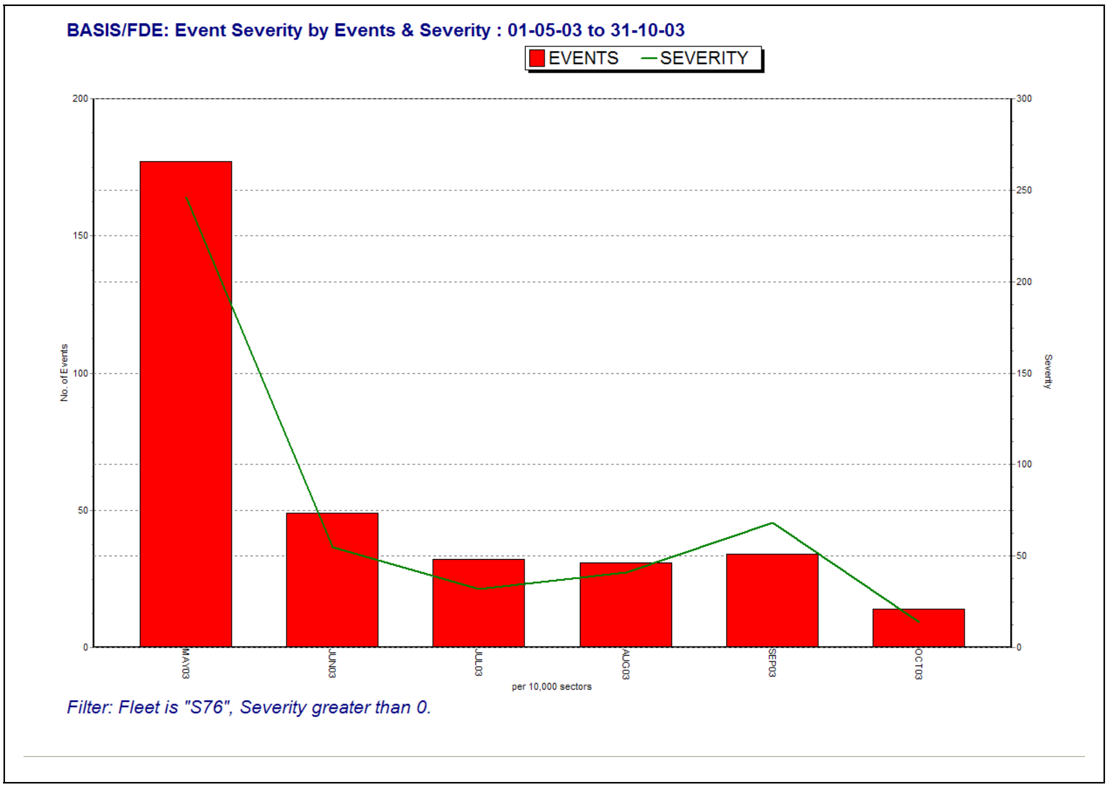


Figure 11 Trend of All BHL S76 Events with a Positive Severity Value

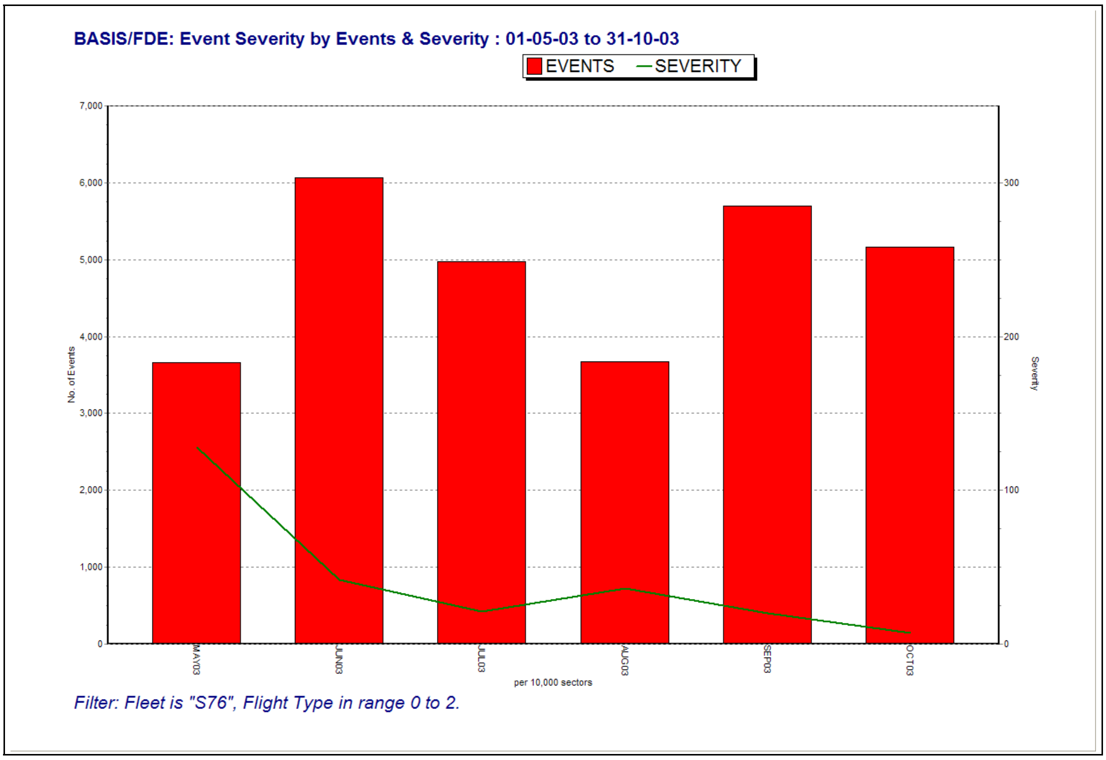


Figure 12 Trend of All BHL S76 Events on Revenue Flights

Figure 12 presents a factored trend of all of events generated on revenue flights during the six period, including those with a zero severity factor. The monthly cumulative severity decreases during the period, but there is no trend in the total number of events being generated by the HOMP. There were no changes in any event limits during this period.

3 BHL AS332L Fleetwide HOMP Implementation

3.1 Individual Events

A number of significant events occurred on the AS332L fleet during the S76 HOMP trial period, a selection of these is described below.

Severe Weather Encounter - Events 1C, 1E, 2C, 2E, 3B, 7B, 9A, 10A, 10C, 10E, 11A, 11C, 12B

An aircraft was damaged following an encounter with severe weather, believed to be a water spout. The aircraft, which was in cruising flight, experienced roll rates of 50 degrees/second, yawed through nearly 90 degrees, and achieved 0.6g lateral, 0.5g longitudinal and 2.1g normal accelerations. The tail rotor contacted the tail pylon, making a hole in it and severely damaging all the tail rotor blades. It was very fortunate that no significant mass was lost from a tail rotor blade, but chordwise cracking showed that this had nearly happened. In the event the aircraft was able to return safely to base. A total of 13 HOMP events were triggered by the incident, including abnormal accelerations, pitch and roll attitudes and rates, and extreme control positions. An FDS replay of the incident is shown in Figure 13.

Figure 13 FDS Replay of Severe Weather Encounter

The AAIB decided to conduct an investigation and to save time and, with the crew's permission, the HOMP data was given to the AAIB inspectors on arrival in Aberdeen. The FDR had been sent to Farnborough for replay, but it would have been a few days before the data was available.

Unfortunately the AAIB were about to replay the data not only to the crew, but also to a representative of the oil company chartering the aircraft. Fortunately the company's Flight Safety Officer was present and stopped them, because this would have been an inappropriate use of the data. Whilst there is no doubt that the AAIB can legally demand to have the HOMP data, in future the HOMP Manager will ensure that they understand the sensitivity of the data before handing it over.

Fuel Management – Event 18A/B

A low fuel event was triggered during a long flight from Aberdeen up to the East Shetland Basin. It transpired that the fuel transfer pump, which is routinely used to move fuel from the right to left-hand engine's tank groups, had been left running for a long period, including throughout the stop at the first destination platform. This continued until landing at the second destination whereupon the right-hand tank group's level had fallen to the point where its low level warning light illuminated, this coinciding with the point at which the HOMP event is triggered. At the same time, the left-hand tank group was nearly full.

The HOMP Manager was very surprised that this mistake could have been made as "Fuel" is an item on the before-takeoff checks, and a green light on the fuel management panel clearly indicates that the transfer pump is running. It is also a routine part of flight monitoring to switch off the fuel transfer once the tank contents are balanced.

The incident was discussed with the crew but, to the HOMP Manager's surprise, they said that it was not an oversight but intentional. The captain's argument was that it was a Sunday, with all en-route refuelling stops closed or in bad weather, and the weather in Aberdeen requiring Edinburgh diversion fuel to be carried. So the only way they could "get the job done" was by filling the tanks to the maximum. One way to increase the amount of fuel loaded is to fill one tank, cap it and then run the transfer pump to add further to its contents whilst refilling the other. By the extreme unbalancing of fuel, the crew would first refill the nearly-full tank and then the transfer pump would be topping this up whilst the empty tank was being refilled.

The transfer pump moves fuel at approximately 600lbs per hour. It would have taken a maximum of 3 minutes to refuel the nearly empty right-hand tank. During this time the transfer pump would have added about 30 lbs of fuel to the left-hand group – enough to fly for less than 2 minutes, which is not significant compared to the overall endurance of nearly 4 hours.

Therefore there had been no significant gain, but there was certainly an increased risk. If the aircraft had suffered a left-hand engine failure, as the fuel consumption of the right-hand engine running at high power is more than the transfer pump can replenish, the aircraft could have run out of fuel in that tank group and had to ditch. If the 30lbs had really been that critical, the same result could have been achieved by prolonging the refuel time on deck by an additional 3 minutes – there was no need to deliberately mismatch the fuel.

Even though the Operations Manual states that the transfer pump shall be used to match the contents of the two tank groups as soon as possible, the captain was not convinced that he had done anything unwise. He simply repeated that this was the only way he could get the job done. Based on past experience, it was decided not to press the matter too strongly as in all probability he had taken the issue on board but was not prepared to admit it. Interestingly, the HOMP office then received feedback from the crewroom that the captain had complained about the debrief by the HOMP department, but that none of his colleagues had any sympathy once the circumstances were revealed. It was therefore concluded that the combination of the debrief and, in particular, peer pressure would be sufficient to ensure that the event did not recur.

Low flying – Event 22A/B

The HOMP Manager's policy with regard to flights where no passengers were carried was that, provided aircraft limitations were not exceeded and the flight was not considered to be in any way dangerous, a 'blind eye' could be turned to exuberant flying on the grounds that it helps pilots to get a better feel for their aircraft in unusual flight conditions. If all flights were limited to the usual 20 degrees of bank, pilots might not be able to cope with anything more severe.

However, one pilot in particular had been testing this limit over a period of time and the HOMP Manager finally decided to intervene following a flight at 130kt, 17 feet above the sea. It was considered that any sudden problem might have caused the aircraft to hit the sea and that a bad example was being set to the very inexperienced co-pilot. A discussion was held with the pilot, who agreed to calm down. There have been no recurrences that have concerned the HOMP Manager.

Training Flights

Bank limits - Event 6C/D

It is expected that training flights will generate numerous events, due to single-engine flight and other unusual flight conditions being practiced. These flights were still reviewed however, and several showed that the Flight Manual weight-related bank angle limits were being exceeded during unusual attitude recovery exercises. The individual training captains involved were reminded of the limits but, as the problem seemed endemic, the Flying and Training Standards Manager issued a letter to all AS332L training captains reminding them that they too were bound by flight manual limits. The recurrence rate subsequently dropped to nearly zero.

Single-engined flight - Event 39A

On one flight it was noticed that the training captain was conducting actual single engine landings to offshore helidecks. Although no doubt good training value, this was considered quite dangerous and is prohibited in the Training Manual – single engine flight is to be simulated by limiting collective travel. The training captain in question pointed out that he was maximising safety by only retarding the throttle once over the helideck edge but, nevertheless, the HOMP Manager believed it would be a dangerous precedent to allow this and asked the training captain to desist, which he did.

Overtorques - Event 25B

A few overtorques occurred during the period under review, some of these were due to excessive right pedal input during an offshore takeoff manoeuvre. One overtorque was caused by a lack of friction on the collective lever after takeoff from Aberdeen, with the collective motoring up by itself. In each case the crew, which had generally included an inexperienced co-pilot at the controls, were shown the data and ways of avoiding a recurrence were explained.

Rollover Limit Exceedances During Taxiing - Event 38B

Some of the taxi events detected in the early days of the HOMP trial continued to occur from time to time, albeit at a much reduced level. On one occasion an event was triggered as the result of too much right pedal whist taxiing without the corresponding right cyclic. The pilot in question was not a company employee and an infrequent flyer of the type and, as such, had probably missed the previous campaign on the issue. This highlighted the need for continued vigilance on events that might otherwise be thought to have been 'fixed'. There will always be pilots new to type that may have missed or forgotten information during their conversions.

Occurrences Leading to New Events

Turbulence

The HOMP office received a visit from a pilot who, when landing on a barge alongside a platform, was surprised by the amount of turbulence encountered. Unfortunately this was not detected by the HOMP as the turbulence caused a yawing motion which was countered by pedal inputs rather than movements of the collective (the current turbulence algorithm uses only collective movements). This was because the turbulence was caused by lateral gusting, rather than the more normal vertical gusting. As a result of this visit, it was realised that the turbulence event did not cover all turbulence phenomena and so a new event was created (see Section 2 sub-section 5.2.1).

Inadvertent Descent During a Night Rig Approach

Although no HOMP event had been triggered, a captain requested a HOMP debrief on an occurrence resulting from a CRM problem when shuttling between two platforms at night. The co-pilot had suspended the AVAD (which gives a "check height" message at 300ft) without the captain's knowledge and, as a result, the aircraft had descended without the captain noticing until the 100 ft warning sounded. The captain recovered the situation and a normal landing was made. The captain was surprised when he saw a replay of the data which showed that, when about 1km away from the platform, the aircraft had descended to approximately 65ft and had an airspeed of only 35-40kt (see Figure 14). This was a potentially serious incident which could have resulted in the aircraft descending into the sea, and the HOMP Manager was pleased that the captain had sufficient trust in HOMP to be prepared to volunteer for a debrief. A new event was implemented to detect an in-flight condition of low height and speed at night (see Section 2 sub-section 5.2.1).

Figure 14 FDS Replay of Inadvertent Descent

Event Trends

Despite the tripling of the number of AS332L aircraft in BHL's HOMP, the rate of occurrence of significant events fell substantially during the HOMP trial follow-on programme. Figure 15 shows the factored trend of event numbers and cumulative severity values for a six month period to the end of September 2003. Only events with a severity greater than zero are included. The chart provides evidence of the success of the programme but, of course, this should not be allowed to lead to any complacency.

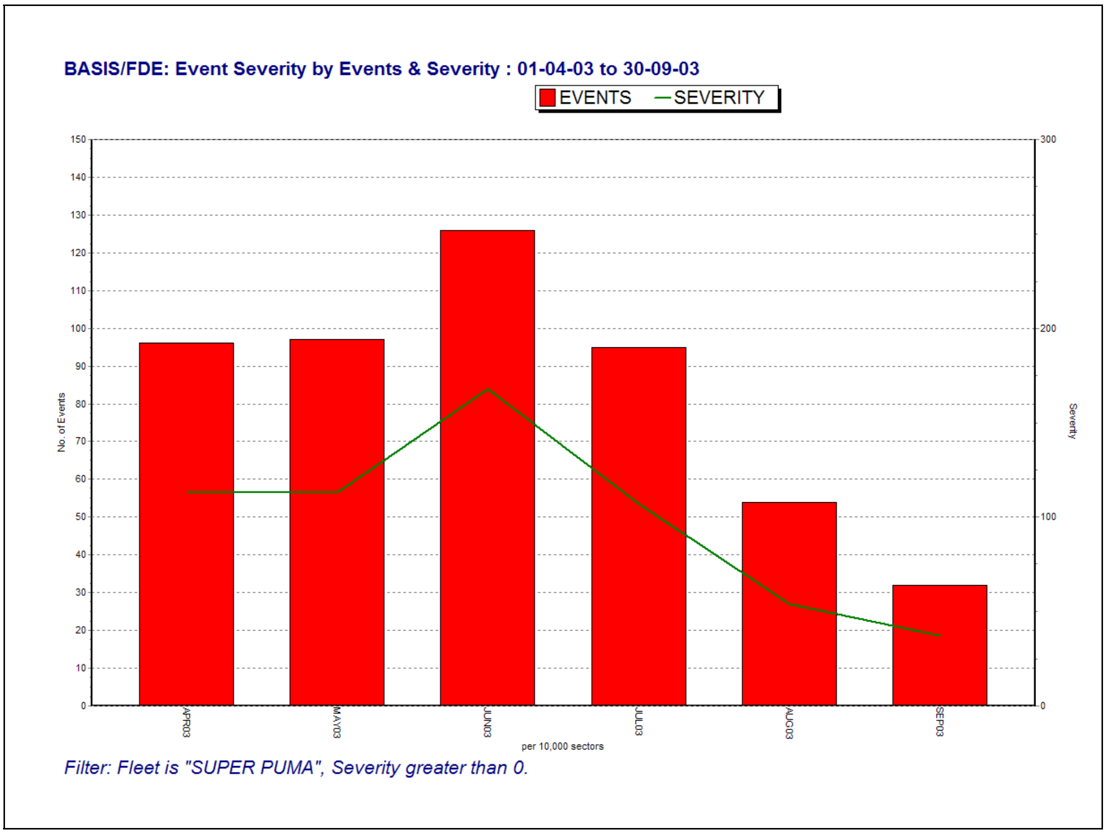


Figure 15 Trend of All BHL AS332L Events with a Positive Severity Value

For comparison, Figure 16 shows a factored trend of all of events generated on revenue flights during the six month period, including those with a zero severity factor. There were no charges to event limits during the period and the figure shows that the total number of events being generated by the HOMP was approximately constant. This is not significant, as all the events given a severity value of zero do not represent any type of operational risk. The total number of events an operator is prepared to accept (i.e. including those given a zero severity value) is largely a workload issue. Event thresholds could be raised to reduce the number, but this would reduce the possibility of discovering a significant safety issue that may not have a clear relationship with any single event.

Figure 17 shows a plot of the cumulative event severities for the six month period to September 2003. As for the BHL AS332L HOMP trial period (described in Reference [2]), the event with the greatest cumulative severity was 17C (Vno exceedance).

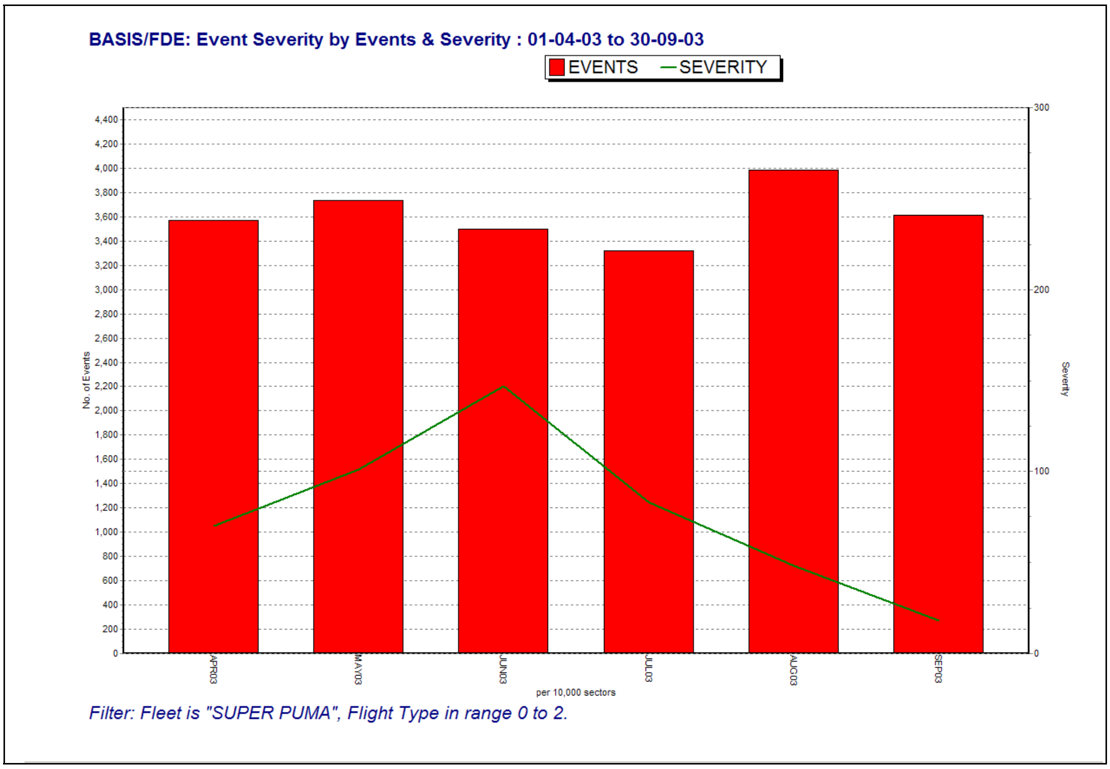


Figure 16 Trend of all BHL AS332L Events on Revenue Flights

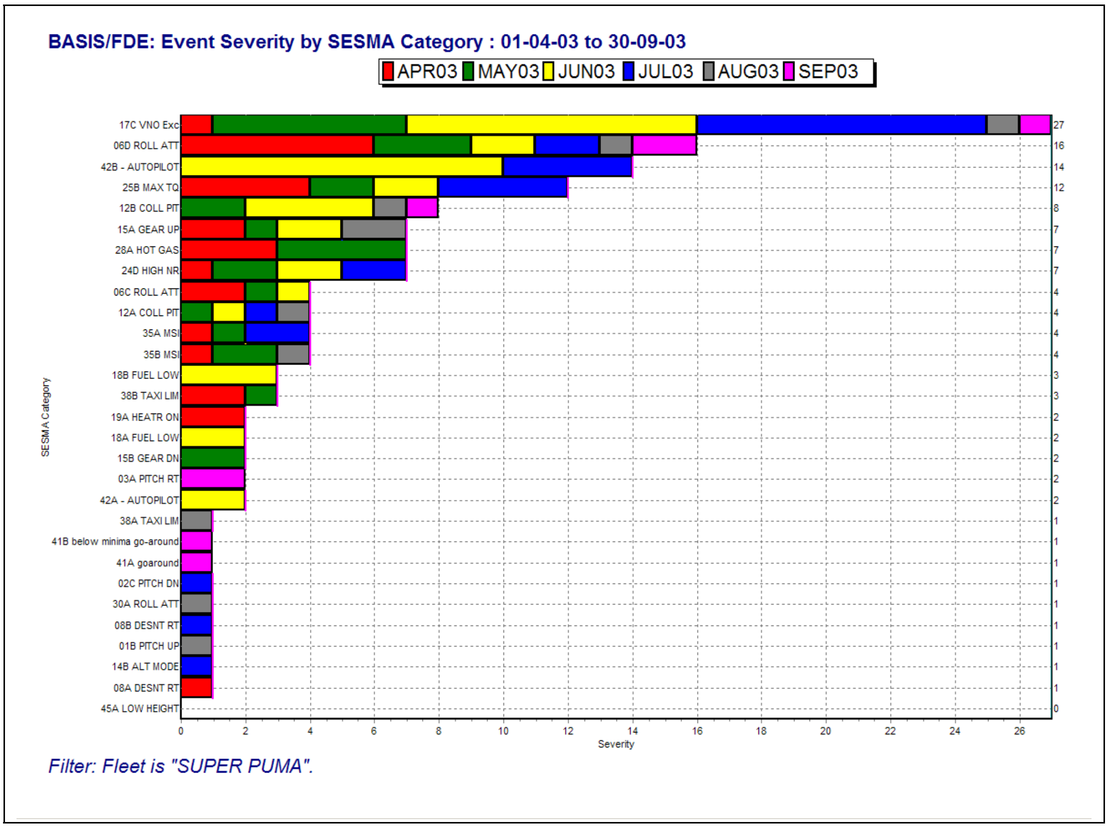


Figure 17 BHL AS332L Cumulative Event Severity

Figure 18 is a plot of cumulative event severity by operating base for event 17C (Vno exceedance) for a one year period up to the end of September 2003. The figure shows that base 2 clearly had a much higher incidence of Vno exceedances. This was despite a fairly strong campaign to raise awareness of the issue at this base. To be fair to the base in question, it is one where short sectors are routinely flown, resulting in the aircraft being over a breakpoint weight where its Vno takes a step reduction.

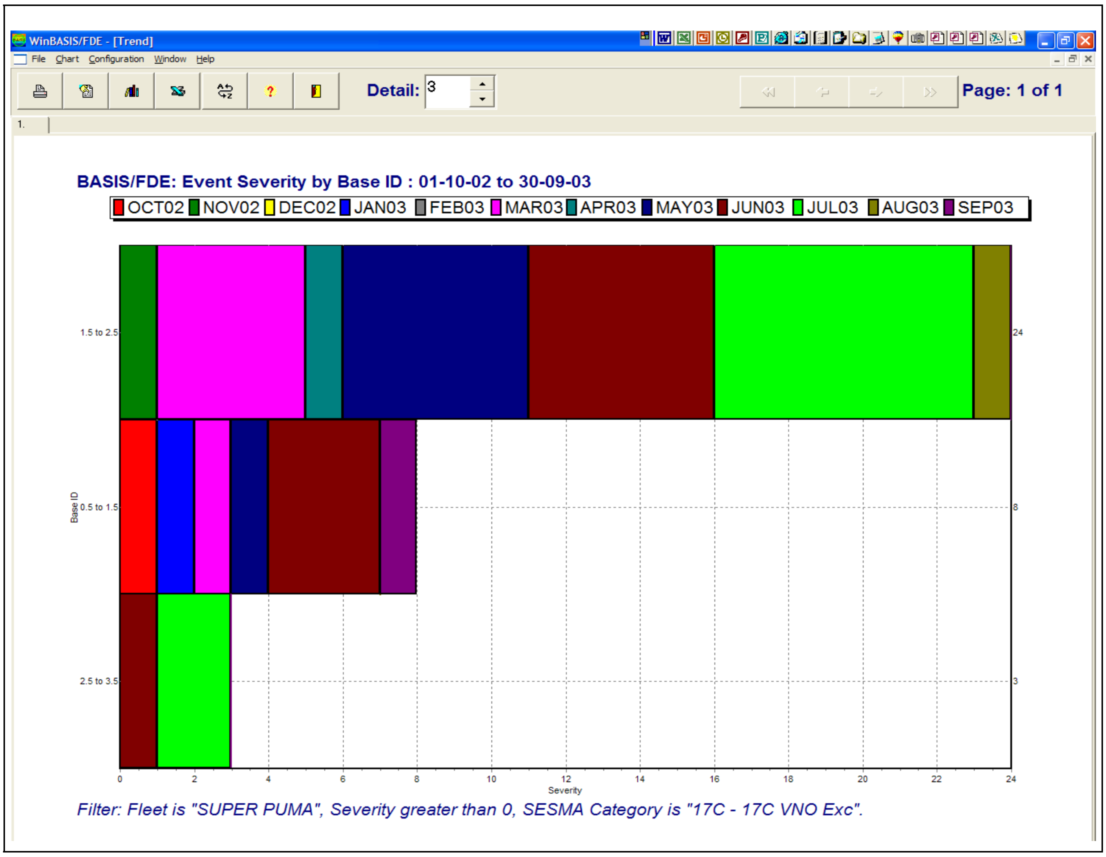


Figure 18 Cumulative Severity of BHL AS332L Vno Events vs Operating Base

Figure 19 presents a count of the numbers of events generated on revenue flights during the six month covered by Figure 17, including those with a severity factor of zero. As for the S76, it can be seen that there is a considerable difference between the ranking of the events in the two charts, which implies that little meaningful safety information can be obtained from simply reviewing the numbers of events that are generated, with no severity assessment process. The fact that the new "Yaw turbulence" events 47A and 47B (see Section 2 sub-section 5.2.1) are ranked second and third in the event count suggests that there is a need to refine the limits for these events.

Comparing Figures 15 and 16, and also 17 and 19, it can be seen that only a small percentage of the HOMP events triggered were given a positive severity value. This result was the outcome of the application of the criteria defined in the severity allocation table described in Section 2 sub-section 5.2.4 by BHL's HOMP Manager and his assistant. The HOMP Manager's justification for this result is as follows:

i) A severity value is allocated to events where it is considered that normal safety factors have been jeopardised. If this occurs, the crew may be contacted or other corrective action taken to reduce the likelihood of recurrences.

ii) HOMP's role is to monitor the flying operation and any adjustments to this operation must be made for a good reason. If not, HOMP will rapidly lose credibility. If the review of a HOMP event does not indicate that there was anything wrong in what occurred and therefore it would be inappropriate to take any form of action, the event should be given a severity factor of zero.

iii) An attempt could be made to redefine some events and eliminate a number of others so that when an event was triggered, it definitely indicated that something was wrong with the flight. Whilst it may be possible to do this for some fixed wing operations, it is not for helicopters that operate over a wide range of conditions (e.g. VFR/IFR, Performance Class 1 or 2, landing at airfields or offshore).

iv) To maximise the scope of HOMP, a decision was made to retain many events that should never generate a positive severity value in isolation and others that are often triggered but rarely result in a positive severity value. With this approach, the operator's attention is drawn to areas of the flight that may be worth investigating and, by taking into account as many factors as possible, the operator can determine whether safety was actually compromised. Any such occurrences are often indicated by the simultaneous triggering of multiple events. In the HOMP Manager's opinion, this approach makes the best use of the system.

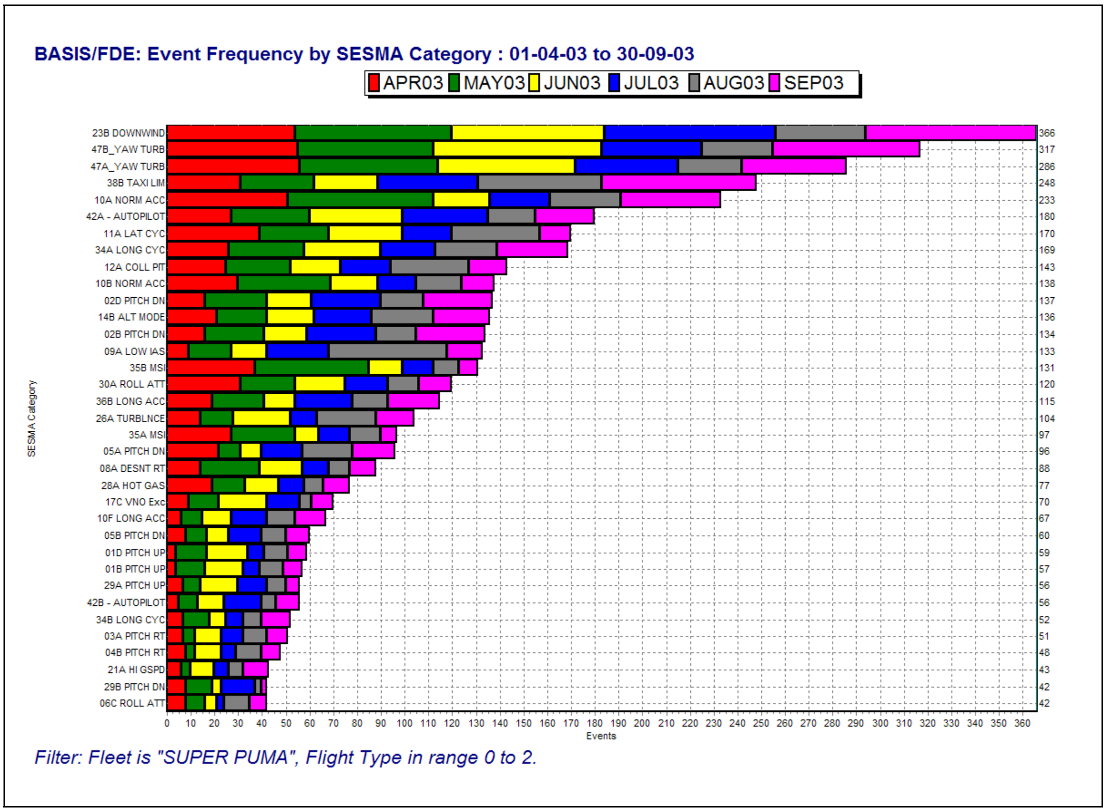


Figure 19 BHL AS332L Event Count (including events with zero severity) on Revenue Flights

Returning to the event trend analysis, it is possible to review cumulative event severities for individual pilot codes by producing charts such as that presented in Figure 20. This indicates that one pilot had a high cumulative event severity value. Although the individual events were all fairly minor, their cumulative severity was high compared to those for the other pilots.

This particular pilot was known to the HOMP office as one of the few who had previously been rather unreceptive to HOMP. It was therefore decided to send him the above chart with an accompanying letter explaining that he was top of the list and giving advice on how he might reduce his count in future. No reply was received, but 3 months later the updated chart presented in Figure 21 shows that the pilot in question, who had previously generated events with positive severity values nearly every month, did not feature at all in the 3-month period.

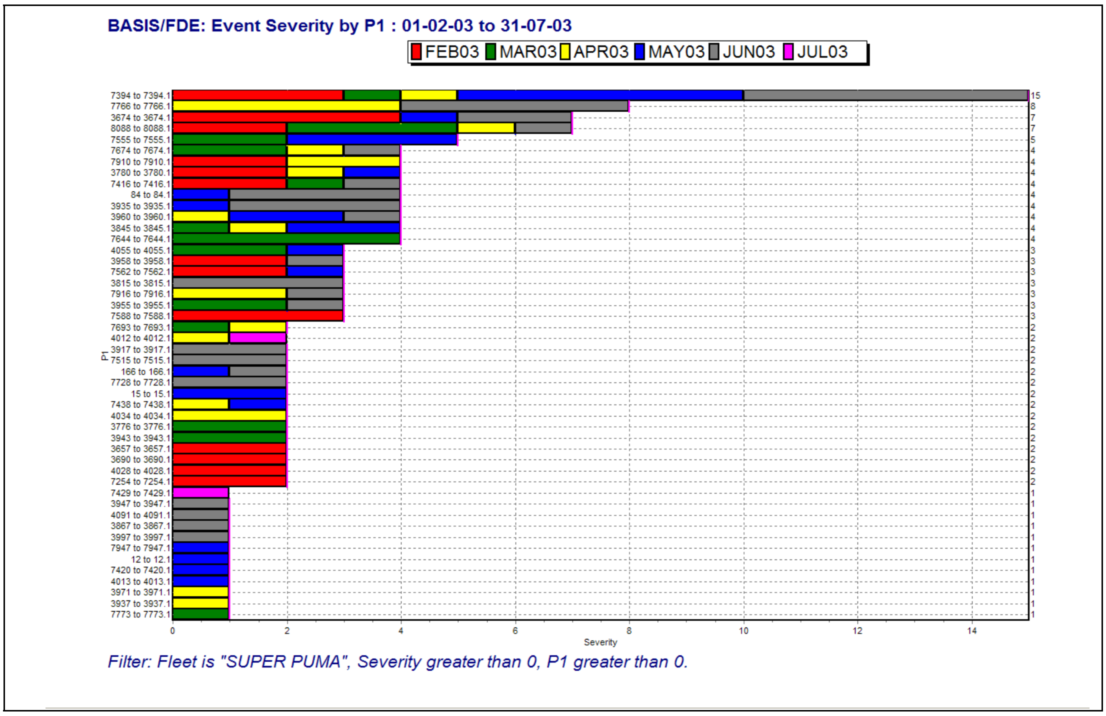


Figure 20 BHL AS332L Cumulative Event Severity vs Pilot (P1) Code

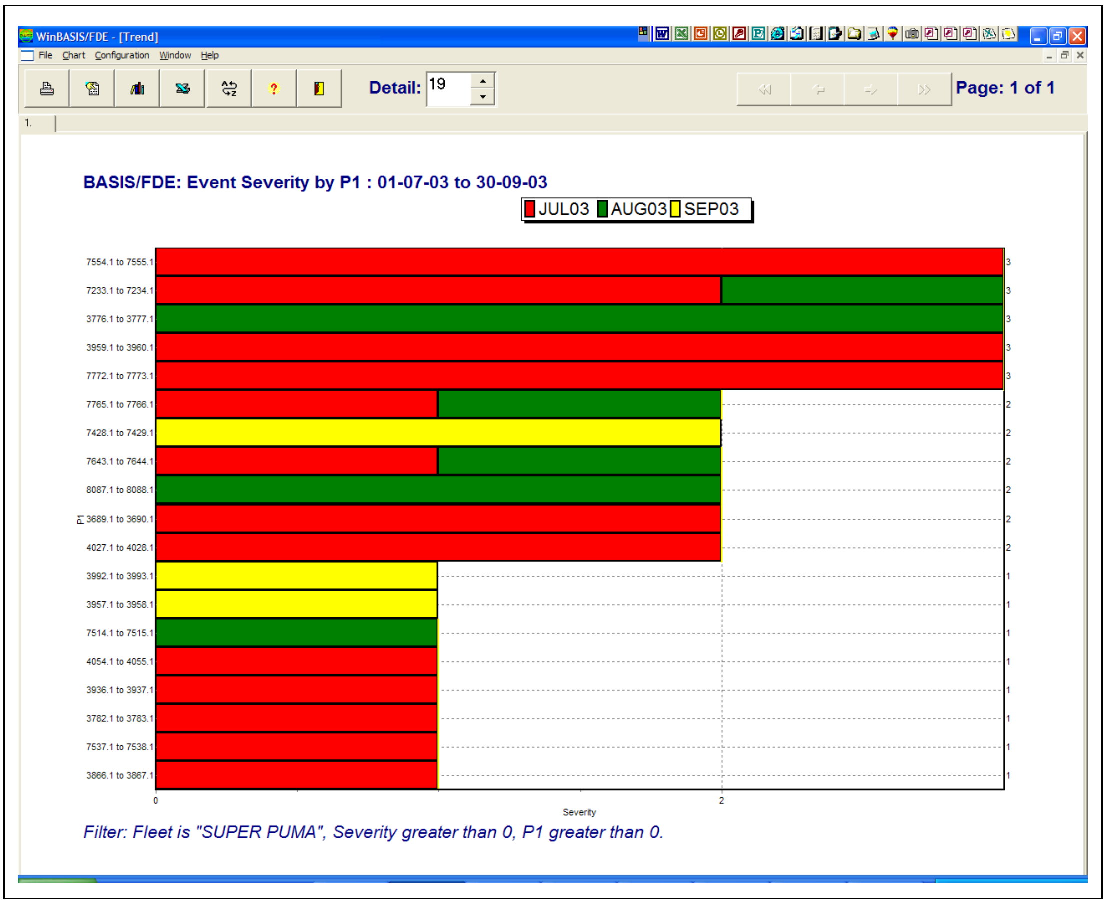


Figure 21 BHL AS332L Cumulative Event Severity vs Pilot (P1) Code

4 Event Severity Assessment

BHL and Scotia both assessed event severities using the severity guide described in Section 2 sub-section 5.2.4 and Table 2 in Section 2.

4.1 BHL AS332L Event Severity Assessment

Table 1 presents a summary of the severity values that were allocated to BHL AS332L events between May 2001 and January 2003, which includes the six month period of gathering trend data for events with severity values allocated during the main HOMP trial. Only those events for which at least one positive severity value has been allocated are included.

Table 1 AS332L Event Severities Allocated by BHL

Event number	Title:	SF= 0	SF= 1	SF= 2	SF= 3	SF= 4	SF= 5	SF= 9
01A	High Pitch-Up Attitude Below 20 ft AGL	39	-	1	-	-	-	-
05A	Low Maximum Pitch-Down Attitude on Rig Take-Off	128	-	1	-	-	-	-
06A	Roll Attitude Above 30 deg Below 300 ft AGL	20	6	-	-	-	-	-
06C	Roll Attitude Above 30 deg Above 300 ft AGL	55	9	-	-	-	-	-
06D	Roll Attitude Above 40 deg Above 300 ft AGL	72	3	-	-	-	-	-
10C	Lateral Acceleration Above 500 ft AGL	9	-	-	-	-	-	1
12A	Excessive Collective Pitch Control in Level Flight	186	5	-	-	-	-	-
12B	Excessive Collective Pitch Control	68	2	-	-	-	-	-
14B	ALT Mode Engaged Below 60 kt IAS	190	1	-	-	-	-	-
15A	Gear Selected Up Below 100 ft AGL on Take-off	14	4	-	-	-	-	-
17A	VNO Exceedance (<= 8350 kg)	7	1	-	-	-	-	-
17C	VNO Exceedance (> 8350 kg)	66	52	-	-	-	-	-
18B	No2. (RH) Fuel Contents Low	6	1	-	-	-	-	-
19A	Heater On During Take-Off	30	9	4	-	-	-	-
19B	Heater On During Landing	18	2	1	-	-	-	-
24D	High Rotor Speed – Power Off	111	-	1	-	-	-	-
25B	Maximum Take-Off Torque (2 Engines)	4	8	-	-	-	-	-
26A	Pilot Workload/Turbulence	121	-	2	-	-	-	-
28A	Flight Though Hot Gas	35	-	5	-	-	-	-
30A	High Roll Attitude on Ground	354	1	-	-	-	-	-
31A	High Normal Acceleration at Landing	55	-	1	-	-	-	-
34A	Excessive Long Cyclic Control with Insufficient Coll Pitch on Ground	156	2	-	1	-	-	-
35A	Excessive Movement of Deck	264	-	1	1	-	1	-
36B	High Longitudinal Acceleration (rapid braking)	141	1	-	-	-	-	-
38B	Taxi Limit (right gear lifts)	183	3	2	1	-	-	-
39A	Single Engined flight	636	-	2	-	-	-	-
41A	Go Around	94	-	1	-	-	-	-
41B	Below Minimum Height on Go Around	13	1	1	-	-	-	-
42A	Autopilot Engaged On Ground Before Take-Off	234	2	1	1	-	-	-
42B	Autopilot Engaged On Ground After Landing	185	5	7	2	1	-	-

Ignoring all the zero severity values that have been allocated to events, the following observations can be made regarding the event severity allocations:

- Of the 30 different types of events, 8 have had more than one different non-zero severity value allocated and 22 have only had a single severity value allocated. However, 11 of these 22 only contain a single event occurrence with a non-zero severity value.
- Certain types of event are typically given a severity value of 1. These include flight manual limit exceedances such as events 17A/C “Vno exceedance”, 06A/C/D “Roll attitude” and 12A/B “Excessive collective pitch”, and some handling items such as event 15A “Gear selected up below 100 ft”.
- Other types of event are typically given a severity value of 2. These include environmentally-related hazards such as events 26A “Pilot workload / turbulence” and 28A “Flight though hot gas” and manoeuvres close to the ground, for example events 01A “High pitch-up attitude below 20 ft”, 05A “Low maximum pitch-down attitude on rig take-off” and 31A “High normal acceleration at landing”.
- Some event types can have a relatively wide range of severity values. These are events where circumstances or other factors have a significant influence on the actual risk, for example events 35A “Excessive movement of deck”, 38B “Taxi limit” and 42B “Autopilot engaged on ground after landing”.

4.2 Scotia AS332L Event Severity Assessment

Table 2 presents a summary of the severity values that were allocated to Scotia AS332L events between September 2002 and May 2003. Again, only those events for which at least one positive severity value has been allocated are included.

Table 2 AS332L Event Severities Allocated by Scotia

Event number	Title:	SF= 0	SF= 1	SF= 2	SF= 3	SF= 4	SF= 5
01B	High Pitch-Up Attitude Above 20 ft and Below 500 ft AGL	5	-	-	7	-	-
01D	High Pitch-Up Attitude Below 90 knots IAS	4	-	-	9	-	-
01E	High Pitch-Up Attitude Above 90 knots IAS	-	-	4	-	-	-
02B	High Pitch-Down Attitude Above 20 ft and Below 500 ft AGL	8	-	-	17	-	-
02D	High Pitch-Down Attitude Below 90 knots IAS	23	-	-	5	-	-
03B	High Pitch Rate Above 500 ft AGL	6	-	6	-	-	-
06D	Roll Attitude Above 40 deg Above 300 ft AGL	10	-	-	14	-	-
07A	High Roll Rate Below 500 ft AGL	-	-	-	7	-	-
07B	High Roll Rate Above 500 ft AGL	9	-	9	-	-	-
08A	High Rate of Descent Below 500 ft AGL	8	-	-	10	-	-
08B	High Rate of Descent Above 500 ft AGL	3	-	19	-	-	-

Table 2 AS332L Event Severities Allocated by Scotia

Event number	Title:	SF= 0	SF= 1	SF= 2	SF= 3	SF= 4	SF= 5
09A	Low Airspeed Above 500 ft AGL	10	-	19	-	-	-
11A	Excessive Lateral Cyclic Control	5	1	-	-	-	-
12A	Excessive Collective Pitch Control in Level Flight	10	29	-	-	-	-
12B	Excessive Collective Pitch Control	3	-	12	-	-	-
14C	HDG Mode Engaged Below 60 knots IAS	-	4	-	-	-	-
18B	No 2. (RH) Fuel Contents Low	-	-	-	-	-	1
19A	Heater On During Take-Off	-	-	13	-	-	-
19B	Heater On During Landing	-	-	11	-	-	-
22A	High Airspeed Below 100 ft AGL	-	2	-	-	-	-
22B	High Airspeed Below 100 ft AGL and Gear Up	-	2	-	-	-	-
24A	Low Rotor Speed – Power On	17	-	-	25	-	-
25B	Maximum Take-Off Torque (2 Engines)	-	-	13	-	-	-
26A	Pilot Workload/Turbulence	1	-	-	13	-	-
30A	High Roll Attitude on Ground	20	-	-	33	-	-
32A	High Rotor Speed on Ground	-	-	-	-	-	1
33A	Rotor Brake Applied at Greater Than 122 Rotor RPM	-	-	-	-	-	2
34A	Excessive Long Cyclic Control with Insufficient Coll Pitch on Ground	3	-	35	-	-	-
38A	Taxi Limit (left gear lifts)	-	-	2	-	-	-
38B	Taxi Limit (right gear lifts)	9	-	-	71	-	-
41A	Go Around	-	-	-	7	-	-
41B	Below Minimum Height on Go Around	-	-	-	-	-	2
41C	Below Minimum Height on Go Around at Night	-	-	-	-	-	2
42A	Autopilot Engaged On Ground Before Take-Off	2	6	-	-	-	-
42B	Autopilot Engaged On Ground After Landing	-	13	-	-	-	-
47A	Yaw Turbulence (+ve Yaw Acceleration)	5	-	14	-	-	-
47B	Yaw Turbulence (-ve Yaw Acceleration)	-	-	18	-	-	-

Ignoring all the zero severity values that have been allocated to events and comparing the Scotia event severity allocations (Table 2) to those made by BHL (Table 1), the following observations can be made:

- Unlike BHL, for all 37 of the different types of events Scotia have allocated a single non-zero severity value. Scotia therefore appear to be applying the concept of a default severity value for each event type. However, this could to some extent be symptomatic of the fact that Scotia allocated all event severity values at the end of the trial period, by which time the ability to gather additional circumstantial information had largely been lost.
- 15 of the 37 different types of events to which Scotia have allocated severity values (Table 4.2) also have had severity values allocated by BHL (Table 4.1). Of these 15, in 1 case Scotia have allocated the same severity value as BHL, in 6 cases Scotia have allocated a severity value that lies within the range of values allocated by BHL, and in 8 cases Scotia have allocated a higher severity value than BHL.
- There are 15 event types that have had non-zero severity values allocated to them by BHL but not by Scotia, and 22 event types that have had non-zero severity values allocated to them by Scotia but not BHL. This suggests that BHL and Scotia have different views on the operational risks associated with different types of events.

4.3 Summary of Severity Assessment Results

There are differences in the patterns of event severity allocation between BHL and Scotia. For example, BHL have allocated a range of values to some events where Scotia have only allocated a single value, Scotia have often allocated higher severity values than BHL, and Scotia and BHL have allocated severity values to different types of event. It is therefore apparent that, using a manual event severity allocation process based on the scale in Table 2 in Section 2, different operators will take a different view of the severity of different events.

The data in Tables 1 and 2 adds support to the view that, at least for certain types of event, it should be possible to define an initial default severity value, together with a range of values either side of the default value to allow for the particular circumstances of the event. With supporting guidance information, this approach could provide the basis for a more standardised approach to event severity allocation.

5 Discussion

The events and event trends presented in this Section provide further evidence of the value of the HOMP. Significant operational risks have continued to be identified and acted upon, resulting in trends that show overall decreasing risk levels.

Even though the Scotia HOMP trial was limited to two AS332L aircraft and a period of six months, Scotia identified notable events and have been able to take action to address them. Comparison of the findings provided by Scotia and BHL on the AS332L shows that the operators have identified a number common problems, for example taxing in the rollover zone, exuberant flying, the heater being left on during offshore take-offs and the autopilot being left engaged after landing. The comparison has also highlighted some differences between the operators, for example in the assessment of event-related risks to the operations. These differences are to be expected and it is important not to make simplistic comparisons between operators that result in false conclusions.

Comparing Figures 4 and 19 showing simple HOMP event counts for Scotia's and BHL's AS332Ls, although rankings differ 16 of the top 25 events are common to both operators, indicating that there is a relatively large degree of commonality in the events being triggered on the two operators' aircraft. Where differences exist, these may be due to differences in the operations or the locations flown to (e.g. 17C “Vno exceedance” and 28A “Flight through hot gas” appear in the BHL list but not the Scotia list).

Comparing Figures 3 and 17 showing the cumulative event severities for Scotia's and BHL's AS332L, only 9 of the top 25 events are now common to both operators, which indicates greater differences in the severity assessment results identifying areas of risk in the two operations. Events showing common areas of concern include 38B “Taxi limit”, 06D “Roll attitude above 40 degrees”, 12A/B “Excessive collective pitch control”, 25B “Maximum takeoff torque”, 19A “Heater on during takeoff”, and 30A “High roll attitude on ground”.

The event trend analysis results have highlighted the criticality of the event severity assessment process in the identification and quantification of operational risks based on HOMP data. Furthermore the results have shown differences between BHL's and Scotia's allocation of severity values to events, based on a common severity scale. One notable result from BHL's severity assessment process is that a large percentage of the HOMP events triggered were given a severity value of zero. BHL's HOMP Manager has provided a justification for this result. Whilst it is important not to try to force any inappropriate standardisation across operators, the HOMP trial results clearly highlight the need to develop guidance material on the allocation of event severity values.

Within BHL, the follow-on work has shown differences in the types of, and also rate of occurrence of, significant events on the AS332L and S76. Although the S76 trial has clearly provided useful findings and a substantial number of events were generated, the range of events that were considered to have any potential safety consequences, and that were therefore given positive severity values, was narrower on the S76 than on the AS332L. Although a specific reason for this could not be identified, some possible explanations were given in Section 4 sub-section 2.2. BHL's S76 HOMP trial represents a scenario where the HOMP data analysis is performed for a fleet type that is located only at a remote base (i.e. BHL's S76s at Norwich), and the best source of experience on that fleet (i.e. BHL's S76 Fleet Representative) is also located at the remote base. The S76 HOMP experience suggests that, for this scenario, there is a need for the HOMP Manager and Fleet Representative to perform a periodic joint review of all the events that have been generated on that fleet. In addition to checking that appropriate event limits are set, the review should ensure that no flight safety issues are being missed in the event assessment process.

Section 5 HOMP Results – Flight Data Measurements

The flight data measurements provide a useful picture of day-to-day operations. It is not their function to automatically draw attention to issues of concern – that is the function of the events. However, if an operator has identified an area of concern through the event analysis or by other means, the measurements provide a valuable source of data to assist investigation. The following examples show how the flight data measurements can be used in specific cases.

1 General Flight Data Measurements

The example chosen to illustrate how use can be made of the general flight data measurements was an investigation of S76 offshore takeoff power margin. There has been some concern expressed by clients over the power margin available during offshore takeoffs in the S76 in conditions of light wind, high temperature and near maximum takeoff weight. BHL therefore decided that individual engine torque should be not more than 85% whilst in the hover, giving a 15% margin during the takeoff manoeuvre. If this was not the case, takeoff weight should be reduced as required.

The measurements were used to determine whether these guidelines were being followed. Figure 1 shows the hover torque measurements, filtered for a takeoff wind of less than 11 kt and a takeoff mass above 10,600lbs. It can be seen that, whilst the majority of takeoffs in light winds are conducted with the recommended power margin, some are not. Caution should be applied when drawing this conclusion because, as explained in Section 2 sub-section 5.3.2, the automatic measurements represent only an approximation of the torque in a stable hover. However, Figure 1 does show that individual engine torque in the hover is below 90% for a high percentage of offshore takeoffs in light wind conditions.

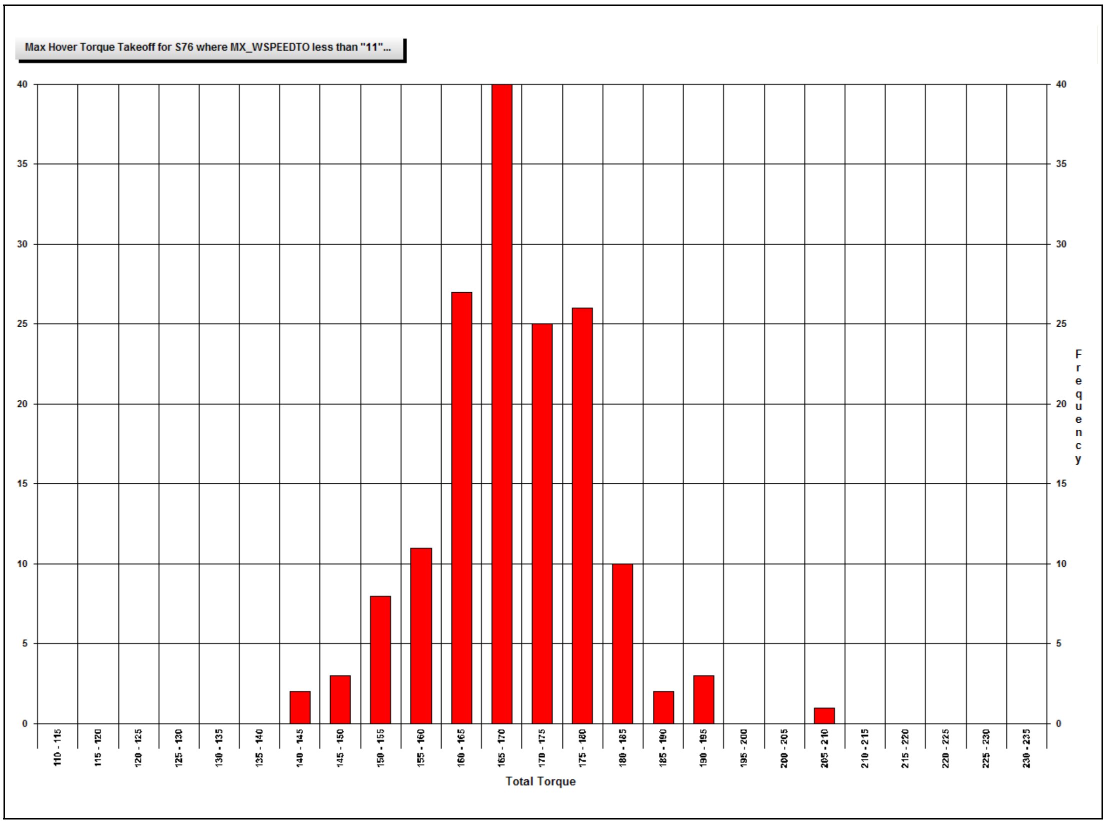


Figure 1 S76 Hover Torque – Offshore Takeoffs with Mass > 10600lbs and Wind < 11kt

Figure 2 shows the distribution of offshore takeoff weights under any conditions, whilst Figure 3 shows the same graph but only for takeoffs where the wind is less than 11 kt. Both data sets are normalised so that each column representing a different weight band shows the percentage of the total number of takeoffs within that weight band. For comparison, the heights of the columns in Figure 2 for all wind conditions have been marked on the corresponding columns in Figure 3 for light wind conditions. It can be seen that the shape of these graphs is most different at the high weight end, which suggests that crews were indeed modifying their takeoff weights under light wind conditions.

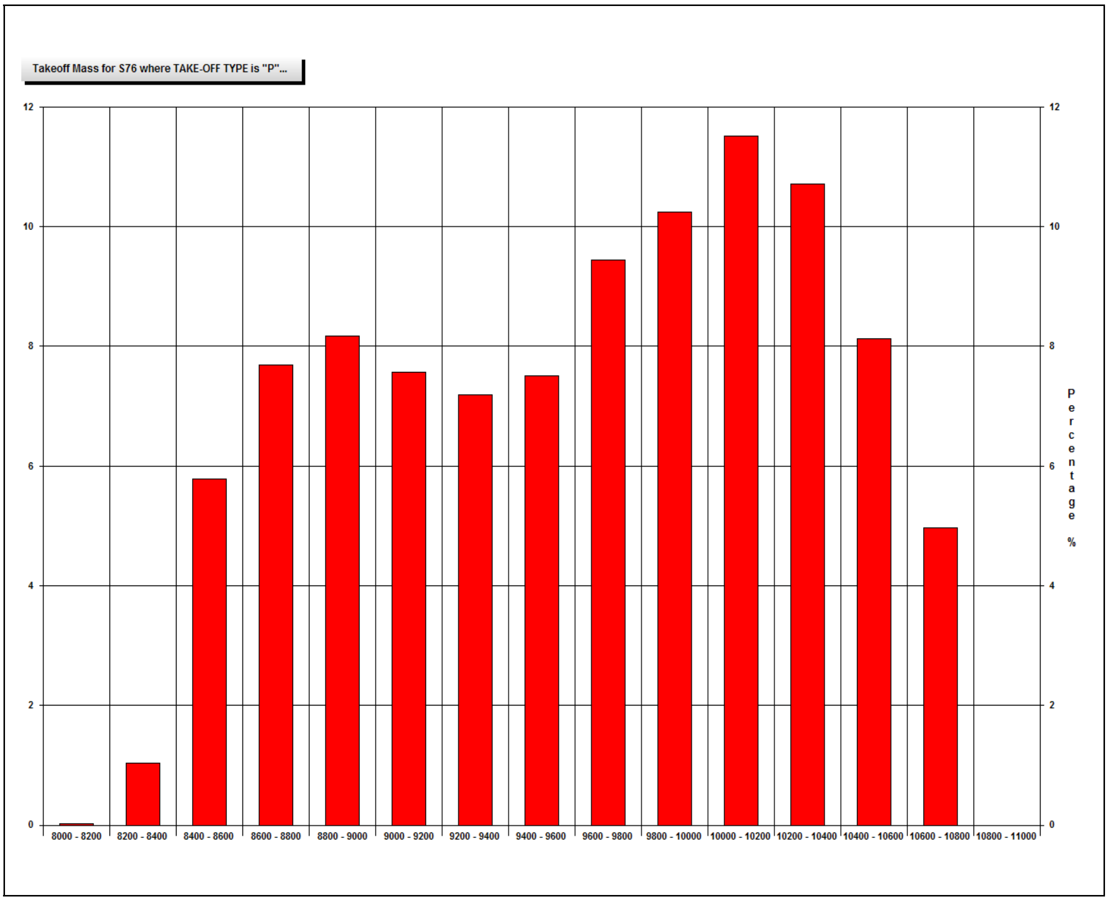


Figure 2 S76 Offshore Takeoff Mass

It might also be useful to know how often light winds are a factor. Figure 4 shows the distribution of offshore wind strength measured by HOMP just after takeoff, on the S76 fleet. From the cumulative percentage graph it can be seen that over 80% of takeoffs are performed at wind speeds of greater than 10 kt. Therefore in a large majority of cases light winds are not a factor.

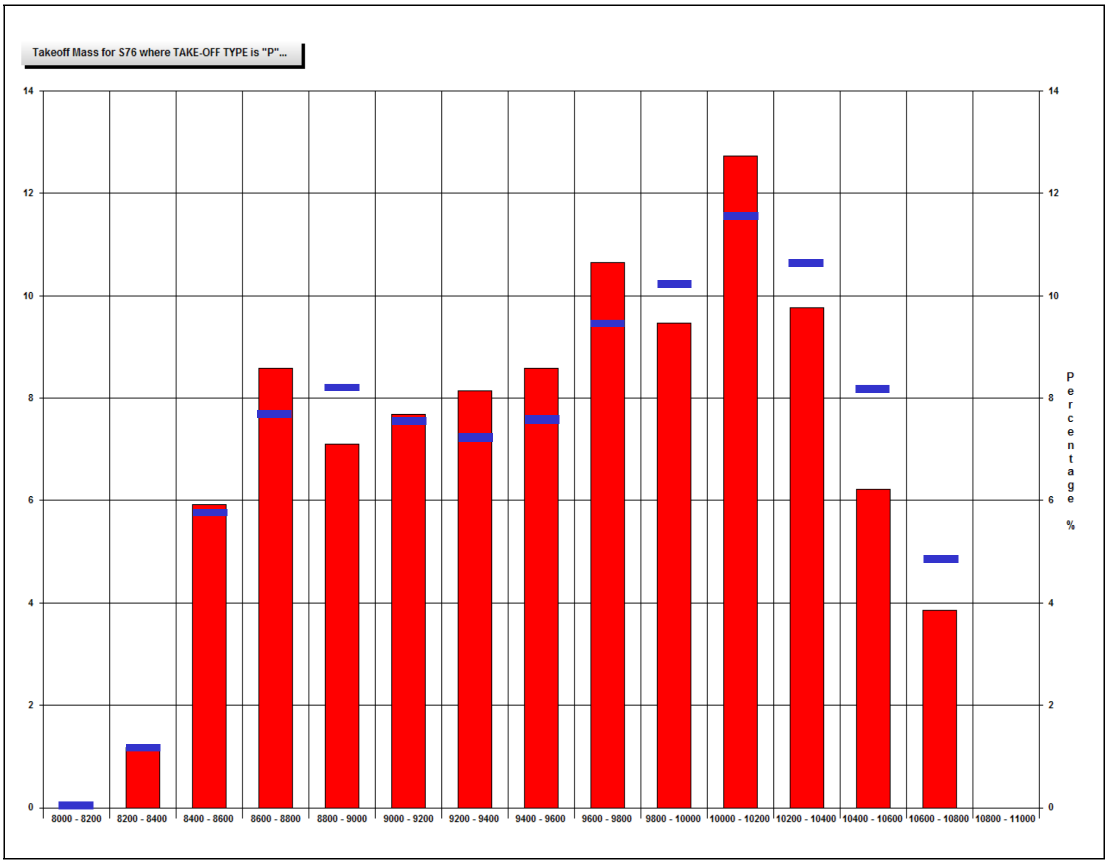


Figure 3 S76 Offshore Takeoff Mass with Wind < 11kt

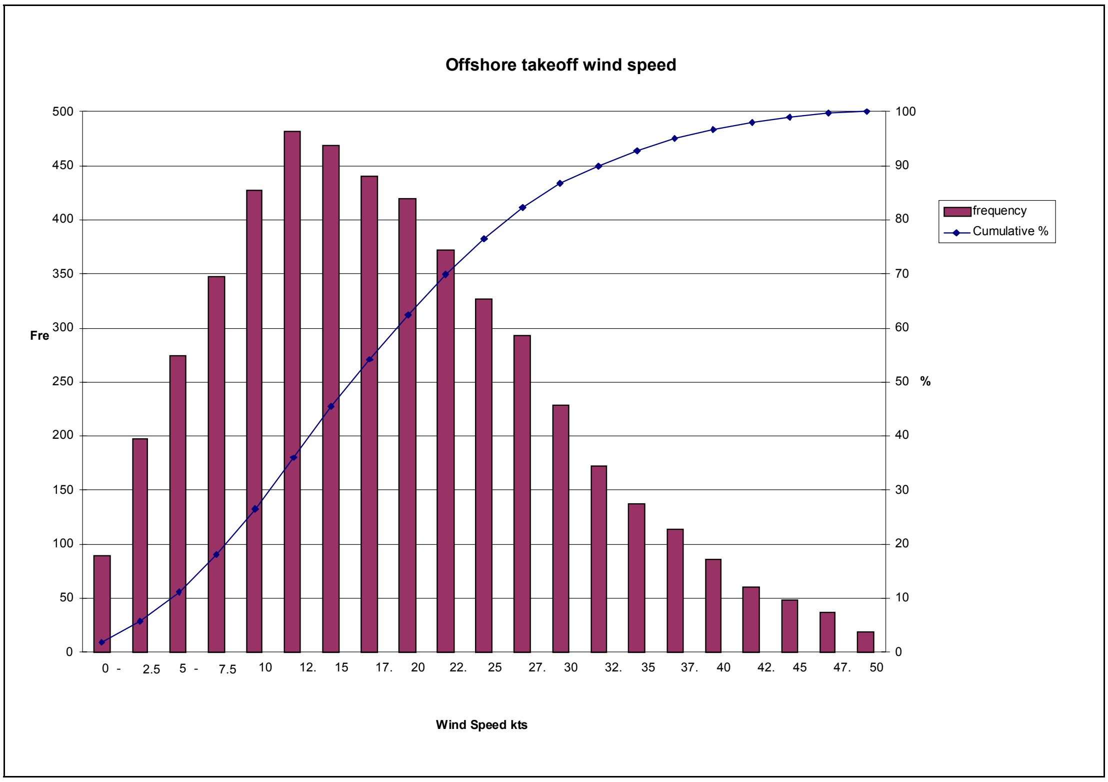


Figure 4 Offshore Takeoff Wind Speed – S76 Fleet

2 Mapping the Helideck Environment – Structure Induced Turbulence

The report on the main HOMP trial (Reference [2]) presented charts showing how the flight data measurements could be used to map structure-induced turbulence on selected platforms (Brae A and Brae B were chosen as examples). Some refinement of the measurements was made early in the follow-on programme to enable more accurate mapping of structure-induced turbulence and also mapping of hot turbine exhaust gas (see Section 2 sub-section 5.3.1). As BHL had implemented HOMP on all of their North Sea AS332Ls, by the end of the follow-on programme there was a substantial amount of data available for the updated measurements.

Figure 5 shows an update of the plot of turbulence around the Brae B platform presented in the main HOMP trial report. The report noted that the predominant turbulent sector is with a Northerly wind, whilst the original HLL restricted sector was a North-Easterly one. In fact the HLL sector had only been changed shortly before preparation of the report to include the Northerly sector (the updated HLL is presented in Figure 6). The additional measurement data continues to show that most turbulent approaches are made in a Northerly wind. Of course, one reason that the North-Easterly sector has not been identified as a problem is that strong winds rarely occur from a North-Easterly direction, as can be seen from the lack of data points in that sector.

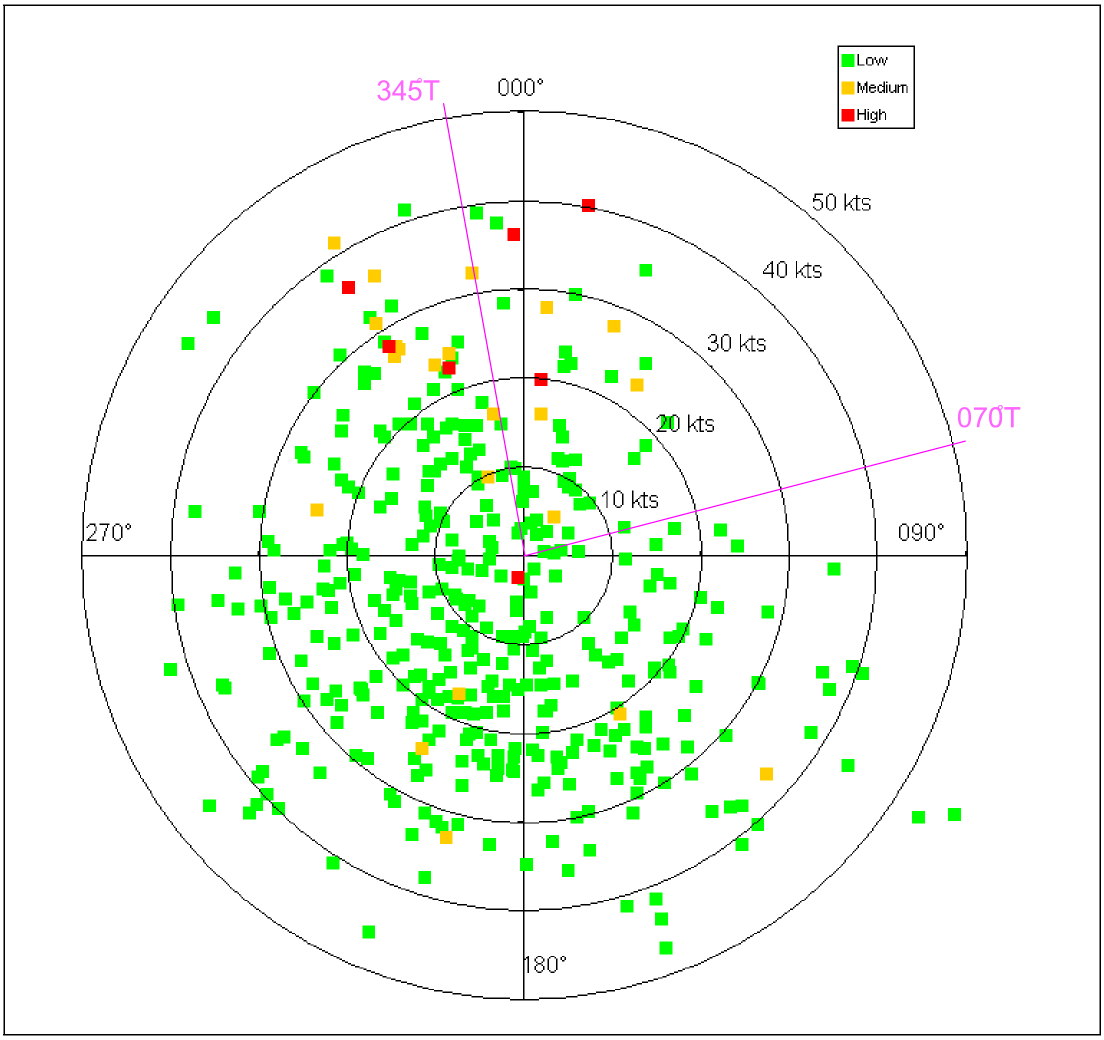
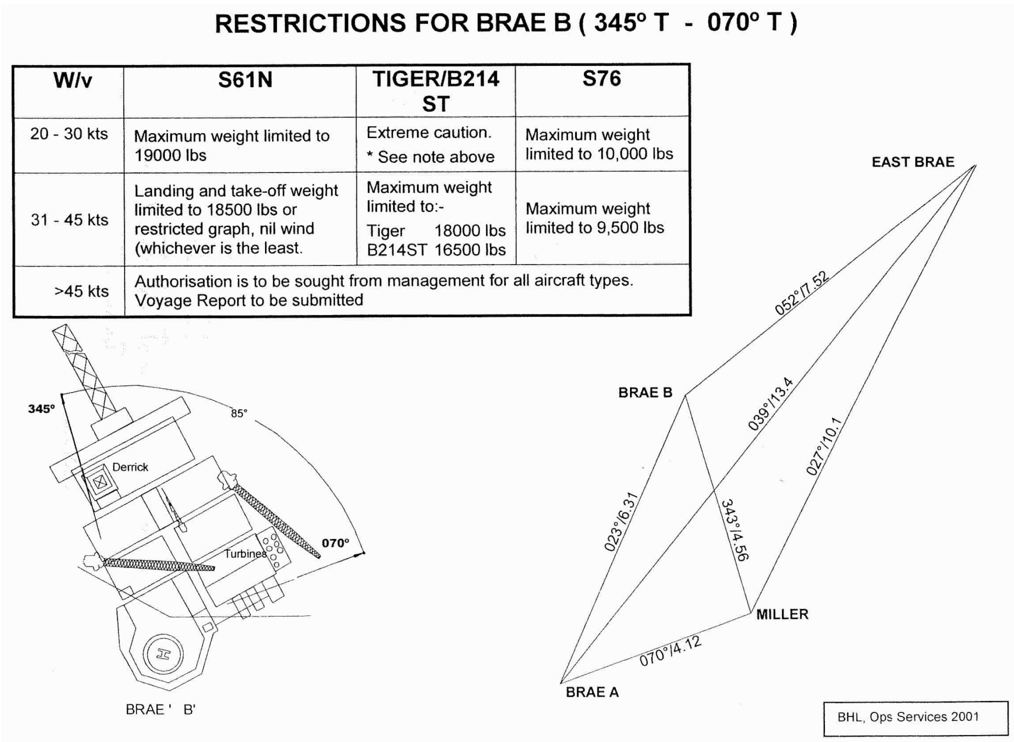


Figure 5 Brae B Turbulence / Workload Versus Wind Vector

The restricted sector (from 345° to 070° true heading) for the Brae B has been superimposed on the turbulence data in Figure 5, with a correction applied to account for the difference between true and magnetic North. It can be seen that some of the 'high' turbulence / workload parameter values are still outside the restricted sector. This could be due to the position of the aircraft relative to the helideck when the high values were recorded, or local variations in the wind vector between the wind measurement point and the platform. Alternatively it may indicate that further refinement of the restricted sector definition is needed.

Whilst all the 'high' turbulence / workload parameter values have remained well grouped, there is more scatter of the 'medium' values. This may be a result of the fact that the turbulence / workload parameter (which is based on rapid movement of the collective) is affected by both environmental factors such as turbulence and by aircraft handling skills.


RESTRICTIONS FOR BRAE B (345° T - 070° T)

W/v	S61N	TIGER/B214 ST	S76
20 - 30 kts	Maximum weight limited to 19000 lbs	Extreme caution. * See note above	Maximum weight limited to 10,000 lbs
31 - 45 kts	Landing and take-off weight limited to 18500 lbs or restricted graph, nil wind (whichever is the least.	Maximum weight limited to:- Tiger 18000 lbs B214ST 16500 lbs	Maximum weight limited to 9,500 lbs
>45 kts	Authorisation is to be sought from management for all aircraft types. Voyage Report to be submitted		

Figure 6 HLL for Brae B

3 Mapping the Helideck Environment – Turbine Exhausts

With the updated measurements introduced early in the follow-on programme, it is now possible to plot temperature rises occurring during landing at a particular location, caused by flight through turbine or flare exhaust. The following examples show how the flight data measurements can be used to investigate the environments of platforms triggering a significant number of “hot gas” events. Figure 7 presents an FDE trend chart showing the rate of occurrence of the “hot gas” event 28A (trigged by a rapid rise in OAT) at different locations.

It can be seen that the platforms that cause the greatest number of “hot gas” events are the Ninians, with the Ninian Central triggering many more events than any other platform. These are followed by the Brent platforms, with the Brent Charlie triggering the most events in this group.

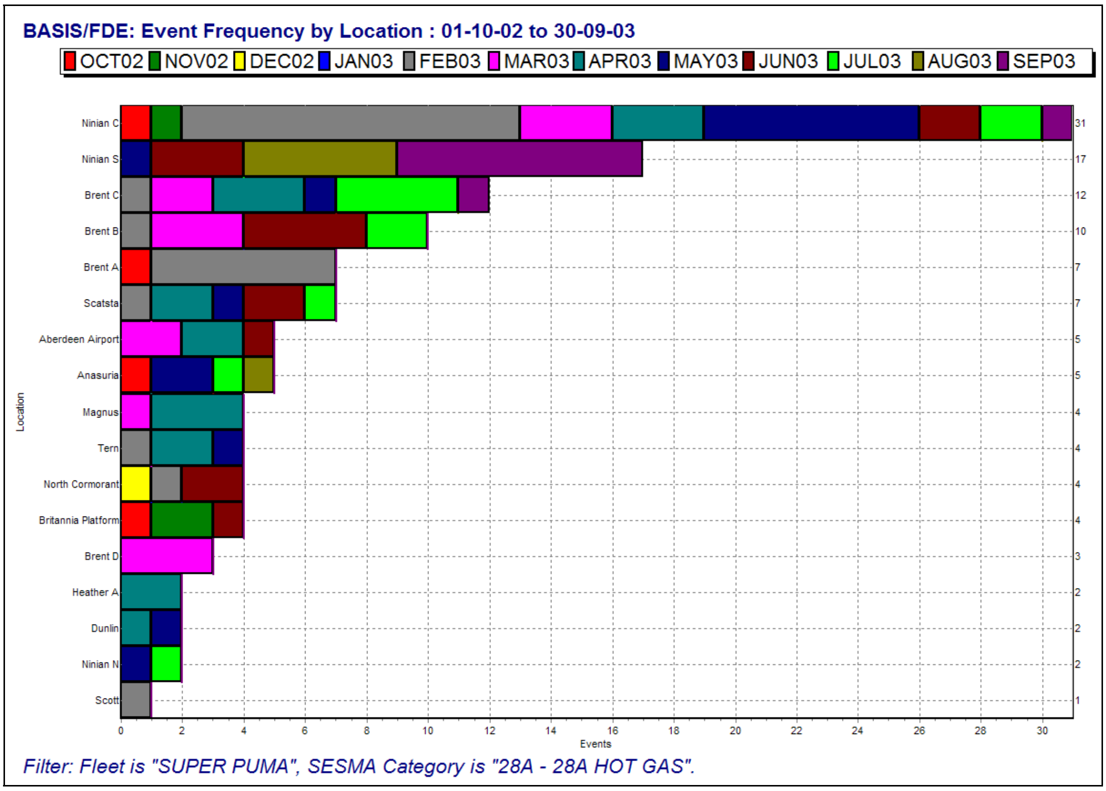
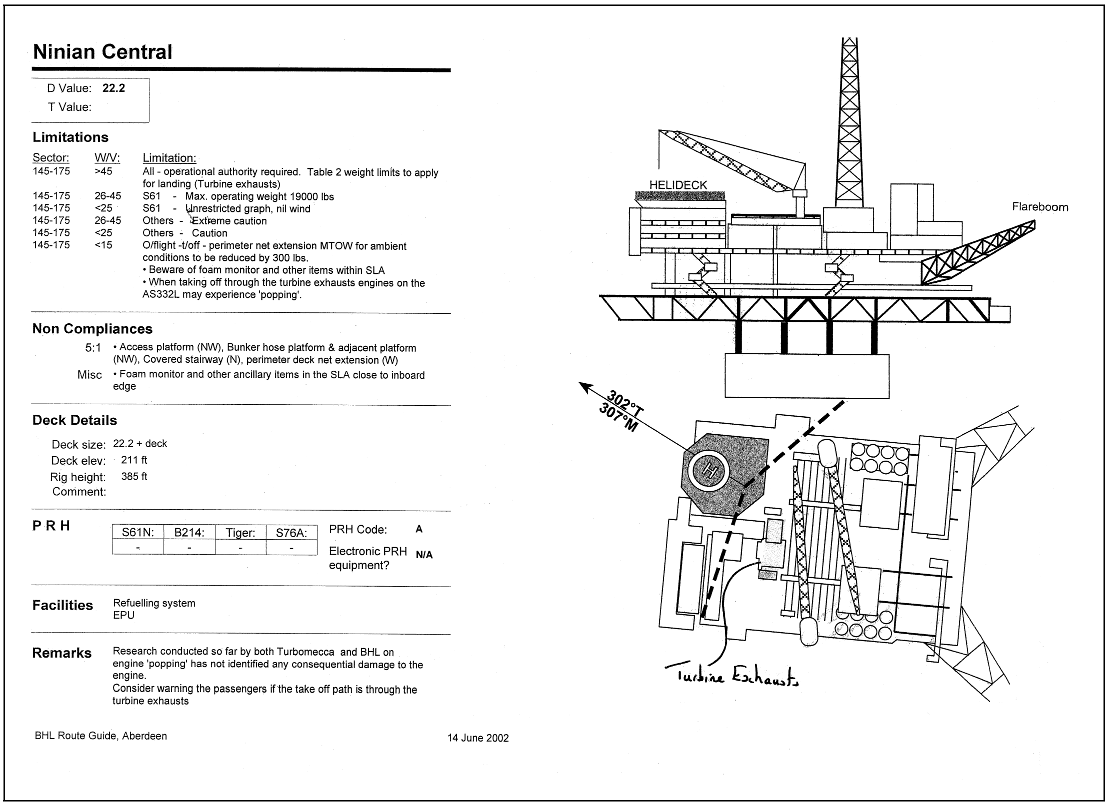


Figure 7 FDE Trend Chart of Event 28A (hot gas) Versus Location

The flight data measurements have been used to map the environments of both the Ninian C and Brent C helidecks, correlating both temperature rises due to turbine exhausts and occurrences of increased turbulence / workload.

The HLL for the Ninian C is presented in Figure 8, the restricted sector is 145° to 175° true heading.



Ninian Central

D Value: **22.2**
T Value:

Limitations

Sector:	W/V:	Limitation:
145-175	>45	All - operational authority required. Table 2 weight limits to apply for landing (Turbine exhausts)
145-175	26-45	S61 - Max. operating weight 19000 lbs
145-175	<25	S61 - Unrestricted graph, nil wind
145-175	26-45	Others - Extreme caution
145-175	<25	Others - Caution
145-175	<15	O/flight -t/off - perimeter net extension MTOW for ambient conditions to be reduced by 300 lbs. • Beware of foam monitor and other items within SLA • When taking off through the turbine exhausts engines on the AS332L may experience 'popping'.

Non Compliances

5:1 • Access platform (NW), Bunker hose platform & adjacent platform (NW), Covered stairway (N), perimeter deck net extension (W)
Misc • Foam monitor and other ancillary items in the SLA close to inboard edge

Deck Details

Deck size: 22.2 + deck
Deck elev: 211 ft
Rig height: 385 ft
Comment:

P R H

S61N:	B214:	Tiger:	S76A:
-	-	-	-

PRH Code: **A**
Electronic PRH equipment? **N/A**

Facilities Refuelling system
EPU

Remarks Research conducted so far by both Turbomecca and BHL on engine 'popping' has not identified any consequential damage to the engine.
Consider warning the passengers if the take off path is through the turbine exhausts

BHL Route Guide, Aberdeen 14 June 2002

Figure 8 HLL for Ninian Central

Figure 9 shows the wind directions where encounters with the turbine exhaust on the Ninian C were detected. It can be seen that there is a good correlation with the existing restricted sector in the HLL. Figure 10 presents an equivalent plot for turbulence/workload, this also correlates well with the restricted sector in the HLL. Comparing Figures 9 and 10, it can be seen that some flights experience both a medium or high temperature rise and also medium or high turbulence/workload, whilst other flights experience only one of the two phenomena.

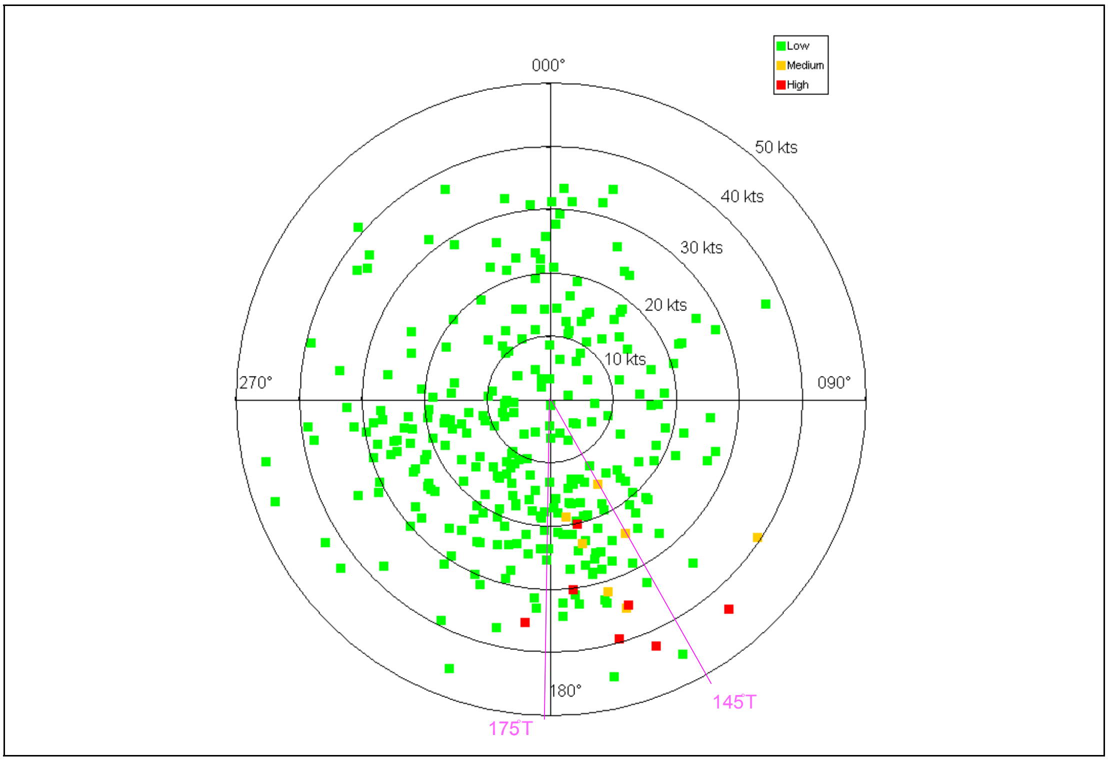


Figure 9 Ninian C OAT Rise Versus Wind Vector

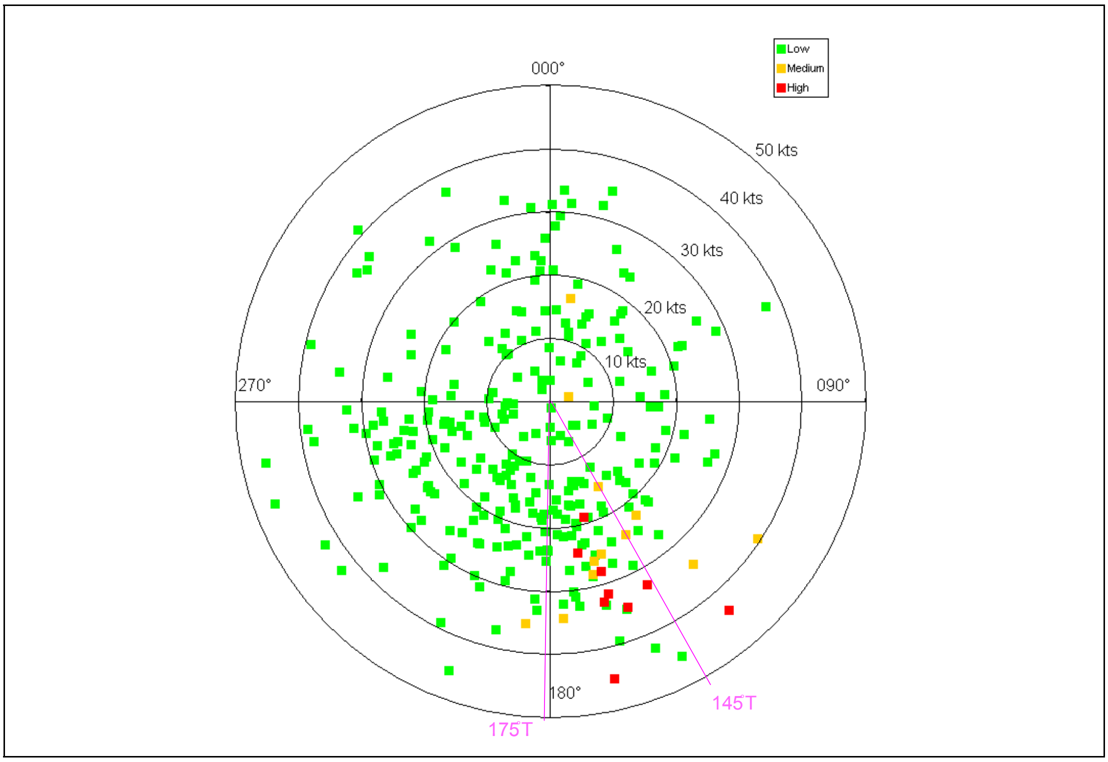


Figure 10 Ninian C Turbulence / Workload Versus Wind Vector

Similar plots were generated for the Brent C. The HLL for the Brent C is shown in Figure 11, the restricted sector is 155° to 215° true heading.

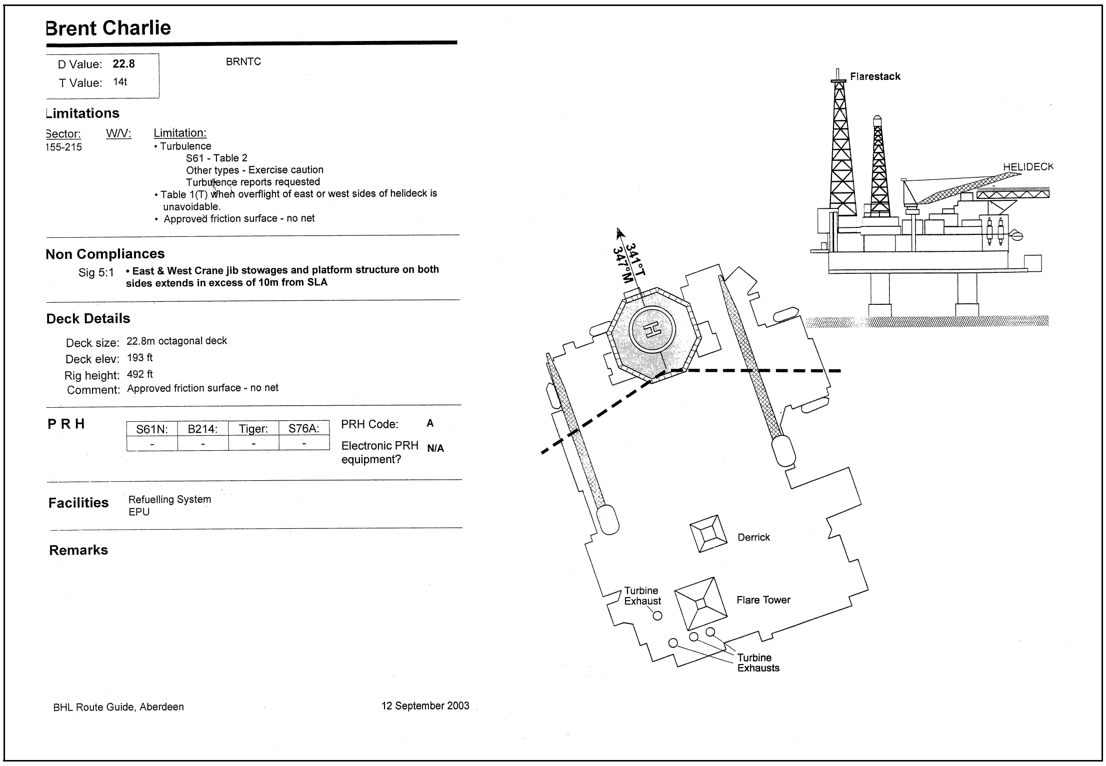


Figure 11 HLL for Brent Charlie

Figure 12 shows the wind directions where encounters with the turbine exhaust on the Brent C occurred and Figure 13 shows the wind directions associated with increased turbulence/workload. Again there is a reasonably good correlation between the two charts, and between these and the restricted sector in the HLL. As would be expected from their relative positions in the hot gas event trend chart, there have been fewer instances of medium or high temperature rises on the Brent C than on the Ninian C.

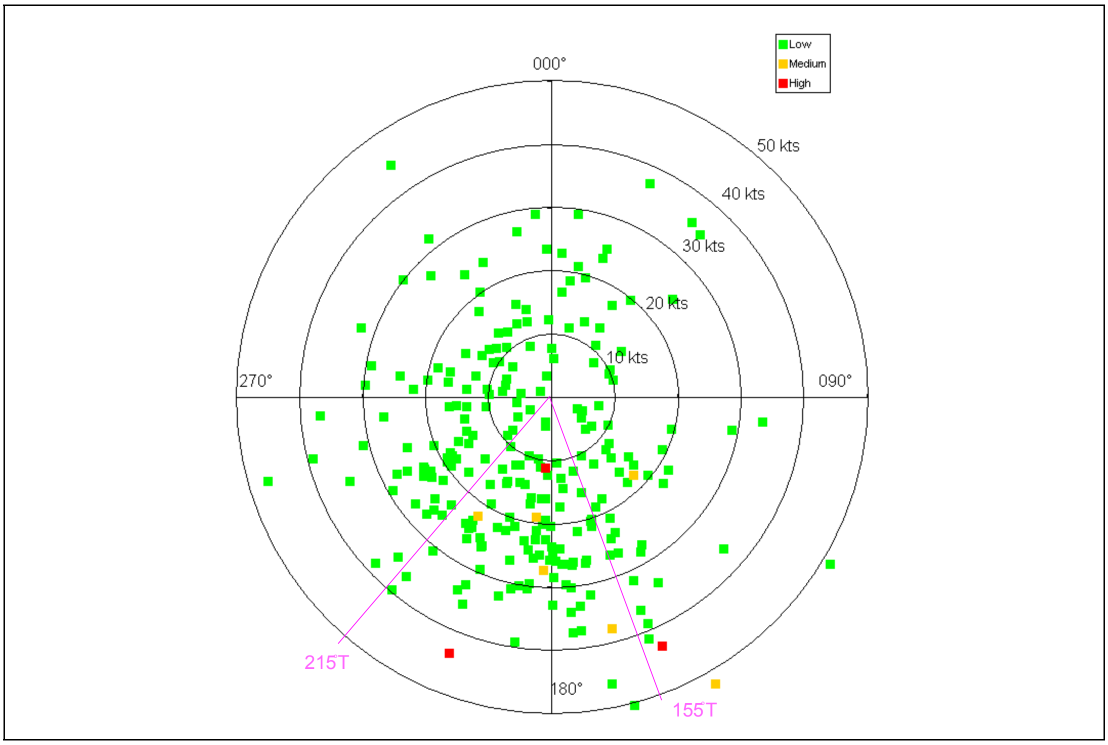


Figure 12 Brent C OAT rise versus wind vector

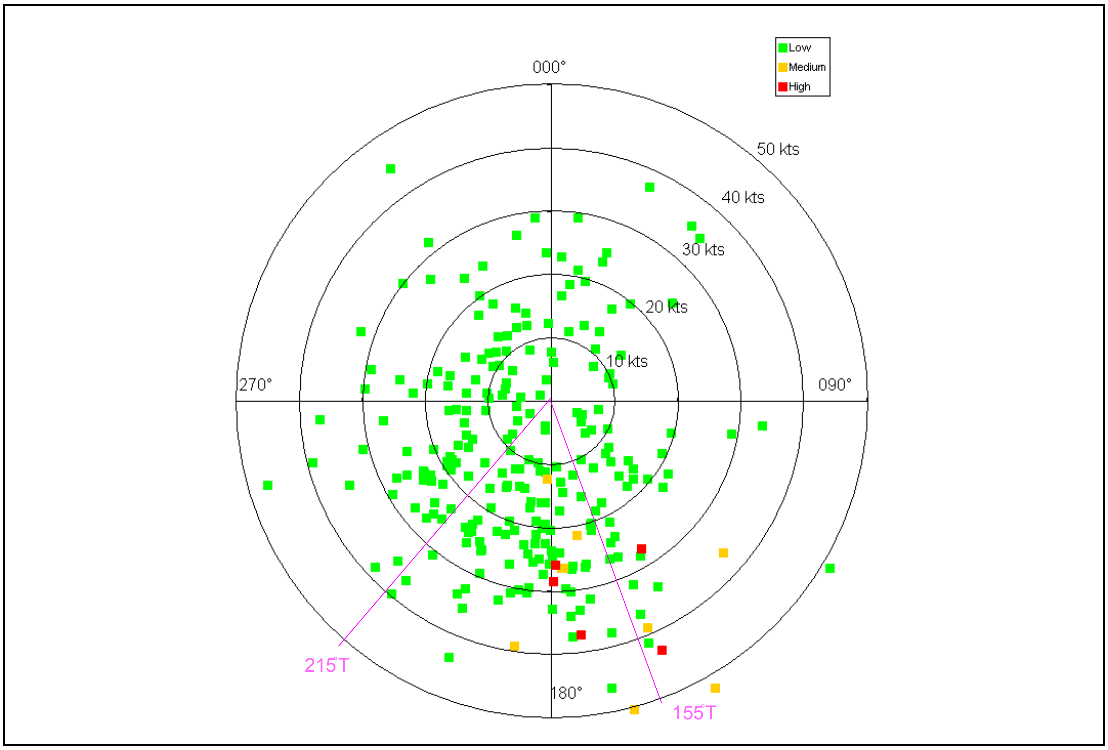


Figure 13 Brent C Turbulence / Workload Versus Wind Vector

4 Discussion

The results presented in this Section show how the flight data measurements routinely gathered on every flight can be used for particular investigations. The examples of the investigation of an aircraft performance issue and also of the environment of an offshore platform are typical of the types of investigation that could readily be performed using the HOMP measurements database.

Section 6 The Application of Data Mining Techniques to Event Data

Although not part of the original statement of work, a small data mining demonstration was performed on a de-identified database of event data extracted from BHL's HOMP system FDE module for the period of March 2001 to January 2003. The background to this demonstration was discussed in Section 2 sub-section 5.2.5.

A few examples of information 'mined' from the de-identified event database are presented below to show how data mining can highlight significant patterns in the data that would be difficult to discover using the standard trend analysis functions within FDE. Some of the first patterns discovered are often found to be due to the presence of 'bad data' in the database (again, without data mining it can be difficult to identify whether any bad data has been inadvertently included in a database). Data mining normally involves a 'data cleaning' process to remove identified bad data, followed by further mining to identify the more subtle patterns than can be masked by the presence of bad data. In this limited demonstration, examples of 'bad data' were clearly highlighted, but no data cleaning was performed.

The displays shown are from a 'decision tree' learning algorithm. Decision trees have proved to be one of the most practical machine-learning algorithms applied to real-world problems. Although the decision tree was the primary algorithm used in the demonstration, additional information was generated using 'clustering'. The 'cluster' algorithm is an 'unsupervised' algorithm that seeks to partition objects (e.g. flight records) into a number of clusters (groups). An object in a cluster has more in common with other objects in the same cluster than it does with objects in other clusters – objects within a cluster are said to be similar. Clustering can reveal any natural structuring in the data. Although not shown, on the FDE database clustering was used to confirm the key findings revealed by the decision tree.

The 'decision tree' is a 'supervised' algorithm that learns to predict the values of a predictable attribute (or item of information, e.g. take-off/landing location, pilot, event type) from a set of predictor attributes (i.e. other items of information). The algorithm can learn to predict multiple attributes during a single learning run. The learnt prediction model is represented as a tree with 'nodes' and 'branches', where a node denotes an attribute and a branch an attribute value. A path in the tree represents a particular combination of attribute values (e.g., location = x and pilot = y). All nodes along a path contain statistics representing the distribution of the predicted values corresponding to the predictor values denoted by that path. For example, in Figure 1 the predicted attribute is 'event type' (Se1) and the table on the right shows the distribution of 'event types' for the single 'leaf' node (i.e. end node) on the bottom branch of the tree, which is the operating base of Norwich (Nudf2 = 3 where Nudf2 = Base ID). This shows that given the attribute 'operating base' (Nudf2) and value 'Norwich' (3), the most likely value of 'event type' (Se1) is 26A followed by 17C.

In the first data mining example, the decision tree algorithm was run on data from all the aircraft types and operating bases included in BHL's FDE database (i.e. AS332Ls at Aberdeen and Scatsa, and S76s at Norwich), but only including events triggered in the flight phase of 'landing'. The resulting tree for the prediction of event type from the other variables in the data set is shown in Figure 1. The operating bases (Nudf2, where Nudf = Numerical user-defined field) are shown to be the most powerful discriminators of the numbers and types of events that have been generated. Unsurprisingly, the most significant finding is that the S76 base at Norwich (Nudf2 = 3) has been separated out as being very different from the AS332L bases at Aberdeen (Nudf2 = 1) and Scatsta (Nudf2 = 2).

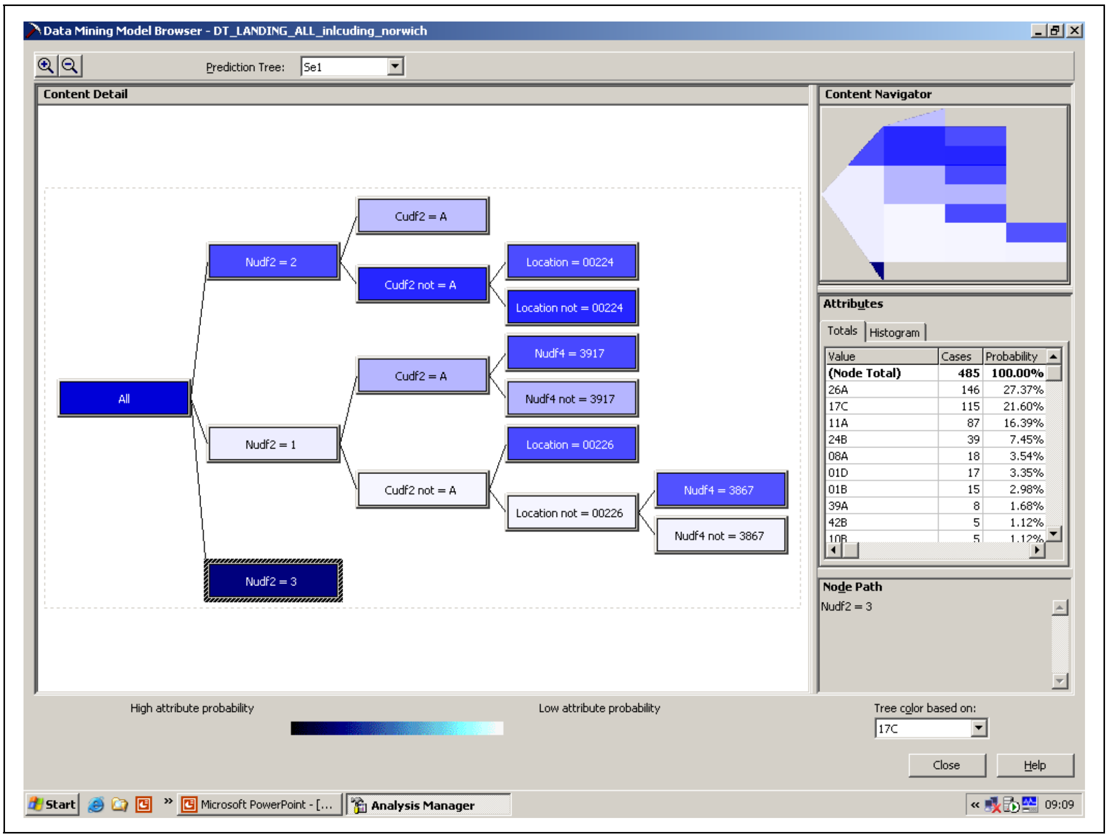


Figure 1 Decision Tree Predicting Event Type (coloured for event 17C)

If the root node of the tree (All) was selected, the table on the right hand side of the display would show the total number of events in the database, which includes 125 17C "Vno exceedance" events occurring during landing. The node for the Norwich base (Nudf2 = 3) has actually been selected, so that the table shows the number of events generated by the S76s at Norwich. It can be seen that 115 of the 125 17C events have been generated by the S76 aircraft at Norwich. Event 17C has been selected from the drop down list at the bottom right of the display, so that the tree has been coloured to show the density of the 17C events at each node (more events = darker colour). The fact that a large majority of the 17C events have occurred on the Norwich-based S76 aircraft can clearly be seen. Although the display could indicate a particular problem with an operating base and aircraft type, in this case, although the events were valid, they were considered to be nuisance occurrences and event 17C was subsequently inhibited on the S76 (see Section 4 sub-section 2.1).

The decision tree algorithm was re-run on event data from the AS332L aircraft operating from Aberdeen (Nudf2 = 1) and Scatsta (Nudf2 = 2), again only including events generated in the flight phase of 'landing'. The tree for the prediction of the de-identified code number for pilot 1 (i.e. the captain, Nudf4) from the other variables in the data set is shown in Figure 2. As before, operating base is identified as the most influential parameter (pilots are usually associated with one particular base). Following the branch of the tree for Aberdeen (Nudf2 = 1), event 21A "High groundspeed within 20 seconds of rig landing" has been identified as significant. This node has been selected and the codes for the pilots who have triggered this event are presented in the table on the right of the display. It can be seen that, of the 14 21A events that have occurred on Aberdeen-based aircraft, 10 have been triggered by one pilot. Event 18A "Fuel contents low" has been identified as significant in the branch of the tree for the Scatsta-based aircraft (Nudf2 = 2). In this case there have been 2 18A events on Scatsta-based aircraft, and both have been triggered by the same pilot. Whilst this information is easily identified using the data mining tool, it would be difficult to find using the standard FDE trend plots.

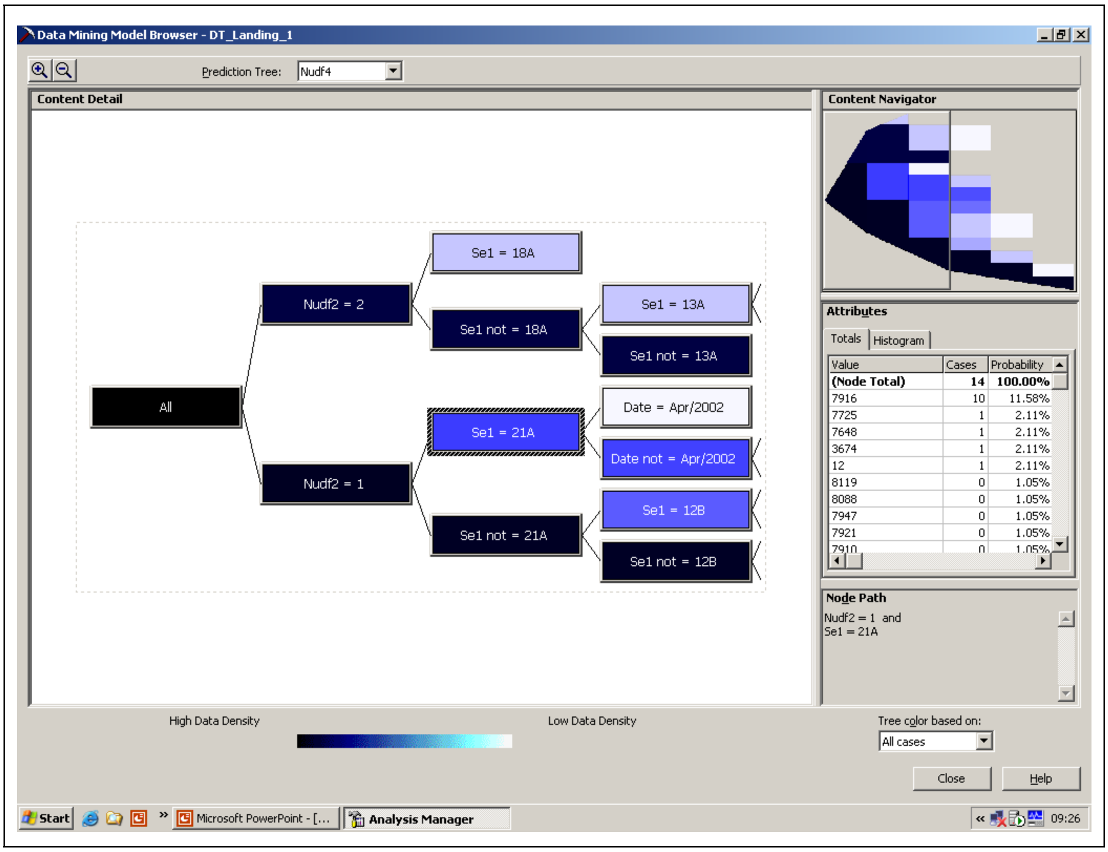


Figure 2 Decision Tree Predicting P1 ID

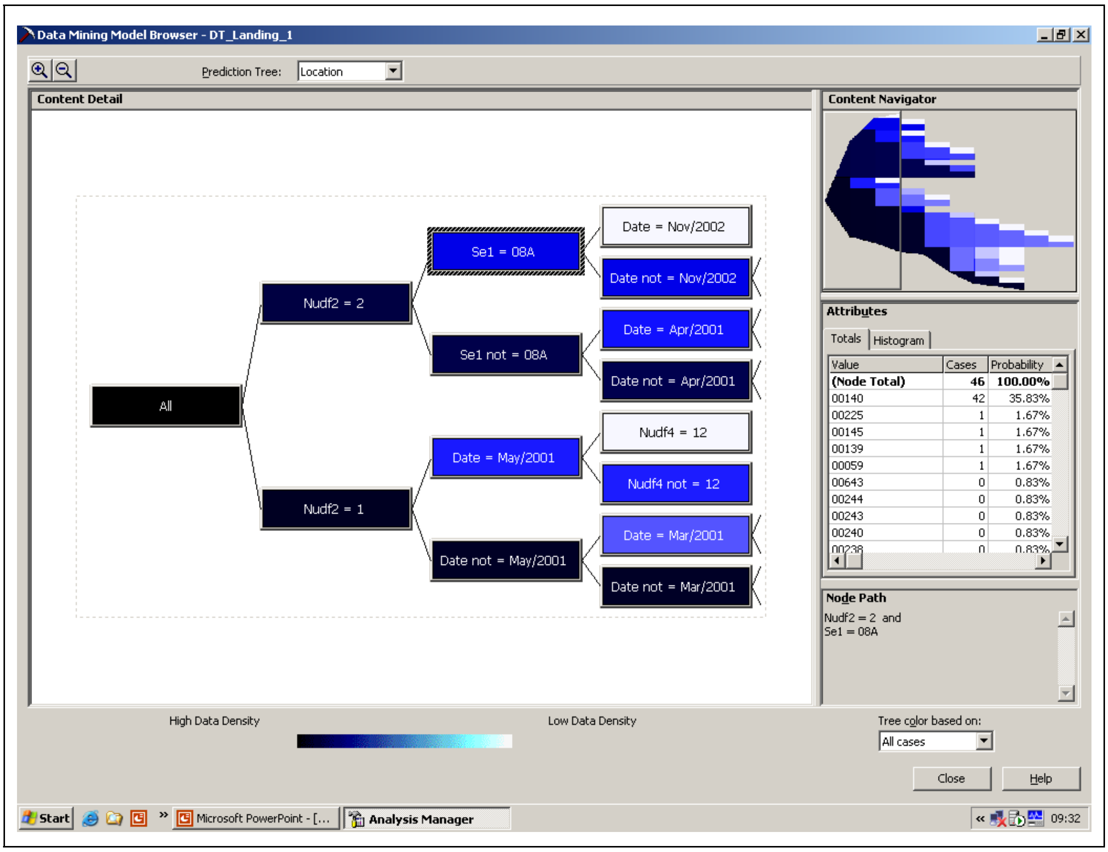


Figure 3 Decision Tree Predicting Location

Using the same data set as for the previous example, the decision tree for the prediction of location from the other variables is shown in Figure 3. Yet again, operating base is identified as the most influential parameter (aircraft from the different bases tend to operate to different locations). Following the branches of the tree for Scatsta (Nudf2 = 2), event 08A "High ROD below 500ft" has been identified as significant. It can be seen from the table on the right that, of the 46 events that have occurred on Scatsta-based aircraft, 42 have occurred at location 00140 (which is in fact Scatsta itself). Whilst in this case the finding might have been expected, the example shows how a location that is associated with a significant number of one type of event could easily be identified.

Although only a very limited exercise, the demonstration has clearly shown how data mining techniques can provide a powerful method of highlighting significant patterns and groupings in HOMP events that are difficult to detect using traditional trending techniques. In the case of the event data, this provides better visibility of operational risks and the factors associated with them and enables the better targeting of actions to address risks. However, data mining is equally applicable to measurement data and could be used to identify more subtle operational trends before they trigger any events. There would therefore be real benefit from the further application of data mining to both HOMP data and fixed wing FDM data.

Section 7 Conclusions

1 The CAA-funded follow-on activities have resulted in the successful trial of HOMP within a second operator (Scotia) and on a second helicopter type (BHL's S76). This, together with UKOOA's commitment to provide funding for HOMP, facilitates the implementation of HOMP on all FDR-equipped UK public transport helicopters operating over the UK Continental Shelf. Indeed, BHL has now fully implemented HOMP on the whole of its North Sea helicopter fleet, located at four different operating bases.

2 The results of the follow-on activities provide further evidence of the safety benefits of HOMP. Both BHL and Scotia identified significant safety issues as a result of their HOMP programmes and were able to take corrective measures to address them. In both cases, the operators have been able to demonstrate a reduction in operational risk as a result of the actions taken (Section 4 sub-sections 1, 2 and 3).

3 Through the development of HOMP agreements, active protection of the HOMP data and use of the HOMP results for non-punitive purposes only, both operators have obtained widespread aircrew acceptance of HOMP and a positive aircrew response to HOMP findings. A range of feedback mechanisms have been used to address identified risks. The most effective have been confidential crew debriefs and the feedback of lessons learned through the training department. The latter has been helped by the involvement of training captains in the operation and management of the HOMP (Section 3 sub-sections 1, 2 and 3).

4 BHL and Scotia identified several common operational risks on their AS332L helicopters, for example the danger of an aircraft rollover as a result of taxiing technique (Section 4 sub-sections 1 and 3). However, the operators sometimes took a different view on the risks associated with different events, as evidenced by differences in the allocation of event severity values (Section 4 sub-section 4). This was to some extent expected and reflected the differences in their operations, (Section 4 sub-sections 1.2, 3.2 and 5). However there is a need for providing more standardisation of the event severity assessment process, with guidance material on the factors that should be considered when determining an appropriate severity value.

5 The BHL S76 HOMP identified some different operational issues on the S76 to those found on the AS332L. In comparison, although substantial numbers of events were generated on the S76, the events considered to have any potential safety consequences were of a narrower range, and generally less significant, than the events triggered on the AS332L. Reasons for the difference could include differences in the helicopter types or operations, differences in the organisation of the data analysis and event review process, or the fact that a BHL S76 suffered a fatal accident shortly before the start of S76 HOMP operations (Section 4 sub-section 2.2). The S76 HOMP represents a scenario where the location of a particular fleet type, and the best experience on that fleet, is remote from the location of the main HOMP data analysis process. The S76 experience suggests that, for this scenario, there is a need for a periodic review of all HOMP analysis results involving key personnel from both locations (e.g. the HOMP Manager and S76 Fleet Representative) to ensure that no safety issues are being missed.

6 The S76 experience illustrated how HOMP capabilities can be negatively impacted by the lack of some key FDR parameters, most notably GPS data and, to a lesser extent, tri-axial accelerometer data (i.e. lateral and longitudinal accelerations in addition to the existing normal acceleration). On BHL's S76s it was a relatively straightforward task

to add the missing parameters. The programme benefited significantly from the addition of the GPS data (Section 3 sub-section 2) and although, due to an event configuration error, the benefit of the triaxial accelerometer was not demonstrated in the trial, fitting this was also considered to be worthwhile (Section 4 sub-section 2.2). Incidentally, the discovery of the event configuration error highlighted the importance of periodically checking that all events are working.

7 The CQAR data recorders continued to operate reliably, with no hardware failures occurring. Some PCMCIA cards suffered external damage, but these were relatively low cost items to replace. The HOMP software also continued to perform well and additional functional enhancements were introduced during the follow-on activities (Section 2 sub-section 5 and Section 3 sub-sections 1, 2 and 3).

8 The HOMP continued to detect a wide variety of events on the AS332L and two new types of event were developed as a result of pilot-reported occurrences. The event trend analysis provided good visibility of overall operational risks and whether risks were increasing or reducing. The trend analysis also enabled the identification of the distribution of risk, for example in relation to operating base or de-identified pilot code, to enable effective targeting of corrective actions (Section 4 sub-sections 1 and 3). The HOMP trial results have clearly highlighted the criticality of the event severity assessment process in identifying and quantifying operational risks, which emphasises the need for guidance material to aid the standardisation of this process (Section 4 sub-section 5).

9 The analysis of the measurements obtained from every flight showed how these can be used for the investigation of particular operational issues, either identified by the event analysis, or by other means. Further work on 'mapping of the helideck environment' illustrated how the HOMP measurements could be used to characterise problems of both structure-induced turbulence and hot turbine exhaust on offshore platforms (Section 5).

10 A small data mining demonstration showed how the application of data mining techniques to a database of events could readily identify otherwise hidden trends in the event data, providing a clearer picture of areas of risk. Data mining could be used in a similar way to identify hidden patterns and anomalies in measurement data (Section 6).

Section 8 Recommendations

The following recommendations are made:

1 Helicopter operators should follow BHL's lead and implement HOMP on all FDR-equipped commercial air transport helicopters.

2 The CAA should make representations to ICAO to have the existing initiative on Flight Data Monitoring programmes for fixed wing aircraft extended to include FDR-equipped commercial air transport helicopters.

3 In respect of HOMP implementation and operation, helicopter operators should:

- ensure that HOMP is properly integrated into the company's Safety Management System.
- standardise the core HOMP events used by different operators where possible to aid the sharing of lessons learned.
- continue to develop and refine the HOMP events to maximise the safety benefits of the programme, and optimise the balance between detecting the widest possible range of operational risks and minimising the nuisance event rate.
- continue to develop and refine the HOMP measurements to maximise their accuracy in characterising different aspects of the operation and to provide further analysis capabilities.
- implement the accurate low airspeed and pilot workload/turbulence measurement capabilities being developed on related CAA research projects to further enhance the capabilities of HOMP.

4 In respect of HOMP capability enhancement the CAA should, together with the helicopter operators:

- work to establish a standardised methodology for event severity allocation and provide guidance material on the factors to be considered in the severity allocation process.
- develop data mining techniques for the efficient analysis of HOMP event and measurement databases to identify hidden event trends and anomalies in measurement data prior to the triggering of any events.
- complete the development of additional functionality on related CAA research projects that will be of benefit to HOMP, e.g. provision of an accurate low airspeed measurement capability and turbulence related pilot workload measurements.
- investigate further possible HOMP applications, e.g. to monitor GPS performance.

Section 9 References

1 CAP 739, "Flight Data Monitoring, a Guide to Good Practice". Civil Aviation Authority 2003. ISBN 0 86039 930 3.

2 CAA Paper 2002/02, "Final Report on the Helicopter Operations Monitoring Programme (HOMP) Trial. CAA Contract No. 041/SRG/R&AD/1". Civil Aviation Authority 2002. ISBN 0 86039 877 3.

Appendix 1 Helicopter Operational Monitoring Programme (HOMP) Agreement

Statement of Understanding between CHC SCOTIA LTD (SCOTIA) and BALPA

Dated 01 October 2002

1 Preamble

This Statement of Understanding is intended as guidance with regard to the SCOTIA HOMP, both from a management point of view and from BALPA.

It is important to be aware that HOMP should form a part, albeit an important one, of the total SCOTIA flight safety monitoring programme.

2 Introduction

It has long been understood by BALPA that the greatest safety benefit to be derived from HOMP and similar Operational Flight Data Monitoring (OFDM) systems is by working in a spirit of mutual co-operation towards improving flight safety. A rigid set of rules can, on occasions, be obstructive, limiting or counter-productive, and it is preferred that those involved in the HOMP should be free to explore new avenues by mutual consent, always bearing in mind that the HOMP is a safety programme, not a disciplinary tool. The absence of rigid rules means that the continued success of HOMP depends on mutual trust - indeed this has always been a key feature of the intent of OFDM programmes.

3 Statement of Purpose

3.1 The primary purpose of monitoring operational flight data by the HOMP is to enhance flight safety. The actions to be taken to reverse an adverse trend or to prevent the repetition of an event may include raising pilot awareness, changing procedures and/ or manuals, and seeking to change pilot behaviour (individually or collectively), amongst others.

3.2 Interested third parties (e.g. Sikorsky, Eurocopter, CAA) may seek HOMP data for safety purposes.

Third parties do not have an automatic right to the data. However, if the request is for de-identified data (i.e. the data does not contain any information that would enable the data to be identified as originating from a particular flight) then SCOTIA may supply this information, and will notify BALPA on each occasion.

If, on the other hand, the requested data only has value when it can be linked to specific flights then SCOTIA must reach an agreement with BALPA under the terms with which the data can be provided.

4 Constitution

4.1 The HOMP requires a monitoring team, consisting of the following roles, although some of these may be combined within an individual's responsibilities:

a) **HOMP Manager**. Trusted and supported by management and crews alike and thereby accepted by all parties. Able to act independently of other line management to make recommendations that will be seen by all to have a high level of integrity and impartiality. The individual should have good analytical, presentation and management skills.

b) **Flight Safety Officer**. Responsible for the follow up of Air Safety Reports, able to put the FDR data into the context of ASR's.

c) **Relevant Fleet Representative**. Probably a senior Captain or trainer with a thorough knowledge of SOP's, the relevant aircraft type characteristics, airfields and routes.

d) **Engineering Interpreter**. Familiar with the power plant structures and systems departments requirements for information and also any existing monitoring techniques employed by the airline.

e) **BALPA Representative(s)**. The BALPA link between the fleet or training managers and the aircrew involved in circumstances highlighted by the HOMP. The BALPA representative(s), preferably representative of each section of the flight crew community, should each have a positive attitude towards safety education and good people skills, encapsulating the trust of both crews and managers in their integrity and good judgement.

f) **Engineering Technical Support**. An avionics specialist knowledgeable of FDR and associated systems needed to run the programme.

g) **Replay Operative and Administrator**. Responsible for the day-to-day running of the system, producing reports and analysis.

NOTE: In addition to their existing subject area expertise all staff should be given at least basic training in the specific areas of FDR data analysis. It is also essential that a regular, realistic amount of time be specifically allocated to these tasks).

Central to the HOMP is the formation of a HOMP Working Group (HWG). This Group should meet on a regular basis, ideally once a month if trends are to be identified and rectified in a timely manner. The following are the core Group members, with other interested parties attending as required/necessary:

HOMP Manager
Flight Safety Officer
Fleet Representative(s)
BALPA Representative(s)

The HOMP Manager chairs the HOMP WORKING GROUP and the HWG will:

i) Review selected events detected by the HOMP.

ii) Examine rates and trends and advise the Flight Operations Department of any potential problems with aircraft operation.

iii) Monitor follow up action.

5 Confidentiality

5.1 It is fundamental to the purpose of the HOMP that the substance of the reports should be disseminated where necessary in the interests of flight safety. However, without prejudice to SCOTIA's proper discharge of responsibilities as required by law, only the HOMP Manager will be aware of the crews identities for the sole purpose of contacting them as in 6.1 below.

Exceptions

5.1.1 If the event is reported by an Air Safety Report. (In which case the HOMP Working Group would not need to investigate the event, provided the ASR relates directly to the HOMP event).

5.1.2 In the case of repeated events by the same pilot in which the HOMP Working Group feel extra training would be appropriate. HOMP Manager will invite the pilot to undertake such extra training as may be deemed necessary after consultation with SCOTIA's Training Department who will arrange the training.

5.1.3 In other cases of repeated events by the same pilot; or a single pilot-induced event of such severity that the aircraft was seriously hazarded, or another flight would be if the pilot repeated the event, BALPA recognises that in the interests of flight safety, it cannot condone unreasonable, negligent or dangerous pilot behaviour and, at SCOTIA's request would normally consider withdrawing the protection of anonymity.

This consideration by BALPA will be undertaken by:

The HOMP Working Group BALPA Representative(s)
The Company Council Chairman
The Company Council Vice-Chairman

6 Contact with Pilots

6.1 It is accepted that an FDR trace may give an incomplete picture of what happened, and that it may not be able to explain "why" it happened. HOMP Manager will first inform BALPA and then contact the pilot(s) involved to elicit further information as to "how" and "why" an event occurred.

6.2 In the case of a single event, or series of events that is judged sufficiently serious to warrant more than a telephone call, but not sufficiently serious to make an immediate application for the withdrawal of anonymity under paragraph 5.1.3, then the HOMP Manager will present SCOTIA's view to the crew member(s) concerned.

6.3 Contact will initially be with the Captain of the flight, but where Human Factors are thought to be involved it may also be necessary to contact the co-pilot.

6.4 It is recognised that the value of the "HOMP Manager call" could be demeaned by over-use. Therefore the number of calls, and the value of each, are to be monitored by the HOMP Working Group.

6.5 At all stages of these procedures, the individual pilots concerned have the right to have BALPA representation, or representation of their own choice, if they so wish.

Signed on behalf of CHC Scotia Ltd

Name…………………………………..……..

Position……………………………..……..

Signed on behalf of BALPA

Name…………………………………..……..

Position……………………………..……..

Appendix 2 HOMP Flight Data Events and Measurements

Table 1 Listing of all HOMP Events

Event number	Title:	Applicable Aircraft Type	Applicable condition	Trigger parameters	Rationale
01A	High Pitch-Up Attitude Below 20 ft AGL	AS332L, S76	Air	Pitch Attitude, Radio Altitude	To detect the risk of a tail rotor strike.
01B	High Pitch-Up Attitude Above 20 ft and Below 500 ft AGL	AS332L, S76	Air	Pitch Attitude, Radio Altitude	To detect excessive flare angle i.e. rushed final approach, likely to alarm passengers or cause crew to lose visual reference
01C	High Pitch-Up Attitude Above 500 ft AGL	AS332L, S76	Air	Pitch Attitude, Radio Altitude	To detect excessive pitch up attitude in flight.
01D	High Pitch-Up Attitude Below 90 knots IAS	AS332L, S76	Air	Pitch Attitude, Indicated Airspeed	To detect excessive pitch up attitude at lower speeds.
01E	High Pitch-Up Attitude Above 90 knots IAS	AS332L, S76	Air	Pitch Attitude, Indicated Airspeed	To detect excessive pitch up attitude at higher speeds.
02A	High Pitch-Down Attitude Below 20 ft AGL	AS332L, S76	Air	Pitch Attitude, Radio Altitude	To detect excessive nose down pitch attitude during take-off transition which might result in striking the ground if an engine failed
02B	High Pitch-Down Attitude Above 20 ft and Below 500 ft AGL	AS332L, S76	Air	Pitch Attitude, Radio Altitude	To detect excessive nose down pitch attitude during take-off transition and at other lower level flight conditions.
02C	High Pitch-Down Attitude Above 500 ft AGL	AS332L, S76	Air	Pitch Attitude, Radio Altitude	To detect excessive pitch down attitude in flight.
02D	High Pitch-Down Attitude Below 90 knots IAS	AS332L, S76	Air	Pitch Attitude, Indicated Airspeed	To detect excessive pitch down attitude at lower speeds.
02E	High Pitch-Down Attitude Above 90 knots IAS	AS332L, S76	Air	Pitch Attitude, Indicated Airspeed	To detect excessive pitch down attitude at higher speeds.
03A	High Pitch Rate Below 500 ft AGL	AS332L, S76	Air	Pitch Rate, Radio Altitude	To detect excessive rate of change of pitch attitude at lower level flight conditions.

Table 1 Listing of all HOMP Events

Event number	Title:	Applicable Aircraft Type	Applicable condition	Trigger parameters	Rationale
03B	High Pitch Rate Above 500 ft AGL	AS332L, S76	Air	Pitch Rate, Radio Altitude	To detect excessive rate of change of pitch attitude in flight.
04A	Low Maximum Pitch Rate on Rig Take-Off	AS332L, S76	Rig Take-Off	Pitch Rate	To detect a low helicopter rotation rate during rotation on a take-off from a helideck which could result in a deck strike if an engine failed
04B	High Maximum Pitch Rate on Rig Take-Off	AS332L, S76	Rig Take-Off	Pitch Rate	To detect a high helicopter rotation rate during rotation on a take-off from a helideck, which might cause crew disorientation and passenger alarm
05A	Low Maximum Pitch-Down Attitude on Rig Take-Off	AS332L, S76	Rig Take-Off	Pitch Attitude	To detect a low nose down pitch attitude during rotation on a take-off from a helideck, which could result in a deck strike if an engine failed
05B	High Maximum Pitch-Down Attitude on Rig Take-Off	AS332L, S76	Rig Take-Off	Pitch Attitude	To detect a high nose down pitch attitude during rotation on a take-off from a helideck, which might cause crew disorientation and passenger alarm
06A	Roll Attitude Above 30 deg Below 300 ft AGL	AS332L	Air	Roll Attitude, Radio Altitude	To detect exceedence of the Flight Manual roll attitude limit for weights above 18,410 lb at lower level flight conditions.
06B	Roll Attitude Above 40 deg Below 300 ft AGL	AS332L, S76	Air	Roll Attitude, Radio Altitude	To detect exceedence of the Flight Manual roll attitude limit for weights above 17,200 lb at lower level flight conditions.
06C	Roll Attitude Above 30 deg Above 300 ft AGL	AS332L	Air	Roll Attitude, Radio Altitude	To detect exceedence of the Flight Manual roll attitude limit for weights above 18,410 lb.
06D	Roll Attitude Above 40 deg Above 300 ft AGL	AS332L, S76	Air	Roll Attitude, Radio Altitude	To detect exceedence of the Flight Manual roll attitude limit for weights above 17,200 lb.
07A	High Roll Rate Below 500 ft AGL	AS332L, S76	Air	Roll Rate, Radio Altitude	To detect excessive roll rate at lower level flight conditions.
07B	High Roll Rate Above 500 ft AGL	AS332L, S76	Air	Roll Rate, Radio Altitude	To detect excessive roll rate in flight.

Table 1 Listing of all HOMP Events

Event number	Title:	Applicable Aircraft Type	Applicable condition	Trigger parameters	Rationale
08A	High Rate of Descent Below 500 ft AGL	AS332L, S76	Air	Rate of Descent, Radio Altitude	To detect an excessive rate of descent at low height.
08B	High Rate of Descent Above 500 ft AGL	AS332L, S76	Air	Rate of Descent, Radio Altitude	To detect an excessive rate of descent.
08C	High Rate of Descent Below 30 knots LAS	AS332L, S76	Air	Rate of Descent, Indicated Airspeed	To detect an excessive rate of descent at low airspeed (where there is danger of entering the vortex ring state).
09A	Low Airspeed Above 500 ft AGL	AS332L, S76	Take-Off, Cruise	Indicated Airspeed	To detect flight at an unusually low airspeed.
10A	Normal Acceleration Above 500 ft AGL	AS332L, S76	Air	Normal Acceleration, Radio Altitude	To detect a high normal acceleration in flight due to turbulence or a manoeuvre.
10B	Normal Acceleration Below 500 ft AGL	AS332L, S76	Air	Normal Acceleration, Radio Altitude	To detect a high normal acceleration at lower level flight conditions due to turbulence or a manoeuvre.
10C	Lateral Acceleration Above 500 ft AGL	AS332L, S76	Air	Lateral Acceleration, Radio Altitude	To detect a high lateral acceleration in flight due to turbulence or a manoeuvre.
10D	Lateral Acceleration Below 500 ft AGL	AS332L, S76	Air	Lateral Acceleration, Radio Altitude	To detect a high lateral acceleration at lower level flight conditions due to turbulence or a manoeuvre.
10E	Longitudinal Acceleration Above 500 ft AGL	AS332L, S76	Air	Longitudinal Acceleration, Radio Altitude	To detect a high longitudinal acceleration in flight due to turbulence or a manoeuvre.
10F	Longitudinal Acceleration Below 500 ft AGL	AS332L, S76	Air	Longitudinal Acceleration, Radio Altitude	To detect a high longitudinal acceleration at lower level flight conditions due to turbulence or a manoeuvre.
11A	Excessive Lateral Cyclic Control	AS332L, S76	Air	Lateral Cyclic Pitch	To detect movement of the lateral cyclic control to extreme left or right positions.

Table 1 Listing of all HOMP Events

Event number	Title:	Applicable Aircraft Type	Applicable condition	Trigger parameters	Rationale
11B/C	Excessive Longitudinal Cyclic Control	AS332L, S76	Air	Longitudinal Cyclic Pitch	To detect movement of the longitudinal cyclic control to extreme forward or aft positions.
12A	Excessive Collective Pitch Control in Level Flight	AS332L	Air	Collective Pitch, Rate of Descent	To detect approaches to, or exceedences of, Flight Manual collective pitch limits for cruising flight.
12B	Excessive Collective Pitch Control	AS332L	Air	Collective Pitch	To detect exceedences of the absolute maximum Flight Manual collective pitch limit.
13A	Pilot Event Marker Pressed	AS332L, S76	Air		To detect when the FDR pilot event marker has been pressed.
14A	IAS Mode Engaged Below 60 knots IAS	AS332L	Air	Autopilot IAS Mode, Indicated Airspeed	To detect inappropriate engagement of autopilot airspeed hold at low airspeeds.
14B	ALT Mode Engaged Below 60 knots IAS	AS332L	Air	Autopilot ALT Mode, Indicated Airspeed	To detect inappropriate engagement of autopilot altitude hold at low airspeeds.
14C	HDG Mode Engaged Below 60 knots IAS	AS332L	Air	Autopilot HDG Mode, Indicated Airspeed	To detect inappropriate engagement of autopilot heading hold at low airspeeds.
15A	Gear Selected Up Below 100 ft AGL on Take-off	AS332L, S76	Take-Off	Gear Select, Radio Altitude	To detect early retraction of the landing gear during take-off.
15B	Gear Not Selected Down Below 300 ft AGL on Landing	AS332L, S76	Landing	Gear Select, Radio Altitude	To detect late lowering of the landing gear during landing.
16A	Excessive Time in Avoid Area				Not yet implemented (awaiting low airspeed algorithm)
17A/C	VNO Exceedence	AS332L	Air	VNO, Weight	To detect exceedance of the Flight Manual VNO limit (this is weight dependent).
17B/D	VNE Exceedence	AS332L, S76	Air	VNE, Weight	To detect exceedence of the Flight Manual VNE limit (this is weight dependent).
18A	No. 1 (LH) Fuel Contents Low	AS332L	Air	LH Fuel Contents	To detect if the total remaining fuel contents fall below the Operations Manual limit.

Table 1 Listing of all HOMP Events

Event number	Title:	Applicable Aircraft Type	Applicable condition	Trigger parameters	Rationale
18B	No2. (RH) Fuel Contents Low	AS332L	Air	RH Fuel Contents	To detect if the total remaining fuel contents fall below the Operations Manual limit.
19A	Heater On During Take-Off	AS332L	Take-Off	Heater	To detect non-conformance with the Flight Manual requirement that the cabin heater should be off during take-off.
19B	Heater On During Landing	AS332L	Landing	Heater	To detect non-conformance with the Flight Manual requirement that the cabin heater should be off during landing.
20A	Early Turn on Offshore Take Off at Night	AS332L, S76	Rig Take-Off	Heading, Ground Speed, Day/Night	To detect an early turn after an offshore take-off at night.
21A	High Ground Speed Within 20 seconds of Rig Landing	AS332L, S76	Rig Landing	Ground Speed	To detect a high ground speed on the final approach to a helideck landing.
21B	High Ground Speed Within 10 seconds of Airport Landing	AS332L, S76	Airport Landing	Ground Speed	To detect a high ground speed on the final approach to an airport landing.
22A	High Airspeed Below 100 ft AGL	AS332L, S76	Air	Indicated Airspeed, Radio Altitude	To detect high speed flight at low level.
22B	High Airspeed Below 100 ft AGL and Gear Up	AS332L, S76	Air	Indicated Airspeed, Radio Altitude, Gear Select	To detect high speed flight at low level with the landing gear retracted.
22C	IAS Above 130 kt and Gear Down	S76	Air	Indicated Airspeed, Gear Select	To detect exceedence of the Flight Manual limit (to prevent overstressing of a landing gear strut).
23A	Downwind Flight Within 60 seconds of Take-Off	AS332L, S76	Take-Off	Indicated Airspeed, Ground Speed	To detect downwind flight shortly after take-off.
23B	Downwind Flight Within 60 seconds of Landing	AS332L, S76	Landing	Indicated Airspeed, Ground Speed	To detect downwind flight shortly before landing.
24A	Low Rotor Speed – Power On	AS332L, S76	Air	Rotor Speed, Total Torque	To detect excessively low rotor speed during power-on flight.
24B	High Rotor Speed – Power On	AS332L, S76	Air	Rotor Speed, Total Torque	To detect excessively high rotor speed during power-on flight.

Table 1 Listing of all HOMP Events

Event number	Title:	Applicable Aircraft Type	Applicable condition	Trigger parameters	Rationale
24C	Low Rotor Speed - Power Off	AS332L, S76	Air	Rotor Speed, Total Torque	To detect exceedence of the Flight Manual minimum rotor speed limit for power-off flight.
24D	High Rotor Speed – Power Off	AS332L, S76	Air	Rotor Speed, Total Torque	To detect exceedence of the Flight Manual maximum rotor speed limit for power-off flight.
25A	Maximum Continuous Torque (2 Engines)	AS332L, S76	Air	Total Torque	To detect more than 5 minutes use of the Flight Manual takeoff rating torque limit
25B	Maximum Take-Off Torque (2 Engines)	AS332L, S76	Air	Total Torque	To detect exceedence of the Flight Manual absolute maximum torque limit.
25C/D	Maximum Continuous Torque – Engine 1/2	S76	Air	Engine 1/2 Torque	To detect exceedence of the Flight Manual single engine maximum continuous torque limit.
25E/F	Maximum Contingency Torque - Engine 1/2	S76	Air	Engine 1/2 Torque	To detect exceedence of the Flight Manual single engine maximum contingency torque limit.
25G	Maximum Combined Torque Over 200%	S76	Air	Total Torque	To detect exceedence of the Flight Manual 200% combined torque limit.
26A	Pilot Workload/Turbulence	AS332L, S76	Landing	Changes in Collective Pitch	To detect turbulence encountered during the final approach to a helideck landing.
27A	Pilot Workload	AS332L, S76	Landing	Collective, Lateral & Longitudinal Cyclic	Not yet implemented (awaiting outcome of CAA research project)
28A	Flight Though Hot Gas	AS332L, S76	Take-Off, Landing	Outside Air Temperature	To detect if the aircraft flies through the turbine efflux or flare plume during a helideck take-off or landing.
29A	High Pitch-Up Attitude on Ground	AS332L, S76	Ground	Pitch Attitude	To detect high aircraft pitch angles when on a vessel's helideck, or on sloping ground.
29B	High Pitch-Down Attitude on Ground	AS332L, S76	Ground	Pitch Attitude	To detect high aircraft pitch angles when on a vessel's helideck, or on sloping ground.
30A	High Roll Attitude on Ground	AS332L, S76	Ground	Roll Attitude	To detect high aircraft roll angles during taxiing, when on a vessel's helideck, or on sloping ground.
31A	High Normal Acceleration at Landing	AS332L, S76	Landing, Ground	Normal Acceleration	To detect a heavy landing.

Table 1 Listing of all HOMP Events

Event number	Title:	Applicable Aircraft Type	Applicable condition	Trigger parameters	Rationale
32A	High Rotor Speed on Ground	AS332L, S76	Ground	Rotor Speed	To detect possible governor problems on the ground.
33A	Rotor Brake Applied at Greater Than 122 Rotor RPM	AS332L, S76	Ground	Rotor Brake, Rotor Speed	To detect application of the rotor brake above the Flight Manual limit for rotor speed.
34A	Excessive Long Cyclic Control with Insufficient Collective Pitch on Ground	AS332L, S76	Ground	Collective Pitch, Longitudinal Cyclic Pitch	To detect incorrect taxi technique likely to cause rotor head damage
34B	Excessive Rate of Movement of Longitudinal Cyclic on Ground	AS332L, S76	Ground	Longitudinal Cyclic Pitch Rate, Rotor Speed	To detect an excessive rate of movement of the longitudinal cyclic control when on the ground with rotors running.
34C	Excessive Rate of Movement of Lateral Cyclic on Ground	AS332L, S76	Ground	Lateral Cyclic Pitch Rate, Rotor Speed	To detect an excessive rate of movement of the lateral cyclic control when on the ground with rotors running.
35A/B	Excessive Movement of Deck	AS332L, S76	Helideck	Motion Severity Index	To detect excessive movement of a vessel's helideck when the helicopter is on the deck.
36A	High Lateral Acceleration (rapid cornering)	AS332L, S76	Ground	Lateral Acceleration	To detect excessive cornering accelerations/speeds when taxiing.
36B	High Longitudinal Acceleration (rapid braking)	AS332L, S76	Ground	Longitudinal Acceleration	To detect excessive deceleration due to braking when taxiing.
37A	High Ground Speed	AS332L, S76	Ground	Ground Speed	To detect excessive taxiing speeds.
38A	Taxi Limit (left gear lifts)	AS332L	Ground	Lateral Cyclic Pitch, Tail Rotor Pedal	To detect the risk of an aircraft roll over due to incorrect tail rotor pedal and lateral cyclic control positions when taxiing.
38B	Taxi Limit (right gear lifts)	AS332L	Ground	Lateral Cyclic Pitch, Tail Rotor Pedal	To detect the risk of an aircraft roll over due to incorrect tail rotor pedal and lateral cyclic control positions when taxiing.
39A	Single Engined flight	AS332L, S76	Air	No1 Eng Torque, No2 Eng Torque	To detect single engined flight.
40A	Torque Split in the Cruise	AS332L, S76	Cruise	No1 Eng Torque, No2 Eng Torque	To detect a possible engine problem, subsequently found to have been caused by module 2 stator vane rotation.

Table 1 Listing of all HOMP Events

Event number	Title:	Applicable Aircraft Type	Applicable condition	Trigger parameters	Rationale
41A	Go Around	AS332L, S76	Cruise, Landing	Gear Select	To detect a go-around.
41B	Below Minimum Height on Go Around	AS332L, S76	Cruise, Landing	Gear Select, Radio Altitude	To detect a descent below the minimum height limit during a go around.
41C	Below Minimum Height on Go Around at Night	AS332L, S76	Cruise, Landing	Gear Select, Radio Altitude	To detect a descent below the minimum height limit during a go around at night.
42A	Autopilot Engaged On Ground Before Take-Off	AS332L, S76	Ground	Autopilot Status	To detect premature engagement of the autopilot prior to take-off which could result in unexpected control movements.
42B	Autopilot Engaged On Ground After Landing	AS332L, S76	Ground	Autopilot Status	To detect failure to disengage the autopilot after landing which could result in unexpected control movements.
43A/B	Maximum Continuous N1 - Engine 1/2	S76	Air	Engine 1/2 N1	To detect exceedence of the Flight Manual single engine maximum continuous N1 limit.
43C/D	Maximum Contingency N1 - Engine 1/2	S76	Air	Engine 1/2 N1	To detect exceedence of the Flight Manual single engine maximum contingency N1 limit.
44A/B	Maximum Continuous T5 - Engine 1/2	S76	Air	Engine 1/2 T5	To detect exceedence of the Flight Manual single engine maximum continuous T5 limit.
44C/D	Maximum Contingency T5 - Engine 1/2	S76	Air	Engine 1/2 T5	To detect exceedence of the Flight Manual single engine maximum contingency T5 limit.
45A	Low Height and Speed at Night	AS332L, S76	Air	Indicated Airspeed, Radio Altitude, Day/Night	To detect flight at low height and speed at night (e.g. due to an inadvertent descent).
45B/C	Low Height and Speed at Night (Take-Off/Landing)	AS332L, S76	Rig Take-Off/ Landing	Indicated Airspeed, Radio Altitude, Day/Night	To detect flight at low height and speed at night (e.g. due to an inadvertent descent).
46A	Inadvertent Lift Off	AS332L, S76	Ground	Weight-On-Wheels	To detect an inadvertent lift off (e.g. due to inadvertent application of collective instead of the parking brake).
47A/B	Yaw Turbulence (+ve/-ve Yaw Acceleration)	AS332L	Take-Off, Landing	Yaw Rate, Tail Rotor Pedal	To detect turbulence causing excessive aircraft yaw motion.

Table 2 Listing of all HOMP Measurements

Measurement	Applicable Aircraft Type	Applicable Condition	Values
Pitch below 20ft AGL	AS332L, S76	Air	Max +ve, Min –ve
Pitch between 20ft and 500ft AGL	AS332L, S76	Air	Max +ve, Min –ve
Pitch above 500ft AGL	AS332L, S76	Air	Max +ve, Min –ve
Pitch below 90kt IAS	AS332L, S76	Air	Max +ve, Min –ve
Pitch above 90kt IAS	AS332L, S76	Air	Max +ve, Min –ve
Pitch rate below 500ft AGL	AS332L, S76	Air	Max absolute
Pitch rate above 500ft AGL	AS332L, S76	Air	Max absolute
Roll below 300ft AGL	AS332L, S76	Air	Max absolute
Roll above 300ft AGL	AS332L, S76	Air	Max absolute
Roll rate below 500ft AGL	AS332L, S76	Air	Max absolute
Roll rate above 500ft AGL	AS332L, S76	Air	Max absolute
Yaw rate	AS332L	Air	Max +ve, Min –ve
Rate of Descent below 500ft AGL	AS332L, S76	Air (Individual phases)	Max
Rate of Descent above 500ft AGL	AS332L, S76	Air (Individual phases)	Max
Rate of Descent below 30kt IAS	AS332L, S76	Air (Individual phases)	Max
IAS above 500ft AGL	AS332L, S76	Air	Min
Lateral acceleration above 500ft AGL	AS332L, S76	Air	Max absolute
Lateral acceleration below 500ft AGL	AS332L, S76	Air	Max absolute
Longitudinal acceleration above 500ft AGL	AS332L, S76	Air	Max absolute
Longitudinal acceleration below 500ft AGL	AS332L, S76	Air	Max absolute
Normal acceleration above 500ft AGL	AS332L, S76	Air	Max absolute
Normal acceleration below 500ft AGL	AS332L, S76	Air	Max absolute
Lateral cyclic control	AS332L, S76	Air	Max , Min
Longitudinal cyclic control	AS332L, S76	Air	Max, Min
Collective pitch control	AS332L, S76	Air (Individual phases)	Max
IAS at which IAS mode engaged IAS at which ALT mode engaged IAS at which HDG mode engaged	AS332L	Air	Min Min Min
IAS	AS332L, S76	Air	Max
IAS below 100ft AGL	AS332L, S76	Air	Max
Main rotor speed above 10% total torque	AS332L, S76	Air	Max, Min
Main rotor speed below 10% total torque	AS332L, S76	Air	Max, Min
Total torque	AS332L, S76	Air (Individual phases)	Max
Increase in OAT	AS332L, S76	Air	Max

Table 2 Listing of all HOMP Measurements

Measurement	Applicable Aircraft Type	Applicable Condition	Values
Increase in OAT at take-off/landing	AS332L, S76	Air (Take-off and landing)	Max
Ng engine 1/2	AS332L, S76	Air (Individual phases)	Max
Engine gas temperature engine 1/2	AS332L, S76	Air (Individual phases)	Max
Ice detector	AS332L	Air	Max
IGB oil temperature	AS332L	Air	Max
MGB oil pressure	AS332L	Air	Max, Min
MGB oil temperature	AS332L, S76	Air	Max
TGB oil temperature	AS332L	Air	Max
Pressure altitude	AS332L, S76	Air	Max
Pilot workload / turbulence (collective only)	AS332L, S76	Air	Max
Pitch	AS332L, S76	Ground	Max, Min
Roll	AS332L, S76	Ground	Max absolute
Main rotor speed	AS332L, S76	Ground	Max
Longitudinal cyclic control	AS332L, S76	Ground	Max
Longitudinal cyclic control rate	AS332L, S76	Ground	Max absolute
Lateral cyclic control rate	AS332L, S76	Ground	Max absolute
Motion Severity Index (excluding airports)	AS332L, S76	Ground	Max
Lateral acceleration	AS332L, S76	Ground	Max absolute
Longitudinal acceleration	AS332L, S76	Ground	Max absolute
Ground speed	AS332L, S76	Ground	Max
NMLA datum value	AS332L, S76	When calculated	Value
Fuel contents tank 1/2	AS332L	At take-off	Value
Fuel remaining tank 1/2	AS332L	At landing	Value
Aircraft weight	AS332L, S76	At take-off	Value
Aircraft weight	AS332L, S76	At landing	Value
Rad alt at gear selected up	AS332L, S76	At gear up	Value
Rad alt at gear selected down	AS332L, S76	At gear down	Value
Normal acceleration at landing	AS332L, S76	At landing	Max
MR speed at application of rotor brake	AS332L, S76	MR brake applied	Value
Engine gas temperature, engine 1/2	AS332L, S76	At engine start	Max
Pitch rate, rig take-off	AS332L, S76	At rotation point	Max
Pitch, rig take-off	AS332L, S76	At rotation point	Max
Rad alt, rig take-off	AS332L, S76	At max pitch rate	Value
Ground speed, rig landing	AS332L, S76	Point before landing	Value
Ground speed, airport landing	AS332L, S76	Point before landing	Value
Pressure altitude	AS332L, S76	At take-off	Value

Table 2 Listing of all HOMP Measurements

Measurement	Applicable Aircraft Type	Applicable Condition	Values
Pressure altitude	AS332L, S76	At landing	Value
OAT	AS332L, S76	At take-off	Value
OAT	AS332L, S76	At landing	Value
Average wind speed	AS332L, S76	Point after TO & before LDG	Value
Average wind direction	AS332L, S76	Point after TO & before LDG	Value
Hover torque on take-off	S76	At take-off	Max
Hover torque on landing	S76	At landing	Max
Take-off profile 1: Lift-off	AS332L, S76	Offshore take-off	Time, Pressure Altitude, Latitude, Longitude
Take-off profile 2: Rotation – Maximum Pitch Rate	AS332L, S76	Offshore take-off	Time from Take-Off, Radio Altitude, Pressure Altitude (AAL), Pitch, Roll, Heading, Airspeed, Groundspeed, Latitude (N/S distance from take-off), Longitude (W/E distance from take-off)
Take-off profile 3: Rotation – Maximum Pitch Down Angle	AS332L, S76	Offshore take-off	
Take-off profile 4: 35 knots Airspeed	AS332L, S76	Offshore take-off	
Take-off profile 5: Gear Selected Up	AS332L, S76	Offshore take-off	
Landing profile 1: Touch-down	AS332L, S76	Offshore landing	Time, Pressure Altitude, Latitude, Longitude
Landing profile 2: 200 feet AAL	AS332L, S76	Offshore landing	Time to Landing, Radio Altitude, Pressure Altitude (AAL), Pitch, Roll, Heading, Airspeed, Groundspeed, Latitude (N/S distance from landing), Longitude (W/E distance from landing)
Landing profile 3: 500 feet AAL	AS332L, S76	Offshore landing	
Landing profile 4: 1,000 feet AAL	AS332L, S76	Offshore landing	
Operations data	AS332L, S76	For flight sector	Flight type, pax number, P1ID, P2ID, day/night on take-off/landing, departure code, destination code