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VN-AEROTOXIC DETECTION SOLUTIONS LTD
2nd Round Enterprise Investment Scheme Funding

Fume event that lasted for two hours onboard a US Airways flight from Phoenix to Maui

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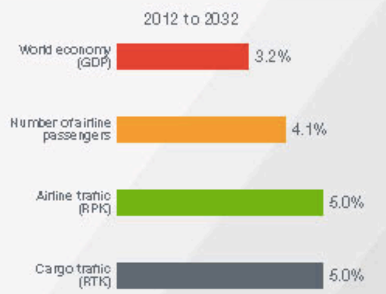
Future Journeys: Global Market Forecast 2013 2032
In the next 20 years demand for air traffic will grow at 4.7% annually
requiring over 29,200 new passenger and freight aircraft
valued at nearly US$ 4.4 trillion
By 2032 there will be
89 AVIATION MEGA-CITIES
up from today's 42
Passengers will more than double from today's
2.9 billion
to
6.7 billion
in 2032
The average aircraft size has increased by
25%
in the last 20 years and this trend will continue to grow. Larger aircraft, like the A380, unlock capacity.
Asia-Pacific will lead the world in traffic
overtaking Europe and North America
Some
10,400
new aircraft
will be replacing older less fuel efficient ones
Demand for air travel will increase as economies grow
AIRBUS

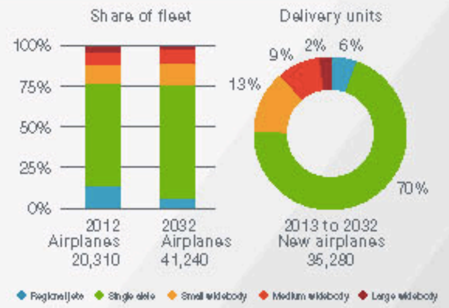
Current Market Outlook
2013 – 2032

Outlook on a Page

World regions
Market growth rates



World regions
Market value: $4,840 billion



World regions
Key indicators and new airplane markets

Growth measures Regions			Asia Pacific	North America	Europe	Middle East	Latin America	CIS	Africa	World
World economy	(GDP)	%	4.5	2.5	1.8	3.8	4.0	3.4	4.4	3.2
Airline traffic	(RPK)	%	6.3	2.7	4.2	6.3	6.9	4.5	5.7	5.0
Cargo traffic	(RTK)	%	5.8	3.8	3.8	6.6	6.0	4.5	6.6	5.0
Airplane fleet		%	5.5	1.5	3.1	4.7	5.6	1.5	4.0	3.6
Market size										
Deliveries			12,820	7,250	7,460	2,610	2,900	1,170	1,070	35,280
Market value	($B)		1,890	810	1,020	550	300	140	130	4,840
Average value	($M)		150	110	140	210	100	120	120	140
Unit share		%	36	21	21	7	8	4	3	100
Value share		%	39	17	21	11	6	3	3	100
New airplane deliveries										
Large widebody			260	30	170	280	—	20	—	760
Medium widebody			1,470	390	650	670	40	60	20	3,300
Small widebody			1,860	760	850	410	270	130	250	4,530
Single aisle			8,810	5,000	5,610	1,240	2,420	860	730	24,670
Regional jets			420	1,070	180	10	170	100	70	2,020
Total			12,820	7,250	7,460	2,610	2,900	1,170	1,070	35,280
Market value (2012 $B, catalog prices)										
Large widebody			90	10	60	110	—	10	—	280
Medium widebody			490	130	210	220	10	20	10	1,090
Small widebody			460	170	210	100	70	30	60	1,100
Single aisle			840	460	530	120	210	70	60	2,290
Regional jets			10	40	10	1	10	10	2	80
Total			1,890	810	1,020	550	300	140	130	4,840
2012 fleet										
Large widebody			330	120	180	80	—	60	10	780
Medium widebody			500	290	360	270	20	20	60	1,520
Small widebody			660	710	340	230	120	170	80	2,310
Single aisle			3,470	3,760	3,160	500	1,050	680	420	13,040
Regional jets			130	1,710	350	60	90	200	120	2,660
Total			5,090	6,590	4,390	1,140	1,280	1,130	690	20,310
2032 fleet										
Large widebody			350	60	200	250	—	50	—	910
Medium widebody			1,550	500	690	700	50	70	50	3,610
Small widebody			2,080	1,040	990	450	380	190	280	5,410
Single aisle			10,350	6,140	5,930	1,420	3,150	1,100	1,040	29,130
Regional jets			420	1,070	200	30	210	120	130	2,180
Total			14,750	8,810	8,010	2,850	3,790	1,530	1,500	41,240

Market values above 5 have been rounded to the nearest 10.

Flight crew ‘spaced out’ on fumes

January 1 2017, 12:01am,
The Sunday Times

British Airways flight attendants on board an Airbus A380 “superjumbo” vomited, became “spaced out” and had to use emergency oxygen after suspected “toxic fumes” were detected in the cabin during a long-haul flight, a leaked internal report reveals.

At least one crew member became so ill that he curled up on the floor and put a blanket over his head. Others displayed bizarre behaviour including “stuffing” food into their mouths while using oxygen masks and wandering around “lost” in the cabin.

The report, which has been seen by The Sunday Times, was written by the cabin service director (CSD), the most senior grade of flight attendant, who was in charge of the 22-strong cabin crew on a BA flight from San Francisco to London on October 25.

About 40 minutes after take-off, while the airliner was over Canada, crew detected a strong noxious smell similar to burning plastic and the flight was diverted to Vancouver. The captain declared an emergency, telling air traffic control that the problem was “toxic gas-type fumes”.

After the aircraft landed safely, all the flight attendants and the three pilots were taken to hospital. BA later described the incident as an “odour event”, prompting claims by the Unite union that it was downplaying the health risks of potentially toxic fumes in aircraft cabins.

The cabin air in most passenger jets is supplied from the compression section of the engine in a process known as “bleed air”. If seals inside the engine leak, it is believed that heated oil fumes can enter the air supply, contaminating it with chemicals that some experts believe can cause serious health problems.
The leaked report graphically describes the severity of the incident. It details how 12 crew members displayed symptoms that gave “cause for concern” and that eight of the nine crew members on the upper deck plus the captain used emergency oxygen.

After the smell was detected by a door towards the back of the main cabin and on the upper deck, the report says “it soon became apparent that more crew were behaving in a non-normal manner . . . [with] reports of dizziness, light heads, headaches, nausea, itchy red eyes, metallic taste in mouth, floating-type feelings, flushed, aggression and, most worryingly, forgetfulness and confusion, inability to think straight and converse in normal manner.”

It describes how one crew member said something “completely out of context” and seconds later had forgotten that he had said it. Senior flight attendants would “lose” colleagues who would say they were going to the lavatory but then ended up at the other end of the aircraft “not knowing how they got there”, it adds.

The CSD described “crew in corners on [the] floor with blankets over their heads” and “crew ‘stuffing food’ in their mouths while on oxygen”.

Crew members continued to complain of feeling ill after they left hospital, according to the report. One collapsed vomiting at Heathrow’s terminal 5 when they returned to the UK.

This weekend another flight attendant told how crew members were “sobbing” during a debriefing session at Heathrow and claimed that some staff are still off work.

“I can’t say how I would have acted in an emergency situation if I had to go through my drills,” said the source, who asked to remain anonymous.

Ciara Parkes, a showbusiness publicist who has represented the actors Jude Law and Ewan McGregor, was on the plane with her husband, Gus. She said they feared they were being hijacked because the crew were so panicked.

“I think that’s probably the most terrified I’ve been in my life,” she said.

She said her chest became “incredibly tight” and she struggled to stand during the incident. She claimed some passengers had bloodshot eyes. Four days later Parkes had a blood test that showed elevated levels of enzymes, which can indicate liver problems. She has had regular headaches since.

BA said its engineers had inspected the aircraft in Vancouver and “no fault was found”.
It added: “The safety of our customers and crew is always our top priority. We have shared our detailed and thorough investigation with the Civil Aviation Authority and fully comply with all safety regulations.”

Airbus said its aircraft are designed to “provide the highest level of cabin air quality”.

‘Fume event’ hospitalises American Airlines crew in latest incident concerning cabin air

Daily Telegraph 4 JANUARY 2017 • 12:35PM

http://www.telegraph.co.uk/travel/news/fume-incident-hospitalises-american-airlines-crew-and-raises-questions-over-safety-of-cabin-air/

Seven flight attendants were taken to hospital complaining of headaches caused by "odours in the cabin" on an American Airlines aircraft.

The crew on flight 1896, which landed safely in Orlando on Monday night, were said to have been involved in what are known as fume events. Seven staff were hospitalised, but none of the 89 passengers needed medical treatment.

According to American Airlines the Airbus A330 is currently undergoing a “thorough maintenance inspection”, but the airline has not yet identified what caused the odour. The flight attendants were released from hospital shortly after their arrival.

This is the third fume event to affect the aircraft in as many months, according to ABC News. The jet is alleged to have experienced a “dirty sock odour” on November 23 and a similar incident five days later.

“The health and welfare of our crews and customers continues to be our top priority at American Airlines,” the carrier said in a statement.

“We take cabin odour issues seriously and have devoted extensive efforts over time, including working with aircraft, engine and auxiliary power unit manufacturers, to address these types of concerns.”

Typically, fume events occur when engine oil and other toxic chemicals leak into the air circulated around the cabin. Campaigners claim this can cause “aerotoxic syndrome” in regular fliers, an illness linked with the deaths of at least two pilots, including British Airways’ Richard Westgate.

The coroner investigating his death ruled in February 2014 that fumes circulating in planes posed “consequential damage” to the health of frequent fliers.

However, the Civil Aviation Authority (CAA) has always maintained that cabin air is safe and that there is no evidence of long-term health effects.

Unite the Union told Telegraph Travel in November that it believes the aviation industry is downplaying serious toxic fume events onboard aircrafts.

“Fume events and continued exposure to contaminated cabin air can lead to serious ill health with long term debilitating effects on people’s wellbeing,” said Howard Beckett, Unite’s director of legal services.

“Brushing these serious incidents under the carpet is shameful and we urged the CAA to investigate and for the people involved in fume events to use our register or phone our hotline.”

Unite says it is pursuing 67 legal cases against UK airlines on behalf of former and serving cabin crew who say they have been affected by contaminated cabin air.

In response to Unite’s allegations, a British Airways spokesperson said: “Safety is always our priority. We continue to conduct thorough and detailed investigations which we share with the CAA.

“We always encourage our people to report any potential incident to allow us to investigate them.”

BA attendant ‘poisoned’ by cabin fumes

Mark Hookham, Transport Correspondent
December 4 2016, 12:01am,
The Sunday Times

A former British Airways flight attendant claims her health collapsed after she was “poisoned” by fumes while working on aircraft, as it emerged that four UK airlines are being sued by 74 cabin crew who say they were exposed to contaminated air.

Trudie Dadd, 56, says she suffered “unbelievable fatigue”, memory and stomach problems, confusion, and numbness in her feet after she was twice exposed in one year to fumes on BA flights.

The former purser, who flew with BA for 20 years, accused airlines of “burying their heads in the sand” and dismissing concerns about the health risks of so-called “fume events”.

Figures leaked to The Sunday Times showed there were at least 292 incidents of fumes or smoke inside aircraft operated by British carriers between June 2014 and May 2015.

Illness was reported in 96 cases. The Civil Aviation Authority (CAA), which collects the data, would not comment on the figures.

Sources say there have been a spate of recent events involving BA's fleet of so-called "super-jumbo" A380 passenger jets. There were 12 fume events on BA A380s in a 30-day period between October and November, according to one source. In one incident, involving a flight between Singapore and Heathrow last month, five cabin crew reported feeling ill, another source claimed.

Nearly all commercial airliners have a system that compresses air from the engines and uses it to pressurise the cabin. If, however, seals inside the engine leak, heated oil fumes can enter the air supply, contaminating it with chemicals that some experts believe can lead to serious health problems and in some cases death.
Campaigners claim cabin crew are most at risk because of the cumulative effect of years of exposure to contaminated air.

Unite, the union, is representing 74 cabin crew, including Dadd, who claim they were made ill by toxic cabin fumes. More than 60 cases involve former BA staff. Virgin Atlantic, easyJet and Jet2 also face personal injury cases.
"It is a health issue which the airline industry has been aware of for some time and is so serious that our members are likening it to the impact of asbestos on the building industry," said Howard Beckett, Unite's executive director for legal services.

Questions remain over the death in January 2014 of a BA steward, Matthew Bass, 35. Toxic organophosphates — which are found in substances such as jet engine oil — were discovered in his body, an inquest heard last year.

The inquest will resume in the new year and could shed light on the risks posed by contaminated cabin air. Dadd, from Sandhurst, Berkshire, claims she was exposed to a strong smell that she described as like bad feet mixed with nail polish remover, while she was preparing drinks in the galley of a BA flight from Madrid to Heathrow in April 2014. She felt ill as she drove home and, after returning to work for a few days, she remained in bed ill for around two weeks.

A year later, in April 2015, she experienced another strong chemical smell and then an exhaust smell as her aircraft came into land at Heathrow from Barcelona. “Over the next few months my health really started to deteriorate badly,” she said. “I couldn’t remember simple things [like] people’s names ... I was in a fog — I just wasn’t functioning.”
Dadd, who worked as a flight attendant on Concorde for five years before moving to short-haul flights, underwent tests at a private medical laboratory in London that specialises in “nutritional and environmental medicine”.

A fat biopsy found above average levels of the chemicals toluene, an industrial solvent that can also be found in jet fuel, and trichloroethane, another solvent. Benzene, xylene, dichlorobenzene and chloroform were also present.

Dadd, who used to fly around 80 hours per month, says her GP said she should consider stopping flying and signed her off work.
After a six-month detox regime, Dadd was retested and the toxic chemicals in her body had reduced, except benzene. “If I hadn’t had the tests, I certainly would not have got my health back and I don’t know if I would still be here,” she said.

Dadd claims there are a “significant” number of BA staff grounded at any one time because they are suffering the ill effects of fumes.

Dadd said she reported the two fume events but said BA did not then talk to her about the incidents, something she described as “disgraceful”. She accused BA of refusing to admit there was a problem, adding: “In their eyes it doesn’t happen.”

BA said it would not operate an aircraft “if we believed it posed a health or safety risk to our customers or crew”.

“We always encourage our colleagues to report any potential safety incidents to allow us to investigate them, and all reports are shared with the CAA.” It said there had been “substantial” research into cabin air quality over many years and the studies had “not shown that exposure to potential chemicals in the cabin causes long-term ill health”.

The company would not comment on Dadd’s case but said it always offered “support and advice” if staff were unwell.

Airbus, the aircraft manufacturer, said its aircraft were designed “to provide the highest level of cabin air quality”, while its rival Boeing said “cabin air is safe to breathe”.

Virgin Atlantic said “multiple studies” had found that a link between contaminated cabin air and illnesses was “unlikely”, while Jet2 said it had seen no evidence of a link.

Easyjet said its aircraft were “fully compliant” with the latest standards of air quality.

Dadd quit BA in September. “I have had to leave a job that I loved — a job I wanted to do since the age of 10. I am very angry that I have had to take that decision,” she said.

Richard Westgate died in 2012 after claiming he had been poisoned by toxic cabin fumes Photo: Cascade

Warning over toxic fumes in plane cabins

Coroner urges action to prevent deaths after warning toxic fumes in cabin air pose a health risk to frequent fliers and aircrew

Telegraph 21 February 2015

Toxic fumes in cabin air pose a health risk to frequent fliers and aircrew, a coroner has said in a landmark report.

Stanhope Payne, the senior coroner for Dorset, said people regularly exposed to fumes circulating in planes faced “consequential damage to their health”.

Mr Payne, who is inquiring into the death of Richard Westgate, a British Airways pilot, called on BA and the Civil Aviation Authority (CAA) to take “urgent action to prevent future deaths”. Most airline passengers, who fly only occasionally, will not be affected by the problem, but some frequent travellers who are genetically susceptible to the toxins could fall ill.

Mr Payne’s call for urgent action is likely to be welcomed by campaigners who have raised similar concerns for a number of years.

His report, obtained by the Telegraph, is the first official UK recognition of so-called “aerotoxic syndrome”, a phenomenon long denied by airlines but which is blamed by some for the deaths of at least two pilots and numerous other incidents where pilots have passed out in flight. Co-pilots can normally take over, but campaigners claim the syndrome is a suspected cause of some mid-air disasters.

Frank Cannon, the lawyer for Mr Westgate’s case, said: “This report is dynamite. It is the first time a British coroner has come to the conclusion that damage is being done by cabin air, something the industry has been denying for years.”

Sheriff Stanhope Payne,
Senior Coroner for The County of Dorset

REGULATION 28: REPORT TO PREVENT FUTURE DEATHS (2)

	REGULATION 28 REPORT TO PREVENT FUTURE DEATHS **THIS REPORT IS BEING SENT TO:** 1. **Chief Executive – British Airways** 2. **Chief Operating Officer – Civil Aviation Authority**
1	**CORONER** I am Sheriff Stanhope Payne, senior coroner, for the coroner area of Dorset
2	**CORONER'S LEGAL POWERS** I make this report under paragraph 7, Schedule 5, of the Coroners and Justice Act 2009 and regulations 28 and 29 of the Coroners (Investigations) Regulations 2013.
3	**INVESTIGATION** On 27th December 2012 I commenced an investigation into the death of RICHARD MARK WESTGATE, aged 43.. The investigation has not yet concluded and the inquest has not yet been heard.
4	**CIRCUMSTANCES OF THE DEATH** On 12th December 2012 Richard Mark Westgate was found deceased in his room at the Bastion Hotel in Bussum, Netherlands. His body was repatriated to Dorset. He was a British Airways pilot who had been on medical leave since September 2011 suffering cognitive dysfunction, ataxia & other deficits. Post mortem examinations gave causes of death of either Pentobarbital toxicity or lymphocytic myocarditis, individually or in combination. Testing of samples taken both prior to and after death disclosed symptoms consistent with exposure to organo-phosphate compounds in aircraft cabin air. Such exposure can cause lymphocytic myocarditis.

Stafford Road, Bournemouth, Dorset, BH1 1PA
Tel 01202 454910 | Fax 01202 780423

Mr Cannon said he was acting for approximately 50 other aircrew allegedly affected by the syndrome, working for airlines including Emirates, Cathay Pacific, Etihad, Thomas Cook and EasyJet. He is also representing two passengers.

Commercial passenger planes have a system which compresses air from the engines and uses it to pressurise the cabin. But it can malfunction, with excess oil particles entering the air supply.
In a confined space, with the air recirculated, the cumulative effect on frequent fliers, especially aircrew, can be harmful, the coroner said.

Mr Westgate, a senior first officer, died in 2012 after claiming he had been poisoned by toxic cabin fumes.

In his "prevention of future deaths report", produced last week, the coroner says that examinations of Mr Westgate's body "disclosed symptoms consistent with exposure to organophosphate compounds in aircraft cabin air".

In the report, sent to the chief executive of BA and the chief operating officer of the Civil Aviation Authority, the coroner raises five “matters of concern”, including that “organophosphate compounds are present in aircraft cabin air”; that “the occupants of aircraft cabins are exposed to organophosphate compounds with consequential damage to their health” and that “impairment to the health of those controlling aircraft may lead to the death of occupants”.

He also says there is no real-time monitoring to detect failures in cabin air quality and that no account is taken by airlines of “genetic variation in the human species that would render individuals … intolerant of the exposure”.

He demands that BA and the CAA respond to the report within eight weeks, setting out the action they propose to take. The report, made under regulation 28 of the Coroners’ Investigation Regulations 2013, is not a full verdict from an inquest, which has yet to be held in this case.

Tristan Loraine, a former BA captain who claims toxic air poisoning forced him to leave his job, said: “I took ill-health retirement only a year after completing the Iron Man triathlon. I had about 10 medical experts give their view to the CAA that I was suffering from ill-health effects of contaminated air. “From the minute I got sick until when I left the airline, I never saw a BA employee.”

Former British Airways pilot Captain Tristan Loraine

Mr Loraine, who is making a documentary about the issue, said he had been left with numbness in his fingers and feet and that he sometimes found it difficult to recall information. He said that a friend in BA — not Mr Westgate — had suffered the same symptoms, continued to fly and died from a brain tumour aged 44.

Mr Cannon said: "There are major crashes where we suspect the only plausible explanation is that the crew were suffering from cognitive dysfunction. More commonly, it causes incredible misery — very fit, intelligent and motivated people fall over sick.

The first thing BA and other airlines have to do is recognise and take care of their injured aircrew."

Most passengers who fly only occasionally will not be affected by the problem, but some frequent travellers who are genetically susceptible to the toxins could fall ill, with around 10 per cent of the population affected. Their bodies are unable to detoxify quickly enough and an accumulation of toxic material over time becomes dangerous.

The main vulnerability is suffered by aircrew, who spend much of their lives on board.

Official records from the Civil Aviation Authority show that oxygen masks are being used by pilots and crew at the rate of at least five times a week to combat suspected "fume events".

The official safety watchdog, the Air Accident Investigation Branch, has called for aircraft to be fitted with equipment to detect any contamination of cabin air.

A spokesman for BA said it could not comment on the case, but would consider the coroner's report and respond. The airline cites independent studies commissioned by the Department for Transport, which found "no evidence that pollutants occur in the cabin air at levels exceeding available health and safety standards".

The Government's position is that "concerns about significant risk to the health of airline passengers and crew are not substantiated". A spokesman for the CAA said it would consider the report in detail but claimed it was "nothing that passengers or crew should be overly concerned about".

Mr Cannon said: "I see this as an impending tsunami for the airline industry — it's been ignored for so long."

The disclosure of Mr Payne's report comes ahead of a meeting in London this week of a group set up by the International Transport Workers' Federation to examine the issue of contaminated air on planes.

A spokesman for the ITF said: "There is growing published evidence of the toxicity of these oil fumes and the increase in reported fume incidents in which flight safety was compromised because of crew member impairment."

Transport minister Robert Goodwill does not believe a fresh investigation is required and defers to studies being carried out by EASA

Jacob Rigby/REX/Shutterstock

SAFETY DAVID KAMINSKI-MORROW LONDON

Fresh scrutiny for aerotoxic syndrome

UK politicians call for independent inquiry into risk of contaminated cabin air and demand installation of monitoring systems

Members of the UK Parliament have pressed for an independent inquiry into the risk of contaminated cabin air and are seeking the installation of monitoring systems on aircraft with bleed-air systems.

The matter was debated by a backbench business committee on 17 March after being raised by an opposition Labour party member, Jonathan Reynolds, and put to transport minister Robert Goodwill. Reynolds said the Unite trade union was acting on behalf of 61 cases of "aerotoxic syndrome", in which contaminated cabin air is suspected to be linked to illness in crew and passengers.

Referring to two cases involving the separate deaths of two British Airways crew members, with questions over whether cabin air quality might have played a role, the matter "must be treated seriously", he adds.

> **"We are obviously very keen to look at how we can work to get further information"**
>
> ROBERT GOODWILL
> Transport minister, UK government

"No-one disputes that fume events, where toxins enter the cabin, occur," he says, adding that the frequency is estimated at once in every 2,000 flights. "It should be of great concern that no aircraft currently flying has any form of detection system fitted to warn crews when cabin air has become contaminated."

Reynolds, with the backing of other parliamentary members, has asked the minister to consider an independent inquiry into the matter, and says the government could consider legislation to mandate monitoring equipment on aircraft or, at least, begin discussions with carriers.

Goodwill responds by pointing out that the inquests into the deaths are still open, but that evidence so far "does not support the view" of a connection to contaminated cabin air.

LONG DEBATE

He points out that cabin air safety has been a subject of debate, punctuated with in-depth studies, for over a decade.

The collective assessments commissioned by the government led to a committee on toxicity publishing a position paper which recognised that – although contamination from engine oil products occurs, and although episodes of illness have occurred shortly after – the level of chemicals in bleed air would need to occur in far higher concentrations, than those found in the studies, to cause serious toxicity.

"But we are obviously very keen to look at how we can work to get further information," says Goodwill, pointing out that the European Aviation Safety Agency has conducted a cabin air measurement exercise, the results of which are due later this year. These will be used to prepare for a larger-scale project.

Goodwill adds that the issue is "complex", with "little evidence to show that a change is needed".

He says: "We need to be very careful about using the precautionary principle. We need to look at the actual evidence." He is pleased that additional research will be carried out, he adds. ■

Filmmaker behind aerotoxic syndrome documentary says only a 'tombstone event' will force the aviation industry to tackle bleed-air poisoning and fume events

Herald Scotland – 28th January 2016

ONLY a catastrophic passenger plane crash will force the aviation industry to come to terms with its "dirtiest secret", according to the director of an explosive new documentary on toxic cabin air.

*Watch film trailer here.

German investigative journalist & former pilot, Tim van Beveren, said airlines and regulators would continue to turn a blind eye to cases of pilots and cabin crew being sickened or incapacitated by poisonous fumes leaking from the engines until there was a "tombstone event" – or fatal crash. Mr van Beveren was speaking at the Grosvenor cinema in Glasgow, where his film on the controversial issue of aerotoxic syndrome will receive its UK premiere tomorrow [Friday] 29th January 2016.

He said: "They call it a 'tombstone event', or 'tombstone imperative', where a cost-benefit analysis is applied to each and every safety intervention. It basically means there needs to be a body count before there is a change.

"This is so contradictory to everything I learned from my first flying lesson where absolutely everything is done to prevent an accident, but now all of a sudden we these areas where there's a huge gap and no one wants to take responsibility and do anything about it."

The film, 'Unfiltered Breathed In: the Truth about Aerotoxic Syndrome', accuses airlines, manufacturers, and regulators worldwide of helping to cover up a health scandal that would cost the industry billions in aircraft modifications and compensation if admitted.

The controversy relates to the use of "bleed-air" to pressurise and ventilate aircraft cabins and cockpit, which has been standard design on passenger jets since the 1950s. All commercial planes – with exception of Boeing's new Dreamliner – use the bleed-air system, which means the air breathed by passengers and crew is contaminated by low-level concentrations of poisonous chemicals coming from the engines.

These compounds, known as organophosphates, have been blamed for causing various neurological symptoms such as numbness, memory loss, mobility problems, and headaches in thousands of pilots and cabin crew worldwide, though industry insists there is no evidence of any connection.

In some cases, severe fume events in the cockpit have left pilots compromised at the controls. The film recounts one case in Germany in 2010 saw both the captain and co-pilot of a Germanwings plane overcome by fumes on approach to Cologne which left them nauseous, dizzy, suffering from tunnel vision, concentration problems and severe tingling.

By the time they put on oxygen masks and recovered some control, the plane was travelling too fast for an autopilot landing and the captain – despite feeling unwell – had to land the aircraft manually. Both pilots, who described feeling in a "dream-like" state during the landing, were subsequently signed off sick for six months.

Mr van Beveren believes the incident was a "near-miss".

The film, which draws parallels with Gulf War Syndrome, also followed the cases of several former airlines stewards suffering chronic and unexplained neurological disorders which they believe were caused by exposure to aircraft toxins.

Researchers interviewed for the film believe that around three per cent of the population are genetically susceptible to the contaminants and will go from "fit and healthy to an invalid" within three years of working on airlines.

Around 30 per cent will take up to 20 years to develop symptoms but two thirds of the population will never fall ill, leading to accusations that sufferers are "imagining it".

Richard Westgate, a former British Airways pilot from Edinburgh who died in 2012 after years of symptoms which his parents likened to "increasingly advanced stages of multiple sclerosis", was eventually labelled with Munchausen's syndrome – where patients feign illness for attention.

However, analysis of his brain, heart, nerves and spinal cord following his death – he donated his remains to advance scientific research into aerotoxic syndrome – have revealed nerve damage consistent with organophosphate poisoning. An inquest is on hold.

Glasgow-based aviation lawyer Frank Cannon, who represented Westgate and currently has "hundreds more" cases on his books, said he recently settled one pilot's case out of court for €250,000.

Mr Cannon cannot name the airline involved, but said his client has been left unable to work due to a neurological disorder.

The film's premiere comes less than a week after joint study by the Open University and University College London stressed the need for more research.

Co-author Dr Gini Harrison said: "While the existence of a relationship between contaminated cabin air and ill-health may be a potentially expensive and inconvenient truth; the costs of ignoring the possibility of ignoring such a relationship are too high to ignore."

Mr van Beveren wants all passenger aircraft fitted with filters to prevent engine chemicals leaking into cabin air. The devices are already used on DHL freight planes.

A spokesman for UK regulator, the Civil Aviation Authority, said passenger and crew safety was "of paramount importance to the CAA".

He added: "Several expert studies on the issue of cabin air quality have been carried out in recent years including Government-commissioned research. The overall conclusion has been that there is ***no positive evidence*** of a link between exposure to contaminants in cabin air and possible long-term health effects – although such a link cannot be excluded."

To see 'positive' evidence from 1955 go to www.aerotoxic.org

For basic Health & Safety principles go to Governments Health and Safety Executive web site.

For CAA on toxic air in passenger jets click here.

'They can't keep brushing this under the carpet', says victim of aerotoxic syndrome

Dee Passon, who has campaigned for six years about aerotoxic syndrome, feels vindicated by the Coroner's letter about Richard Westgate's death

Telegraph February 21st 2015

Dee Passon, left, feels vindicated by the Coroner's letter about Richard Westgate's death Photo: Andrew Hasson/Cascade

Ever since Dee Passon's father took her to watch the planes flying over Gatwick on a Sunday morning when she was five, she dreamt of becoming an air hostess.

However, what began as her perfect job soon turned into a living nightmare when she spent over a decade battling with ill health before eventually being diagnosed with aerotoxic syndrome.
Now she feels vindicated by an official report in which a British coroner raises concerns about the presence of toxins in cabin air.

Ms Passon, 56, thinks the concerns, raised in relation to the death of Richard Westgate, a British Airways pilot, will finally force the aviation industry to address the problem. "Richard Westgate was not an isolated case," she said. "They now know the world is watching and they can't keep brushing this under the carpet.

"Passengers and cabin crew are suffering terribly. Now there are a lot of people pushing for the truth to come out."

She said her first encounter with toxic gas on board an aircraft was in January 1996, when she returned from a short-haul flight. The previous crew and dispatcher had all been taken to hospital with breathing difficulties and she developed a persistent cough.

“Over the next 12 years, my health steadily declined. My doctor couldn’t understand why, it was a total mystery,” Ms Passon said. “My symptoms included migraines, joint pains, muscle pains, constant gastro-intestinal problems, diarrhoea and vomiting. My brain was affected, too. I became dyslexic and my memory became worse.”

In 2005, she was diagnosed with high grade breast cancer. Then, after a flight from Cape Town in 2008, her health took a sudden turn for the worse. “I was in total agony with nervous pain everywhere,” she recalled. Her GP diagnosed her with aerotoxic syndrome, advising that she could not return to work as she was “permanently incapacitated”.

She began campaigning to raise awareness, and says thousands of concerned passengers and aircrew have contacted her over the past six years with symptoms similar to hers.

After her diagnosis, Ms Passon, who lives in Bexhill-on-Sea, East Sussex, with her partner Nick, began investigating the syndrome and believes it to be widespread.

A spokesperson for BA, for whom she worked, said: "We would not operate an aircraft if we believed it posed a health or safety risk to our customers or crew”.

"All our crew are encouraged to report any incident of odour or fume events on board our aircraft."
BA said it had not noticed any trends in sickness rates relating to cabin air issues in its 18,500 air crew.

Mr Westgate died aged 43 after suffering years of ill health, including severe headaches, mental confusion, sight problems and insomnia.

Before his death he considered suing BA over alleged health and safety breaches, as he believed he had been poisoned by toxic fumes. However, he died before any claim was brought.

Mr Westgate, from Dorset, was a graduate of Sheffield University and had achieved two world records for tandem paragliding, for a 200km distance flight and a climb reaching almost 20,000ft.

He became a commercial pilot in 1998, flying with smaller airlines before joining BA in 2007.

He was not married and had no children when he died in December 2012 at a clinic in Holland. He had stopped in Amsterdam for treatment while on his way to Dignitas, the suicide clinic in Switzerland, having lost hope of finding a cure.

He died within days of fellow BA pilot Karen Lysakowska, 43, who had also complained of being exposed to toxic oil fumes on passenger planes.

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The attention of prospective investors is drawn to the contents of page 25 of this document entitled "Risk Factors".

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Investors are encouraged to seek independent legal and tax advice prior to submitting an application to invest in the company and to conduct their own due diligence into the terms of this offer and the investment opportunity.

Information Memorandum Index

Introduction

The cabin air of all commercial aircraft, except the very recently introduced Boeing 787 is bled off the jet engines and is, therefore susceptible to contamination from engine oil, some ingredients of which are known neurotoxins, (tricresyl phosphate being one). Although the aircraft certification standards promulgated by EASA, FAA etc. stipulate that 'crew and passenger compartment air must be free from harmful or hazardous concentrations of gases or vapours' there is no 'real time' instrumental monitoring of aircraft cabin air to ensure that this is in fact the case. Due to the growing awareness of the grave health consequences of chronic exposure following the Coroner's report into Richard Westgate's death in February 2015, and his subsequent letters to both British Airways and the CAA on prevention of future deaths, it is expected that airlines and ultimately regulators will demand onboard sensors capable of continuously monitoring air quality. No such sensor is commercially available currently.

Key Information Summary

The Company proposes to raise £1,800,000 in 3 tranches. Initially in April 2014 a Round 1 SEIS 'New Founder Shareholder' offer was over-subscribed, and the company issued 150 Ordinary Shares at £1000 per share to fund Stage 1 of the project. The proceeds were used by the Company to develop a working prototype (suitable for mass production) with the requisite sensitivity clearly demonstrated in an environmental chamber.

Funds from the Round 2 EIS raise will be used to design, build and certify 100 Mk1 prototype handheld devices fitted with this technology for distribution to air and cabin crew throughout the industry, carry out further fibre end coating research to build up a broader and more comprehensive compound detection database, together with improving the fibre-end coating process to increase detection sensitivity.

Round 2 funding will also identify project and cost planning for the scientific, technical and delivery components of Stage 2B, plus further IP identification leading to the application for further patents (within the specific field mentioned above) to provide maximum protection for the company and investors.

HMRC has been advised of the Round 2 fundraise, and VN ADS has been granted EIS Advanced Assurance. See HMRC EIS Advanced Assurance letter for VN ADS on page 29.

A Round 3 EIS raise will fund Stage 2B. This stage will improve the Mk1 hand-held design using the results from Stage 2A coating research, together with the design, build and certification of a 'built-in' system for retrofitting to existing fleets and incorporation into all new build aircraft. The aviation certification and approval process for systems of this type, costs in excess of £240K per aircraft variant, and so the company will target those aircraft types on which the most fume events have been reported. These include the Boeing 757, Airbus A300 series and the British Aerospace Avro series.

An IP Development Licence in relation to the use of 'Monofibre Optical Metering Technology (MOMT) to detect and measure organophosphate (or other relevant molecules), in particular tricresyl phosphate, (TCP) onboard commercial aircraft has been acquired. The licence deriving from International Patent numbers; GB2.428.290 & US7.876.447 has been negotiated with the beneficial owner Viridis Navitas JR-IP Ltd (VN-JR-IP) to complete a technology application development programme.

This will be conducted in conjunction with industry aviation partners, third party OEM technical suppliers and led by Professor Jeremy J. Ramsden. All additional IP created by this development will be owned jointly by VN-ADS Ltd and VN-JR-IP for their mutual benefit, on a royalty free basis. All stages of the programme are developed with clear 'Go' – 'No Go' break points.

Stage 1: (Round 1 New Founder Shareholder ("NFSH") offer £150,000 via the issue of 150 shares @ £1000 per share) delivering a prototype detector with the requisite sensitivity to detect TCP and other volatile organic compounds, clearly demonstrated in an enviromental chamber. Designs for the incorporation of this technology into a 'handheld' device, and a mockup of the actual handheld detector. **(Over Subscribed and successfully completed)**

The technology solution has been peer reviewed by Emeritus Professor Derek Fray FRS FREng of Cambridge University, where he commented as follows:

"I witnessed a successful demonstration, by Professor Jeremy Ramsden, that showed that coated fibre sensors responded quickly to organic vapours, including ethanol and toluene. It is the intention to have a series of coatings which will form the basis of a device that will monitor volatile organic compounds found in the aircraft cabins.

The results of Prof. Ramsden's research (i.e. the findings and data presented to me on the 12th February 2016) are valid, and demonstrate the potential of the device for accurate measurement of Volatile Organic Compounds and Semi-Volatile Organic Compounds (VOCs and SVOCs) on board passenger aircraft.

Subject to more comprehensive experimentation and development to assure the device's sensitivity and consistency of measurement further, I would agree that this technology/project should continue with the appropriate funding to develop a commercial VOC- & SVOC-measurement device for the aerospace industry."

Stage 2A On Offer: Financed by a 2nd Round funding raising £600,000 via the issue of a 300 further shares @ £2,000 per share.

> 2A. Development of the 'Handheld' unit into a saleable solution, demonstration of its capabilities to Airlines, Operators & Crew alike. Ongoing research and testing of new coatings for other Volatile Organic Compounds (VOCs) and Semi-Volatile Organic Compounds (SVOCs) detection, and further experiments in the environmental chamber to broaden the database, determine its sensitivities and therefore increase its capabilities.

Once Stage 2A is in progress, the VN-ADS Sales & Marketing team will commence communication with Global Aviation industry players to demonstrate and promote the solutions, whilst also communicating with the necessary regulatory bodies to ensure compliance issues are covered pre-aircraft installation and flight trials. It is anticipated that post this stage an established industry OEM will licence the technology for distribution through their existing channels.

Stage 2 (2A & 2B inclusive) Final Deliverable: Design and production of both mass-manufactured 'Handheld' and 'Built-in' units with proven 'real time' detection & data download capability together with full airworthy certification and compliance.

Commercialisation, Timings and Costs

Stage 1 of the programme was completed within 22 months of the raise closing. Costs were estimated at £126,000 including a minimum stage 1 payment (£25,000, being 10% of the full cost of £250,000) of the negotiated development licence fee and the project was delivered within budget. *Note: All Legal, Accountancy and 3rd Party costs as indicated on Page 18 of this IM and (estimated at £24,000) were made before project commencement. Project expenditure at £126,000 included a 10% overrun / contingency fee.*

Stage 2A will take place over a 12-month period from funding close and costs are estimated at £540,000 including a minimum second payment (£50,000 being 20% of the full cost of £250,000) of the negotiated development licence fee. *Note: All Legal, Accountancy and 3rd Party costs as indicated on Page 18 of this IM (estimated at £58,800) will be made before project commencement. Project expenditure at £540,000 includes a 10% overrun / contingency fee.*

Stage 2B will take place over a 24-month period from funding close and costs are estimated at £945,000 including a minimum third payment (£175,000 being 70% of the full cost of £250,000) of the negotiated development licence fee. *Note: All Legal, Accountancy and 3rd Party costs as indicated on Page 18 of this IM (estimated at £102,900) will be made before project commencement. Project expenditure at £945,000 includes a 10% overrun / contingency fee.*

A Business Development Plan describing the science and technology background, the market drivers, size and target sectors, competition, key objectives and high-level deliverables, organisation and structure, commercialisation, timings and costs, business model, market development, risks and risk mitigation and partner relationships has been developed and can be found in the executive summary. All other relevant supporting documents are included in Schedules 1, 2, 3 and 4.

The successful development of VN-ADS technology in this multi-billion £ pa market has the potential to generate profits at VN-ADS worth hundreds of millions of £'s every year. In turn, this has the potential to produce returns for subscribers in VN-ADS worth significant multiples of their original investment.

Directors, Professional Advisers and Company Information

Directors:

Jeremy J. Ramsden (Science &Technical)

Mark Gilmore (Sales & Operations)

David Newman (Commercial and Managing)

Secretary and Treasurer:

Steven Strauss FCA

Solicitors:

Howard Kennedy,
19 Cavendish Square,
London W1A 2AW

Auditors:

Sopher & Co
38 Berkeley Square
London W1J 5AE

Registrars:

Simmons Gainsford LLP
7-10 Chandos Street,
London W1G 9DQ

Registered Office:

4th Floor, 7-10 Chandos Street,
London W1G 9DQ

Directors:

Jeremy J. Ramsden Ph.D. is Honorary Professor of Nanotechnology, at Buckingham University UK and the inventor of Aerotoxic Detection Technology.

Jeremy was educated at the Universities of Cambridge and Princeton and the Ecole Polytechnique Fédérale de Lausanne, where he obtained his doctorate in the Department of Chemical Physics for research on semiconductor nanoparticles.

He held the post of visiting scientist at the Eidgenössische Technische Hochschule (Laboratory of Chemical Engineering), Zürich (1993) and the Biocenter (Institute of Biophysics) of the Hungarian Academy of Sciences in Szeged (1987).

Jeremy worked for 12 years at the Basel Biocenter (Institute of Biophysical Chemistry), served as a Member of the Faculty of Natural Philosophy of Basel University 1994–2002. Chair of Nanotechnology at Cranfield University 2002–2012 and Research Director for Bionanotechnology, Cranfield University at Kitakyushu 2003–2009.

His main research focus today is integrated-optical fibre sensors, complex adaptive systems, and emergent nano-info-bio-cogno converging technologies. He has authored or co-authored more than 200 research articles published in international refereed journals, made a comparable number of conference presentations, co-invented three patents, written or edited a dozen books, chaired several international conferences, and served as visiting professor in Argentina, France, Hungary and Japan.

He is a Fellow of the Institute of Materials, Minerals and Mining (London) and a IUPAC Fellow.

Mark Gilmore is a founding Director of Viridis Navitas Capital Partners Ltd *(sponsor of the VN-ADS technology)* and a serial entrepreneur who has successfully managed to blend a career of high-level professional corporate roles, and an enviable track-record in start-ups. Mark brings more than 20 years successful operating experience at senior and executive level sales and operational management to VN ADS.

Mark's most recent corporate role was managing COLT Managed Services strategic markets region (6 countries and 27 employees). In his last year he delivered over £30m in revenues (118% against target) and nearly £13m of new business bookings (122% against target). This achievement was coupled with the process of transitioning the pre-sales technical architects, with corporate incentive structures to technical consultants holding personal incentive schemes.

Prior to this Mark held a number of senior Business Development roles including; Dimension Data for over 4 years, significantly exceeding revenue, bookings and margin targets in each of the 4 years he was there; GTS Carrier Services; and TGNS S.A. In between these roles, Mark started Big Picture Interactive, a brand new digital multimedia and interactive web company and took the company from start-up to over £1m turnover in the first year, and prior to that converted an antique shop into a pub and restaurant and ran it for 2 years before exiting.

David Newman is also a founding Director of Viridis Navitas Capital Partners Ltd *(the sponsor of the ADS technology)* and another highly commercial, innovative and success driven individual. He is also an entrepreneur with a strong electronic, electro-mechanical, automotive and heavy engineering background.

Following 10 years of military service operating throughout the world, David spent the next 10 learning the commercial realities of international business by apprenticing himself to the most successful business owners and companies he could find. During this time, he was tasked across a broad range of industries including, leisure, entertainment, automotive, telecoms, advertising and IT.

His corporate roles have included: Project Management, New Business Procurement, Financial Restructuring, Technical Creation and Support, IT Solution Creation & Delivery, Training Program Creation & Delivery and Change Management.

In 1999 he formed his own Telecoms consultancy and later that year created Trans Global Network Services, the world's first global fibre optic leasing operator.

After successfully exiting TGNS in 2002 with annual revenues of $27m, David accepted the role of Commercial advisor to the then Maltese Minster of Finance, The Right Hon Mr John Dalli.

There he formed part of a 3-man team charged with redesigning the Countries FDI programme, agencies and Industrial Estate Management.
Successful completion of this project delivered a 'step change' in Government attitude toward FDI procurement, Business Promotion and even its own work force, pre the Country's accession to Europe.

In 2004 David continued his career by taking on international consultancy roles within the restructuring IT and telecoms sector and later within the emerging renewable energy industry.

He returned to the commercial 'start-up' market place in 2008, designing and building an "outsourced" Debt Management and Cash Collection business for top 50 London accountancy practice, Simmons Gainsford LLP. SG Debt Management was initially created to assist SG client's post-recession but today has exceeded that brief. The business currently manages annual cash collections in excess of £16m and continues to quietly attract new clients by user recommendation only.

In mid-2009, David was invited to lead the design team in building an 'algae to fuel' Photo Bio Reactor for a US project. In mid-2010 working with the same US affiliates, he went on to manage the design and build of an innovative 'oleophilic membrane' crude oil recovery rig. With support from the US Department of Energy, the machine was deployed in the Gulf of Mexico and trialled as part of the Deep Water Horizon clean-up operation.

In September 2010 David joined forces with Mark and formed Viridis Navitas Capital Partners Ltd (VN-CP) specifically to target the renewable energy start-up funding gap experienced by inventors, engineers and scientists alike.

Since inception VN-CP has delivered 7 successful funding rounds for platform technology application spinouts raising in excess of £2M via HMRC Advanced Assured Seed Enterprise Investment Schemes & Enterprise Investment Schemes. The above-mentioned experiences have allowed David to build up a broad network of contacts throughout Governments and industries alike that he leverages to the benefit any company he works with. Understanding the financial risk versus reward balance for investors, as a 'real' investor himself, he brings an unusual but extremely useful skill set to the company.

Secretary and Treasurer

Steven Strauss is a Chartered Accountant and Fellow of the Institute of Chartered Accountants in England and Wales. Steven read Economics at the London School of Economics, gaining a BSc Honours Degree in 1981, studied for his articles and qualified in 1985 receiving an associate membership of the Institute of Chartered Accountants in England and Wales later in that year.

In addition to work in the tax field, Steven has also had a significant amount of commercial experience, advising and consulting corporate entities on a wide range of matters.
Steven has been a Director of an Australian Stock Exchange Quoted company and is currently Chairman of an International payments solution company and Financial Director of VN-CP.

Consultants

VN-ADS Engineering Design & Electronic Manufacturing Consultants:

Fordfleet Design Ltd and Circad Design Ltd

Aviation Industry Specialist Advisor:

Tom Benzie CEng MRAeS

Laboratory Partner:

A combination of National and University test and laboratory facilities, including the National Physical Laboratory (NPL), UCL, Aston, Loughborough & Nottingham Universities. (Subject to change as the project progresses)

Chemistry & Physics Partners:

Prof. Dr. Vladimir M. Mirsky
Lausitz University of Applied Sciences
Faculty of natural sciences – Nanobiotechnology

Dr Christian Serre, Director of the Lavoisier Institute, French National Centre for Scientific Research (CNRS), at the University of Versailles, Paris, France.

Dr Clémence Sicard, Institute Lavoisier, University of Versailles.

Dr Andras Hamori, Institute of Materials and Technical Physics, Hungarian Academy of Sciences, Budapest.

Principal Definitions

In this Memorandum, where the context so admits:

Closing Date	The date the offer of subscription will be closed
Consultancy Revenues	Income received from design and outsourced manufacturing
Directors	The Directors of the Company from time to time
EASA	European Aviation Safety Agency
EIS	Enterprise Investment Scheme
FAA	Federal Aviation Agency
Full Subscription	The total subscription required from all Subscribers
Initial Subscription Price	The amount payable by the Initial Subscribers
IP	Intellectual Property
Licence Revenues	Receipts from manufacturers and operators using specific MOMT detection solutions
Minimum Subscription	The minimum individual investment as decided by the Company
MOMT	Monofibre Optical Meter Technology
NFS	New Founder Shareholders
O&M	Operation and Maintenance
Second Round Funding	100 shares issued pursuant to successful completion of the second subscription
SEIS	Seed Enterprise Investment Scheme
SG LLP	The accounting firm of - Simmons Gainsford LLP
Shares	Ordinary shares of 1p each in the Company
STC	Supplemental Type Certificate
Subscribers	Those persons who subscribe for the Shares in the company
SVOCs	Semi Volatile Organic Compounds
TCP	Tricresyl Phosphate
Third Round Funding	115 shares issued pursuant to successful completion of the third subscription
TSO	Technical Standard Order
TUV SUD	Aviation component suppliers and testing authority
UKTI	United Kingdom Trade and Investment
VN-ADS	VN- Aerotoxic Detection Solutions Ltd
VN-CP	Viridis Navitas Capital Partners Ltd - Sponsor of ADS Technology
VOCs	Volatile Organic Compounds

Executive Summary

Company Objectives

This Information Memorandum has been published to enable the Company to raise a total of £1,800,000 in three rounds of funding. The initial funding was offered on terms that enabled subscribers to benefit from the SEIS regime, whilst the subsequent offers are targeting EIS relief (subject to future changes in the relevant statute).

The first round raised £150,000 from New Founder Shareholders through the issue of 150 ordinary shares of 1p each in the capital of the Company at £1000.00 per Share.

Upon successfully meeting the Stage 1 project development milestones the Company is now seeking to raise an additional £600,000 via a 2nd funding round. Issuing a further 300 ordinary shares of 1p each at £2,000.00 per share as new subscription capital.

Upon successfully meeting the Stage 2A project development milestones the Company will seek to raise an additional £1,050,000 via a 3rd funding round, issuing a further 210 ordinary shares of 1p each at £5,000.00 per share as new subscription capital, which (upon full subscription post Round 3) will represent 12.65% of the total share capital in the Company.

Upon the successful closing of Round 3 funding round the shareholdings will be:

Founding shareholders:	60.24%
1st Round subscribers:	9.04%
2nd Round subscribers:	18.07%
3rd Round subscribers	12.65%

The objectives of the company are to develop VN-ADS technology into the targeted markets by delivering designs for mass-manufactured units with demonstrated airworthiness & performance certified by an industry recognised third party. Subsequently the company intends to exploit the technology by:

1. Global sales of 'Handheld' VN-ADS designed detection solutions for use on existing aircraft to all commercial aircraft operators
2. Global 'licencing and rights of use' sales of the VN-ADS 'built-in' detection solution to aircraft manufacturers, OEM's & Tier 1 equipment suppliers to commercial aircraft manufacturers.

Market Research carried out by VN-ADS, shows that there are currently 20,310 commercial aircraft in service today. Given the total absence of 'real-time' organophosphate (or suitable surrogate) detection & measuring technology available today, and the unique nature of the patent coverage acquired by VN-ADS, the company will be targeting a selling price of $100,000 per unit, providing an immediate market opportunity of $3.9billion.

Growth in commercial aircraft numbers (both passenger & cargo) is projected at 5% pa, delivering 41,240 aircraft flying by 2032. 14,320 of these will replace older, less efficient airplanes, with the remaining 20,930 used for fleet growth. When any of the safety legislation (currently under discussion and legal investigation) is passed, or recommendations are made, it will affect all aircraft designed with a 'bleed air' ventilation system. It is entirely probable that with all new aircraft design, the 'bleed air' ventilation system will be eliminated (as with the Boeing Dreamliner).

Airplanes in service 2012 and 2032

Size	2012	2032
Large widebody	780	910
Medium widebody	1,520	3,610
Small widebody	2,310	5,410
Single aisle	13,040	29,130
Regional jets	2,660	2,180
Total	**20,310**	**41,240**

Demand by size 2013 to 2032

Size	New airplanes	Value ($B)
Large widebody	760	280
Medium widebody	3,300	1,090
Small widebody	4,530	1,100
Single aisle	24,670	2,290
Regional jets	2,020	80
Total	**35,280**	**4,840**

*$ values throughout the CMO are catalog prices.

However, all aircraft will still have to take air from outside the cabin and external contaminants are present whenever the aircraft is static at an airport from fuelling, de-icing or even jet engine exhaust. Therefore, the requirement for constant air quality control & monitoring within the aircraft, will still require some form of 'real-time' detection system to be installed onboard that is capable of recognising neurotoxic compounds, be they organophosphate, relevant/surrogate particles, or any other form of air contamination present in the aircraft that may be harmful to crew and passengers alike.

The total supply market value up to 2032 is projected to be in the region of $4.8Trillion or an average of $136million per aircraft. With a 'rights of use' licence fee for the 'built-in' solution of $250,000 per aircraft, the total market opportunity between 2014 & 2032 is therefore estimated to be in the region of $8.8billion.

Health, Safety, Legislative History & Business Drivers

Despite the continuing exponential growth of air traffic, surprisingly few people, whether pilots, other aircrew or passengers, are aware of a hazard that has been present ever since air for pressurising the cabin started (in the mid- 1960s) being bled off the gas turbines powering the aircraft.

One of the essential components of jet engine lubricant is tricresyl phosphate (TCP), the neurotoxicity of which is well established *"TCP is chemically similar to nerve gases like sarin and many organophosphate (OP) pesticides"*.[1] The lubricant is separated from the air by oil seals, which usually leak slightly and sometimes fail catastrophically, admitting TCP into the cabin. In consequence, everyone in the cabin is subject to the risk of neurological damage from inhaling the substance.

This risk has occasioned much lively debate during the recent passage of the new Civil Aviation Bill through the UK Houses of Parliament. Until recently, the greatest concern was among aircrew exposed to a "fume event", in which catastrophic failure of a component usually an oil seal—results in the aircraft cabin becoming filled with fumes or even visible smoke.

In 2009 a flight attendant won an action brought against her employer, an airline in Australia, for the ill health which, it was judged (and upheld upon appeal by the defendant), had been caused by a single fume event.[2]

Despite many other known cases of post-flight neurological illness experienced by aircrew, and despite the association between jet aircraft travel and the illness adequately fulfilling Hill's criteria for causation,[3] there is continuing reluctance by aircraft manufacturers, airlines, their regulators and their governments to recognise and address this particular hazard.

Since it is estimated that the probability of occurrence of a fume event serious enough to warrant a formal report lies between 0.0005 and 0.01 on any particular flight, the risk of being made seriously ill is quite small, despite the significant hazards that such an event represents. There is, however, another danger—the chronic exposure to low levels of TCP during normal flight operation, which a recent study detected during 25% of the total number of flights (100) sampled.[4]

Complementary to this work is the recent development of an efficient blood test for exposure to TCP; 50% of a random sample of jet airplane passengers tested within 24 to 48 hours after a flight gave positive results.[5] Three to seven months later TCP was no longer detectable, from which one might infer that infrequent flying is unlikely to be associated with adverse health effects. However, the most insidious problems arise from the cumulative effects of frequent exposure.

The short term cholinergic toxicity of a fume event may pose a direct safety risk—especially on the approach to landing—since the pilot may no longer be able to control the aircraft.

Longer term, persistent organophosphate-induced delayed and chronic neurotoxicities are known pathologies;[6] there is physical degradation of the peripheral and central nervous systems. If the central nervous system, including the brain, is impaired, a great variety of behavioural and other disorders may ensue, which seems to have caused difficulties in making an accurate diagnosis. It is pertinent to mention that in many cases of chemically-induced neuropathy, sensitisation to subsequent exposures occurs.

Thus, for example, chronic low-level exposure during frequent normal flights may render someone more susceptible to suffer dangerously acute symptoms after a fume event.

An attempt has been made to group the symptoms commonly mentioned by aircrew, a comprehensive collection of which has been compiled,[7] into an *aerotoxic syndrome*.[8] A small study of 29 affected pilots revealed a distinct pattern of cognitive dysfunction,[9] which, in its early stages, might not even be apparent to the sufferer, except in rarely encountered emergency situations.

Severe fume events would be reported in the flight log by the pilot, and upon landing after such an event aircrew may be immediately examined by paramedical staff or even hospitalised. In such cases the cause of illness and appropriate treatment should be obvious. Diagnosis of the persistent effects is however much more problematic.

Initially there may be only slight discomfort and a range of common symptoms such as coughing and headache that could arise from many other causes. Passengers in particular are familiar with the vague complaint of "jet lag", to which the symptoms might well be ascribed. Aircrew are subject to stress and fatigue as part of their working environment,[10] and these are more immediately perceptible possible causes than a chemical substance that is, at present, *never monitored in flight*. If medical opinion is sought, a diagnosis such as "depression" or "hyperventilation" or even "somatic disorder" (i.e., physical symptoms caused by a psychological state) is quite likely to be made, which could lead to the application of inappropriate therapies, possibly exacerbating the illness.

As cumulative chronic exposure increases—taking due account of periods in which no exposure at all occurs, allowing detoxification to take place—the symptoms gradually become more severe but it is well known that a gradual onset of symptoms is far more difficult to detect than a sudden one.

It is noteworthy that in the case referred to above,[2] the fume event took place in 1992, but the complaint against the employer was only filed in 2001.

Neurotoxicity is difficult to recognise even in cases with a clear occupational hazard (such as someone working in a factory manufacturing a neurotoxic chemical).[11,12] The result of inhaling TCP onboard a jet aircraft is in the same category, but might not even be considered as a case of neurological damage by an investigating physician because of the current poor awareness of the presence of the neurotoxin, TCP, in the air.

Furthermore, aviation medicine recognises so many and diverse neurological complaints associated with flying, it is easy to suppose that the symptoms presented by affected people are due to some cause other then TCP inhalation.

In this regard, the development of a diagnostic test is a valuable advance.[5] Of comparable significance is the realisation that people vary widely in their ability to eliminate TCP from their bodies. This situation is familiar in other contexts such as the widely varying ability of individuals to metabolise alcohol.

The mechanism of TCP detoxification has by no means been completely elucidated but is considered to involve cytochrome P450 enzymes.

This suggests that a low-cost, routine type of genetic test could be useful in identifying potential susceptibility to TCP-induced neurological damage, although experience with other chemical toxins indicates that enzyme activities, which are also dependent upon epigenetic factors and not, therefore, revealed by genetic testing alone, may also need to be characterised in individual cases.

Present regulatory regimes typically make provision for ensuring safe cabin air. For example, the European Aviation Safety Agency (EASA) stipulates *that "crew and passenger compartment air must be free from harmful or hazardous concentrations of gases or vapours"*,[13] albeit without prescribing how this is to be ensured. *Chemical sensors for known hazardous contaminants such as TCP, suitable for installing on aircraft, do not even seem to exist at present other than, possibly, as laboratory prototypes.* A pilot has to make a decision about the presence of hazardous contaminants on the basis of smell, but this is unsatisfactory for many reasons, including: the differing senses of smell among individuals; the fact that TCP has no smell in its pure form; and the plethora of possibly unpleasant but medically benign smells that might originate from the galley, for example, and which might be ignored in the breakfast room of a large hotel but which become obtrusive in the confined space of an aircraft cabin.

The recent debates in the UK parliament have, furthermore, highlighted that there is uncertainty about what concentration of TCP is hazardous to humans.

Workplace exposure limits have been established for one of the ten TCP isomers, namely the tri-*ortho* isomer, which is far from being the most toxic one,[1] but exposure limits are undefined for the special conditions prevailing in a jet aircraft flying at high altitude. If a poison is cumulative the safe exposure limit is, in fact, zero and for some highly susceptible individuals this may be the case regardless of the interval between flights.

Others have more robust metabolisms but pilots, flight attendants and frequently flying passengers will be at risk under almost all circumstances. The newest aircraft to enter the commercial arena, the Boeing 787, does not use bleed air but the tens of thousands of conventionally pressurized jet airliners in the world will be around for many more years and, therefore, greater awareness of the neurotoxic hazards of air travel is needed for facilitating correct diagnosis and, *a fortiori*, treatment for those succumbing to them.

Even making sure that whether a patient has recently flown is part of the anamnesis recorded by the physician would be a significant step forward on the medical side. On the technical side, the recent judgment in a case brought by a KLM pilot [14] required the airline to investigate the concentration of TCP in its aircraft, and the outcome may provide pressure to the installation of continuously monitoring devices, which would be a decisive step towards the effective protection of aircrew and passengers.

Furthermore, the insurance industry should welcome the introduction of sensors capable of determining whether exposure to neurotoxins had taken place, in order to avoid abusive claims for compensation of ill health following alleged exposures, but which in reality had some other cause not related to aviation.

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The business opportunity that VN-ADS seeks to exploit is therefore being driven by the following four processes:

1. ***Legal action and investigations that if successful will see agency and government legislation across the world focus on the monitoring and elimination of organophosphates (TCP's) in the cabin air supply***

2. ***A very real fear from flight crew and cabin staff within the industry that they are being constantly exposed to unseen poisons every time they report for work***

3. ***The manufacturers understanding that design changes are required to move away from the existing 'bleed-air' flow & capture system (e.g. Boeing Dreamliner) and that organophosphate detection equipment (once proven & certified) will therefore be an integral part of that redesign***

4. ***The insurance industries exposure to potential compensation claims for ill health following alleged exposures. The introduction of sensors capable of determining whether exposure to neurotoxins had taken place onboard (complete with a date/time stamp), would obviously negate abusive claims, which in reality had some other cause not related to aviation.***

New Aircraft Market Size (Airbus projections)

Current Fleet and Demand by Size (Boeing projections)

Airplanes in service
2012 and 2032

Size	2012	2032
Large widebody	780	910
Medium widebody	1,520	3,610
Small widebody	2,310	5,410
Single aisle	13,040	29,130
Regional jets	2,660	2,180
Total	20,310	41,240

Demand by size
2013 to 2032

Size	New airplanes	Value ($B)
Large widebody	760	280
Medium widebody	3,300	1,090
Small widebody	4,530	1,100
Single aisle	24,670	2,290
Regional jets	2,020	80
Total	35,280	4,840

*$ values throughout the CMO are catalog prices.

Market Growth by Region

Key indicators 2012 to 2032

Growth measures	
World economy Gross domestic product (GDP)	3.2%
Airplane fleet	3.6%
Number of passengers	4.1%
Airline traffic Revenue passenger-kilometers (RPK)	5.0%
Cargo traffic Revenue tonne-kilometers (RTK)	5.0%

Demand by region 2013 to 2032

Region	New airplanes	Value ($B)
Asia Pacific	12,820	1,890
Europe	7,460	1,020
North America	7,250	810
Middle East	2,610	550
Latin America	2,900	300
CIS*	1,170	140
Africa	1,070	130
Total	**35,280**	**4,840**

*Commonwealth of Independent States.

WORLD	
Airplane Type	Fleet in 2012
Small Wide-body	2,310
Medium Wide-body	1,520
Large Wide-body	780
Single aisle	13,040
Regional jets	2,660
Total	**20,310**

The VN-ADS Solution

ADS Technology

The concept of using changes in optical properties of a fibre-optic sensor to detect chemical changes in solution has been understood for some time, and is described as present art within the ADS application of the patent. The method of detection in other fibre-optic based chemical sensing technologies has been to monitor the absorbance or fluorescence of a surface coating on the sensor tip. ADS technology utilises the measurement of changes in interference patterns generated by analyte-responsive layers deposited on the sensor tip. The main advantages of this method are: greatly increased sensitivity compared with absorbance and fluorescence changes; increased robustness, and universality, i.e. the same sensing platform can be used to cover a very wide range of analytes. Stage 1 of the project focused on delivering a suitable sensor tip sensitising material for organophosphates in particular TCP detection.

The Business Model

Revenue Streams

There are two immediate revenue streams used in this business model:

1. Global sales of 'Handheld' VN-ADS designed detection solutions for use on existing aircraft to all commercial aircraft operators
2. Global 'licencing and rights of use' sales of the VN-ADS 'built-in' detection solution 'licencing' to aircraft manufacturers, OEMs & Tier 1 equipment suppliers to commercial aircraft manufacturers.

On the basis of Market Research carried out by VN-ADS, there are currently 20,310 commercial aircraft in service today. The immediate opportunity is to satisfy this market using the VN-ADS 'Handheld' detection device. Industry experts have advised that a minimum of two units per 'narrow-body' aircraft will be required (1 x flight crew & 1 x cabin crew), 3 units for 'medium body' aircraft (1 x flight crew and 2 x cabin crew) and a minimum of 4 on a 'wide-body' aircraft (1 x flight crew & 3 x cabin crew) with 1 unit located at each cabin crew service station area.

Given the complete lack of organophosphate detection & measuring technology available today and the uniqueness of the patent coverage acquired by VN-ADS, it is envisaged that the unit selling price point will be in the region of $100,000, providing an immediate market opportunity of $3.9billion

Value of VN-ADS "Rights of Use" Contracts

Growth in commercial aircraft numbers (both passenger & cargo) is projected at 5% pa, delivering 41,240 aircraft flying by 2032. 14,320 of these will replace older, less efficient airplanes, with the remaining 20,930 used for fleet growth.

The total aircraft supply market value up to 2032 is predicted to be in the region of $4.8Trn or an average of $136million per aircraft. With an average 'rights of use' licence fee for the 'built-in' solution of $250,000 per installation or approximately 0.018% of the aircraft cost, the total market opportunity between 2014 & 2032 is estimated to be in the region of $8.8billion.

Note: Stage 2A will take place over a 12-month period from funding close and costs are estimated at £450,000 including a minimum second payment (£50,000 being 20% of the full cost of £250,000) of the negotiated development licence fee. *Note: All Legal, Accountancy and 3rd Party costs as indicated on Page 18 of this IM (estimated at £50,000) will be made before project commencement. Project expenditure at £450,000 includes a 10% overrun / contingency fee.*

Structure for Investment in the Company

The Company is to raise £1,800,000 in three tranches to enable it to deliver the project and to provide for the Company's overhead and working capital

(i) Round 1: £ 150,000
(ii) Round 2: £ 600,000
(iii) Round 3: £1,050,000

Initial subscription for 150 Shares in the Company was made to parties interested in becoming Round 1 'New Founder Shareholders'.

Prior to the subscription of equity capital by the Round 1 'New Founder Shareholders', the Founding Shareholders, with their associates, negotiated terms for the IP development licence, access to the original scientific research file, access to the results from, and test rights to, all further ADS research carried out in Stage 1 & 2. They also created the business plan, negotiated consultancy / services supply contracts with the necessary industry partners to deliver the project, and submitted it successfully to HMRC for SEIS Advanced Assurance, thus enabling the company to be successful positioned top deliver profitable revenue streams derived from sales of detection solutions to the aviation industry once the technology is proven.

In consideration of this, the Founding Shareholders currently hold, and will retain, 1,000 shares. The Company issued a further 150 shares priced at £1000 per share to the NFSH upon successful closing of Round 1 funding. In Round 2 the Company will issue a further 300 shares (priced at £2,000 per share) and in Round 3 a further 210 shares (priced at £5,000 per share).

Upon the successful closing of the Round 3 funding, the Founder Shareholders (FS) will have been diluted to 60.24%, Round 1 New Founder Share Holders (NFSH) to 9.04%, Round 2 subscribers (R2S) to 18.07% and Round 3 subscribers to 12.65%.

All new subscribed funds will be used to pay for the project proof and development, acquisition of any identified (now or in the future) external expertise or know how, IP registration, legal fees, and to meet the assembly and working capital and costs of the Company, as below:

Projected Development cost (including VAT)	£1,620,000
Capital Raising and Project Assembly Costs	£ 108,000
Legal and Accounting Costs	£ 72,000
TOTAL	£1,800,000

The Company has budgeted for a distribution fee equal to 6% of the capital raised by the Company through the issue of the Shares, less any amount payable by the Company in respect of any introductory fees payable to authorised third parties.

Options on 15 shares at a Strike Price of £0.01 have be issued to the 'Aviation Industry Specialist Consultant' in lieu of salary or contract fees for all assistance the company may require to succeed in the successful delivery of profitable revenue streams. These options may not be exercised within three years of the date of Round 2 closing and then only in the event of a change of ownership in the company or in the event of a public offering for the shares in the company.

Successful Project

The project will be deemed successful in three stages:

1. When a working prototype device is demonstrated succesfully detecting VOCs and SVOCs in an enviromental chamber & a mockup of the handheld detector is designed and built. (leading to a Round 2 funding)

2A. When an integrated unique PCB is designed for the 'Handheld' model, cases and components are sourced/developed for unit mass-manufacturing, the handheld unit is found 'fit-for-purpose' by an industry recognised examining and aviation certification body and distributed throughout the industry for trials, and initial unit sales are made. (funded by a Round 2 EIS raise)

2B. When the 'built-in' system is designed, installed, tested and found 'fit for pupose' on a commercial aircraft that uses 'bleed air' as the source for cabin air-conditioning by an industry recognised examining third party. (Funded by a Round 3 EIS raise)

The shareholders will share in any initial and all ongoing profits resulting from Design, Consultancy, technology sales or 'Rights of Use' revenue generated by the Company within the target Industries on an annual dividend basis.

Note: Dividends paid may be subject to tax in the investor's hands at the relevant rate at the time payment is made.

Unsuccessful Project

In the event that the project is not successful or it is determined that it is not commercially viable to continue with the sales and development effort at any of the milestone points described within the development program, the Directors undertake that the Company will not incur creditor liability beyond the amount raised in the funding rounds pre revenue, therefore:

a) The Company may be sold to a third party for the value of any residual assets and the proceeds distributed amongst the investors

b) The Company may be put into liquidation, the liquidated assets sold and the proceeds distributed amongst the investors.

In either of the above, the disposals will require shareholder approval to a special resolution on the action to be taken.

Exit Strategy and Potential Returns to Subscribers

The Directors plan an Initial Public Offering of the shares in the company between 2020 and 2022 or at such time as the Directors believe a significant multiple on initial investment may be achieved for subscribers.

No guaranteed forecast can be given of the likely or potential returns to Subscribers upon the successful delivery of the project. Therefore, given current market uncertainties, allowances have been made for a broad spectrum of returns, on the basis of Market Research carried out by VN-ADS.

VN-ADS is budgeting for fixed annual operating costs of £1m in 2019/20 rising to £2m in 2020/21.

Sales of 'Handheld' detection devices will follow the aviation 'channel supplier' route with potential partners identified and marketed to, whilst the initial PR campaign commences. VN-ADS will completely outsource the delivery and maintenance of the devices to third party specialist service providers, retaining only the scientific development, product technology design, supply chain audit, management, certification and sales/marketing/distribution elements of the business.

Penetration into the licenced 'rights of use' Aircraft marketplace is restricted by the *number of 'built-in' prototype designs VN-ADS can produce annually*, and by the *number of different aircraft each manufacturer builds.* There are 5 major manufacturers in the 'new build' marketplace with 3 of those specialising in 'wide-body' & 'narrow-body' aircraft & two in 'regional aircraft'. We will approach all 5 with the target of winning 2. Once successful trials are completed with those manufacturers we will publically leverage our relationship to access the remaining players. It should be noted that STC certification by aircraft variant costs in the region of £240k per application.

The following tables demonstrate possible Investor returns given a varying range of circumstances and market uptake. (The total available market size for 'rights of use' licences over the 20 years is forecasted by Boeing & Airbus to be 1000 planes pa

1. 16 aircraft or 1% penetration re 'rights of use' licences granted for new aircraft pa & 1% Handheld device penetration into the existing commercial aircraft fleet. (30% retained margin on Handheld devices)
2. 32 aircraft or 2% penetration re 'rights of use' licences granted for new aircraft pa & 2.5% Handheld device penetration into the existing commercial aircraft fleet. (30% retained margin on Handheld devices)
3. 64 aircraft or 4% penetration re 'rights of use' licences granted for new aircraft pa & 5% Handheld device penetration into the existing commercial aircraft fleet. (30% retained margin on Handheld devices)
4. 80 aircraft or 5% penetration re 'rights of use' licences granted for new aircraft pa & 7.5% Handheld device penetration into the existing commercial aircraft fleet. (30% retained margin on Handheld devices)
5. 162 aircraft or 10% penetration re 'rights of use' licences granted for new aircraft pa & 10% Handheld device penetration into the existing commercial aircraft fleet. (30% retained margin on Handheld devices)

Round 1 SEIS @ £1000 per Share

Table 1

Minimum Investment			£20,000 = 20 Shares		
Rights of use licence fees $250k each - Hand-held devices $100k per unit (£1 = $1.5)			Potential Return on Investment		
Year	EBITDA	Sales Projections	P/E	P/E	P/E
			7	10	12
2020	£5,604,156	Scenario 1	£472,640	£675,200	£810,239
2020	£13,614,562	Scenario 2	£1,148,216	£1,640,309	£1,968,370
2020	£27,872,874	Scenario 3	£2,350,724	£3,358,178	£4,029,813
2020	£39,445,780	Scenario 4	£3,326,753	£4,752,504	£5,703,004
2020	£62,037,392	Scenario 5	£5,232,069	£7,474,385	£8,969,261

Round 2 EIS @ £2,000 per Share

Table 2

Minimum Investment			£20,000 = 10 Shares		
Rights of use licence fees $250k each - Hand-held devices $100k per unit (£1 = $1.5)			Potential Return on Investment		
Year	EBITDA	Sales Projections	P/E	P/E	P/E
			7	10	12
2020	£5,604,156	Scenario 1	£ 236,320	£ 337,600	£ 405,120
2020	£13,614,562	Scenario 2	£ 574,108	£ 820,154	£ 984,185
2020	£27,872,874	Scenario 3	£ 1,175,362	£ 1,679,089	£ 2,014,907
2020	£39,445,780	Scenario 4	£ 1,663,376	£ 2,376,252	£ 2,851,502
2020	£62,037,392	Scenario 5	£ 2,616,035	£ 3,737,192	£ 4,484,631

Round 3 EIS @ £5,000 per Share

Table 3

Minimum Investment			£20,000 = 4 Shares		
Rights of use licence fees $250k each - Hand-held devices $100k per unit (£1 = $1.5)			Potential Return on Investment		
Year	EBITDA	Sales Projections	P/E	P/E	P/E
			7	10	12
2020	£5,604,156	Scenario 1	£ 94,528	£ 135,040	£ 162,048
2020	£13,614,562	Scenario 2	£ 229,643	£ 328,062	£ 393,674
2020	£39,445,780	Scenario 3	£ 665,351	£ 950,501	£ 1,140,601
2020	£39,445,780	Scenario 4	£ 665,351	£ 950,501	£ 1,140,601
2020	£62,037,392	Scenario 5	£ 1,046,414	£ 1,494,877	£ 1,793,852

The potential investor returns assume the following:

1. A minimum New Founder Shareholder investment of £20,000
2. Shares in the company are offered for sale to the public
3. Market penetration assumption numbers 1-5 above are met
4. Shares in the company trade at a significant multiple of the underlying earnings per share
5. All options are fully subscribed.

Note: These figures were prepared using Industry P/E ratios prevailing in July 2011.
Note: None of the figures contained in this section are guaranteed as they rely on a range of assumptions that may ultimately prove to be inaccurate. Accordingly, subscribers should not rely on these figures, which are not guaranteed by the company, when making a decision to subscribe for shares.

Terms, Conditions and Procedures for Subscription in the Round 2 – EIS Raise.

1. Subscriptions for the Shares are subject to the terms and conditions set out below.

2. Subscribers will subscribe for Ordinary 1p shares in the Company at a premium of £1999.99 per share, giving a subscription price per share of £2000.00.

3. The Minimum Individual Amount of £20,000 will be a subscription for 10 shares. The Directors retain the option to vary the amount. Currently the Founding Shareholders hold the 1,000 Ordinary Shares (1p each) issued shares by the Company and the New Founder Shareholders 150 Ordinary Shares.

4. The full subscription of £600,000 under this offer, as satisfied wholly through the proceeds derived from the allotment of the Round 2 shares, will be a subscription for 300 shares. At the time that these shares are issued, the total issued shares of the Company will be 1450 shares, of which the Founding Shareholders will hold 68.97% via their 1,000 shares, NFSH will hold 10.34% via their 150 shares, and the Round 2 Shareholders 20.69% via their 300 shares.

5. The offer of subscription will be closed immediately on the receipt of applications for the full amount required by the Company or such earlier date as the Directors may decide by any changes in circumstances that may affect the start date of the project, including any Government or Technology Strategy Board offered co-funding, a negotiated reduction of the Stage 2 development budget, operational availability of the technical partners, legislative or regulatory requirements

6. The Directors at their absolute discretion will determine the basis of allotment. The Letter of Subscription should be completed in full and sent or delivered to the Company, as set out in the Letter of Subscription together with the due payment to be made by bank transfer to the designated ‟ client bank account" set up for VN-ADS and operated by Simmons Gainsford LLP. The Directors may have to scale down applications or they may accept them on a first come, first served basis or otherwise.

7. Upon completing and delivering the Letter of Subscription at the end of this Information Memorandum, a fourteen-day period shall commence (cooling-off period) during which the Subscriber may withdraw the Letter of Subscription.

8. If the Letter of Subscription is not so withdrawn, the Subscriber undertakes and confirms as follows:

    a) To subscribe for the number of Shares specified in the Letter of Subscription on the terms of, and subject to, the conditions set out in this Information Memorandum and the Company's Articles of Association, including these terms and conditions

    b) That a subscription for the Shares shall be deemed to be an offer to subscribe up to the value of the Subscriber's subscription and that such offer shall be deemed to take effect on dispatch by post of the Letter of Subscription

    c) To accept such Shares as may be allotted to the Subscriber in accordance with the Letter of Subscription or such smaller amount as the Directors may determine prior to the allotment of the Shares

    d) That all subscriptions, acceptances, allotments and contracts arising from the Letter of Subscription will be governed by and construed in accordance with English law and the English courts will have exclusive jurisdiction to determine any disputes

    e) That the Subscriber is not under the age of 18 and that if the Subscriber signs the Letter of Subscription on behalf of somebody else, or a corporation, that the Subscriber has the authority to do so and such person will also be bound accordingly and will be deemed also to have given the confirmations, warranties and undertakings contained in these terms and conditions of subscription

f) The Subscriber authorises the Company or any of its respective agents to send by post certificates for the number of Shares for which his subscription is accepted, to his or her address (or that of the first named Subscriber) as set out in the Letter of Subscription and to procure that his name(s) together with the name(s) of any other joint Subscriber(s) is/are placed on the Share register of the Company in respect of such Shares

g) That the Subscriber is not relying on any information or representation other than those contained in this Information Memorandum and accordingly he or she agrees that neither the Company nor any person responsible solely or jointly for this Information Memorandum or any part thereof shall have any liability for any such other information or representation in the absence of fraud

h) That the Subscriber is a person in one or more of the categories listed in the Important Regulatory Notice on the first page inside this Information Memorandum, namely a Certified High Net Worth Investor, a Sophisticated Investor or a Self-Certified Sophisticated Investor

i) That the advisers to the Company named in this Information Memorandum are acting for the Company and not acting for the Subscriber and that accordingly, they will not be responsible to the Subscriber for providing protections afforded to their clients for advising the Subscriber on the information in this Information Memorandum or ensuring that the Shares are suitable for the Subscriber

j) That the Subscriber has read and complied with the Terms, Conditions and Procedures for Subscription.

9. No person receiving a copy of this Information Memorandum and Letter of Subscription in any other territory (other than the United Kingdom) may treat the same as constituting an invitation to him or her to subscribe, nor should he or her in any event use such Letter of Subscription, unless in the relevant territory such an invitation could lawfully be made to him or her and such Letter of Subscription could lawfully be used without contravention of any regulation or other legal requirements.

10. It is a condition of any subscription by any such person outside the United Kingdom that he or she has satisfied themselves as to the full observance of the laws of any relevant territory, including the obtaining of any governmental or other consents which may be required and has observed any other formalities in such territory and paid any issue, transfer or other taxes due in such territory.

11. The Company reserves the right to request Subscribers to produce evidence satisfactory to them of their right to subscribe for the Shares and that such subscription would not result in the Company, its advisers or the Directors being in breach of any laws or regulations of the relevant jurisdiction.

12. The Company reserves the right to treat any subscription, which does not comply strictly with the terms and conditions of the subscription as nevertheless valid.

13. Subscriptions will be irrevocable.

14. By completing and delivering a Letter of Subscription, the Subscriber declares that he or she has read, understood and agreed to the terms and conditions contained in this Information Memorandum (including the Risk Factors), the Letter of Subscription, and where applicable, these Terms and Conditions for subscription and that he or she has taken all appropriate professional advice which he considers necessary before submitting the Letter of Subscription and that he is aware of the special risks involved and he understands that his subscription is made upon the terms of the aforementioned documents.

Risk Factors

Share Liquidity and Currency

- There is no established market in the shares. Accordingly, any subscriber may be unable to dispose of their shares.
- Subscribers will subscribe in pounds sterling; revenue proceeds may be in currencies other than sterling. The exchange rate between currencies is subject to continuous fluctuation and can distort the net returns arising.
- Potential Subscribers are reminded that this investment may not be suitable for all recipients of this Information Memorandum and are accordingly advised to consult an investment adviser who is authorised under the Financial Services and Markets Act 2000 before making the decision to subscribe. The ability of the project to pay costs which are in a currency other that of sterling may be impaired by an adverse exchange rate.

The Company's Stage 2 business involves a degree of risk, inasmuch as:

- Whilst it has completed a successful Stage 1 programme providing access to a substantial amount of research and data regarding the detection of TCP using Mono Optical Measuring Technology, and has a full IP exploitation licence for the use of such technology within the avation field granted by the IP owner, MOMT technology has been proven in the laboratory environmental chambers only, i.e. not in a 'real world' aircraft environment
- The design engineering being utilised to enable the MOMT to operate onboard aircraft will be modelled upon known and industry recognised technology, utilising 'industry standard' materials and certification emission requirements. However, it has not been used in conjunction with the aviation industry technology to date and could therefore fail upon airworthiness testing
- Although best endeavour has been used to verify all the scientific research and data the Company is relying on for this project, it may transpire when physically tested onboard aircraft, not to be a reliable or relevant solution

- The market uptake for a MOMT type product is unproven. The projects success is driven in one part by the legislation that will eventually follow any successful court claims currently being heard around the world, and public fear generated by the continuing onboard 'fume events' now being given the publicity they and the victims concerned deserve. This will eventually force manufacturers to confront the issue or lose the operation of their fleets. Manufacturers are quietly designing and building alternative aircraft fresh air intake systems such as that demonstrated on the 787 that circumvents the current ' bleed air' option, and one may assume that detection will be a vital part of that process. However, there is no guarantee that the MOMT technology will become the industry's 'preferred' detection solution.

Estimates of potential value and costs may not be reliable inasmuch as:

- The potential licence income values are illustrations based on available comparable industry information

- The estimates are subject to market input variables that cannot be determined until the unit is developed and ready for market

- The illustrations of potential income value in this Information Memorandum may, accordingly, not be reliable despite the Directors best efforts to judge them accurately.

Enterprise Investment Scheme

- A condition of HMRC's approval of EIS is that the conditions relating to the Company and its trade have to be complied with throughout the three-year period following the issue of the Shares. Although it is the intention that the Company's activities should qualify under the EIS, if the conditions are not complied with, the Company would have breached the EIS regulations and EIS income tax relief would be withdrawn.

Statement of Certified High Net Worth for Individuals

I declare that I am a certified high net worth individual for the purposes of the Financial Services and Markets Act 2000 (Financial Promotion) Order 2005.

I understand that this means: -
a) I can receive financial promotions that may not have been approved by a person authorised by the Financial Conduct Authority
b) The content of such financial promotions may not conform to rules issued by the Financial Conduct Authority
c) By signing this statement I may lose significant rights
d) I may have no right to complain to either of the following:

(i) The Financial Conduct Authority or
(ii) The Financial Ombudsman Service

e) I may have no right to seek compensation from the Financial Services Compensation Scheme.

I am a certified high net worth individual because at least one of the following applies: -
a) I had, during the financial year immediately preceding the date below, an annual income to the value of £100,000 or more; or,
b) I held, throughout the financial year immediately preceding the date below, net assets to the value of £250,000 or more.

Net assets for these purposes do not include:
(i) The property which is my primary residence or any loan secured on that residence; or
(ii) Any rights of mine under a qualifying contract of insurance within the meaning of the Financial Services and Markets Act 2000 (Regulated Activities) Order 2001, or
(iii) Any benefits (in the form of pensions or otherwise) which are payable on the termination of my service or on my death or retirement and to which I am (or my dependants are), or may be, entitled.

I accept that I can lose my property and other assets from making investment decisions based on financial promotions.

I am aware that it is open to me to seek advice from someone who specialises in advising on investments.

Name: ……………………………………….. Address: ……………………………………………………………………………

Please print in block capitals

………

Signature: ………………………………… Date: ………………………………….

Please sign here **Please Date**

Letter of Subscription

To: The Directors of VN-Aerotoxic Detection Solutions Limited
C/o Simmons Gainsford LLP,
4th floor, 7/10 Chandos Street,
London, W1G 9DQ

Dear Sirs,

OFFER FOR SUBSCRIPTION – 300 Ordinary Shares of 1p each in the Company @ £2000 per share

I request and authorise you to register any allotted Shares for which this application is accepted in the name(s) set out below in the Company's Share Register and to forward the definitive certificate or any moneys returnable by post to the first named person below at his/her risk.

Any capitalised term, which is not defined in this letter, has the same meaning given to that term in the Information Memorandum.

I refer to the Information Memorandum issued by the company dated January 2017 (the "Information Memorandum") and confirm I am Certified High Net Worth individual within the meaning of The Financial Services and Markets Act 2000.

I agree to provide the Company (and its professional advisers) with such evidence, as, in its absolute discretion, it requires as to my identity or that of any persons on whose behalf I am acting for the purpose of all money laundering rules and regulations currently in force in the United Kingdom.

I have arranged for payment of the full amount of the subscription for the Shares to be made to the Company c/o the designated client account set up and operated by Simmons Gainsford LLP representing the Company.

I declare that I am resident in the United Kingdom.

VN-Aerotoxic Detection Solutions Limited

SUBSCRIPTION FOR ORDINARY SHARES OF 1P EACH IN THE COMPANY

Please complete using block capitals:

I………………………………………………………………… hereby offer to subscribe for ……….. Shares in the capital of the Company on the Terms, Conditions and Procedures for Subscription contained in the Information Memorandum and the Memorandum and Articles of Association of the Company, with a total subscription consideration of **£**……………….

Any term, which is not defined in this letter, has the same meaning given to that term in the Information Memorandum.

Yours faithfully

.... ……………………………………………………………………………………………………….
(Signature of Subscriber/Applicant)

Date………………………………………………… ……………………………………………………………………………………………………….
Address

Round 2 EIS Advanced Assurance Confirmation

HM Revenue & Customs

Small Company Enterprise Centre
Cardiff
Wealthy & Mid-sized Business Compliance
Mid-sized Business
S0970
Newcastle
NE98 1ZZ

Phone 0300 123 1083

Fax 03000 582 456

Email enterprise.centre@hmrc.gsi.gov.uk

Web www.hmrc.gov.uk

David Newman
Viridis Navitas Capital Partners
4th Floor
7/10 Chandos Street
LONDON
W1G 9DQ

Date 26 September 2016
Our ref WMBC/MSB/S0970/7403126057/SCEC
Your ref

Dear Sir

VN Aerotoxic Detection Solutions Ltd - Enterprise Investment Scheme

Thank you for your application dated 01 September 2016.

I am pleased to confirm that, on the basis of the information supplied, I would be able to authorise the company to issue certificates under Section 204(1) ITA 2007 in respect of Ordinary Shares issued to individuals, following receipt of a properly completed form EIS1 within the time limit prescribed by Section 205(4) ITA 2007.

You are reminded that:

- Responsibility for the accuracy of the information supplied and considered by me rests wholly with the company.

- This provisional assurance is based solely on the information supplied in and with the clearance application and will not apply in circumstances that vary from those described therein. You are therefore advised to forward particulars of any proposed changes, and the draft of any shareholders subscription, investment or similar agreement, for clearance prior to the issue of shares.

- This clearance does not guarantee the availability of any form of relief under the Enterprise Investment Scheme to any particular subscriber.

This assurance is given on the basis of the legislation as enacted at the date of this letter. In the event of any changes to the legislation which take effect on or before the date of any share issue, the assurances given may not continue to apply.

Yours faithfully

Miss L M Phillips
H M Inspector of Taxes

Information is available in large print, audio and Braille formats.
Text Relay service prefix number – 18001

Assistant Director: Colin Wood

HMRC Authority to Issue SEIS 1 Certificates

HM Revenue & Customs

Seed Enterprise Investment Scheme

Small Company Enterprise Centre (Cardiff)
Mid-size Business S0970
PO Box 3900
GLASGOW
G70 6AA

Mr M Gilmore
VN Aerotoxic Detection Solutions Ltd
4th Floor
7/10 Chandos Street
London
W1G 9DQ

Our Ref LC/L&C/S0970/74031 26057/SCEC/KD

Please use this reference if you write or call.
It will help to avoid delay.

Your Ref

Name **Karen Davies**

Phone **03000 588 907**

Authority to issue certificates relating to subscriptions for eligible shares

Name of company

VN Aerotoxic Detection Solutions Ltd

I authorise the company to issue certificates, on the attached forms SEIS3, for subscriptions for eligible shares issued on

04 April 2014

which are listed at Page 1 of the form SEIS1 signed on

04 August 2014

Investments made under SEIS constitute de minimis aid within the meaning of Article 2 of Commission Regulations (EC) No 1998/2006.

This does not guarantee the availability of reliefs under the Seed Enterprise Investment Scheme to any particular subscriber. Subscribers receiving a form SEIS3 should read the information given on it before deciding whether they are able to claim relief.

Page 1 of each form SEIS3 should be completed **fully** before it is issued.

The termination date for these shares is

04 April 2017

Until that date, the shares, and the company, must continue to meet all the requirements of the Scheme as summarised on the SEIS1. If that is not the case, income tax relief will be withdrawn from investors, and any deferred chargeable gains will be brought back into charge.

In the event of a failure to continue meeting these requirements, the company must tell me within 60 days of the event which caused that failure.

Authorised by

HMRC
SMALL COMPANY
ENTERPRISE CENTRE
CARDIFF
02 AUG 2014
TY GLAS, LLANISHEN
CARDIFF
CF14 5FP

K Davies

Karen Davies
SCEC Officer

Please use the reference 74031 26057 when completing forms SEIS3

SEIS2

HMRC 10/12

EIS Information

Highlights

- An individual can invest annually up to £1 million in EIS companies and obtain a tax credit equal to 30% of the cash investment.
- For EIS it is possible to invest up to £1 million in 2015/16 and carry back £1 million to 2014/15, provided certain conditions are met.
- Certain types of trade do not qualify for EIS relief. These include certain financial activities, property development, hotels and providing legal or accountancy services.
- A 'disqualifying arrangements' test has been introduced to exclude VCTs, EIS or SEIS that do not invest in qualifying companies and are set up solely for the purpose of giving investors tax relief.

The following sections analyse the main features:

- Income tax credit on the amount invested and when it may be withdrawn
- The capital gains tax exemption and/or utilisation of capital losses on the disposal of the shares
- Deferral relief, provided the relevant conditions (explained below) are met and
- Business Property Relief (BPR) from inheritance tax (IHT), where certain conditions are met.

Income tax

- Income tax credit at 30% of the amount invested in subscribing for new shares (maximum annual investment of £1 million).
- By election, where an EIS investment is made in one year it can be treated as though it was an investment made in the immediately preceding tax year, subject to the overall limit for that year.
- Dividends paid on EIS shares are taxable.
- Where the EIS shares are sold within 3 years, the EIS investor receives value or an option is placed over the shares, then the EIS tax credit is clawed back.
- The claw-back amount is the lower of:

  Original income tax credit; and
  30% x sale proceeds received (only applicable if sold for a loss)
  There can also be a claw-back if the company loses its EIS status within 3 years.

Capital Gains Tax (CGT) Relief

- An EIS investor is entitled to exemption from CGT on a disposal of those shares, provided he has held them for three years. Therefore, any growth in value is effectively tax-free.

Relief for Capital Losses on Disposals

- Relief is given for allowable losses arising on the disposal of the shares against either income of the tax year of disposal (or of the previous tax year) or chargeable gains, provided all the relevant conditions referred to below are met.
- Any income tax relief obtained under EIS, which was not withdrawn, reduces the capital loss.

CGT Deferral relief

- The tax due on a gain on any asset can be deferred by subscribing for shares in EIS qualifying companies, in a period beginning one year before and three years after the disposal of the original asset.

Business Property Relief

- Shares in EIS companies held for at least two years will normally qualify for 100% BPR for IHT purposes.

EIS Conditions

For EIS purposes, both the investee company invested and the investor need to meet certain conditions:
Conditions to be met by the company:

- The company's gross assets must not exceed £15 million immediately before the shares are issued and £16 million immediately afterwards
- The Investee Company must be unquoted when the shares are issued and there must, broadly, be no arrangements for it to become quoted. A company admitted to AIM will not be regarded as quoted for these purposes
- The Company must exist to carry on a qualifying trade (i.e. conducted on a commercial basis with a view to making profits; and the trade does not include, to a substantial extent (20% or more), excluded activities such as property development, leasing, dealing in land, shares and/or commodities etc.)
- The company must not be a 51% subsidiary of another company
- The Company must not have any subsidiaries that are not 51% subsidiaries
- The issuing company must either be a UK resident company carrying on a trade in the UK or be an overseas company with a UK permanent establishment carrying on a trade
- The Company must not be in financial difficulty
- The Investee Company must have fewer than 250 full-time employees
- The Investee Company cannot raise more than £5 million in total over a 12-month period under the EIS and the VCT scheme.

Conditions to be met by the investor:

The key conditions are as follows:

- The subscription must be in newly issued, ordinary shares and paid for in cash, as well as being for genuine commercial reasons and not for tax avoidance purposes
- To retain the income tax relief and to be exempt from capital gains tax, the shares must be held for at least three years
- The investor must not be connected for EIS purposes with the company. Investors who are connected with the company cannot claim income tax relief but may still qualify for capital gains tax deferral relief
- An investor will be connected with the company if he, either on his own or with associates, possesses or is entitled to acquire more than 30% of the issued share capital, voting power or assets of the company or any subsidiary on a winding up
- An investor will also be connected if he or she is an employee of the company or its group. They can be directors provided they meet certain conditions. An investor must not receive any amount of remuneration as a director that is excessive in comparison to the services performed. Relief will be withdrawn if the investee company, or a person connected with the company makes a payment to the investor (which is not "insignificant") up to one year before, and three years after, the share issue.

Schedule 1 - Patent Portfolio

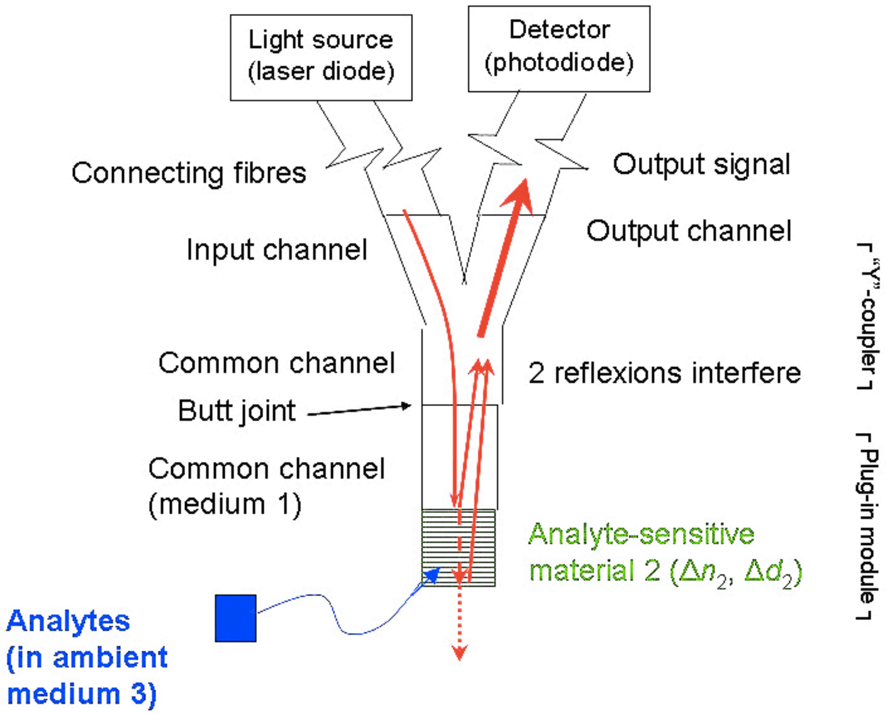
Title	Country	Application No.	Patent No.	Filing Date	Status
Monofibre Optical Meter for chemical measurement	UK	514245	GB2428290	12/07/2005	Granted 24/1/2007
Monofibre Optical Meter for chemical measurement	USA	12/018,693	US7,876,447B2	23/01/2008	Granted 25/1/2011
Fibre Tip Coating for MOMT	Europe	EU/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Russia	RU/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	India	IND/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	China	CHI/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Canada	CAN/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Brazil	BRZ GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Indonesia	INDO/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Austria	EU/GB2428290/A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Belgium	EU/GB2428290/A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Switzerland	SWZ/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Liechtenstein	EU/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Germany	EU/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Spain	EU/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Finland	EU/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	France	EU/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Hungary	EU/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Italy	EU/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Netherlands	EU/GB242829.0A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Romania	EU/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Sweden	EU/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Slovak Republic	EU/GB2428290.A		End of Stage 1	Pending
Fibre Tip Coating for MOMT	Turkey	EU/GB2428290.A		End of Stage 1	Pending

Schedule 2 – Financials

Projected 'Built-in' Licence fees & Hand Held Detector Sales with Inward Cash Estimates. £1=$1.5

Year	2020	2021	2022	2023
Licence Fees	£166,666	£166,666	£166,666	£166,666
Hand Held Unit Sale price	£62,500	£62,500	£62,500	£62,500
OEM Design & Consultancy for Manufacture				
New In-Built Design Income	1pa	1pa	1pa	1pa
Design Cost	£375,000	£375,000	£375,000	£375,000
Design Charge	£750,000	£750,000	£750,000	£750,000
Design Gross Profit	£375,000	£375,000	£375,000	£375,000
Licencing Total Market Size averaged = 32,253 new aircraft built between 2013-2032	32,253	32,253	32,253	32,253
Average aircraft new build per year = 1627				
Licence Cost	£166,666	£166,666	£166,666	£166,666
A- Penetration 16 pa or 1% of the available annual marketplace	£2,666,656	£2,666,656	£2,666,656	£2,666,656
B- Penetration 32 pa or 2% of the available annual marketplace	£5,333,312	£5,333,312	£5,333,312	£5,333,312
C- Penetration 64 pa or 4% of the available annual marketplace	£10,666,624	£10,666,624	£10,666,624	£10,666,624
D- Penetration 80 pa or 5% of the available annual marketplace	£13,333,280	£13,333,280	£13,333,280	£13,333,280
E- Penetration 162 pa or 10% of the available annual marketplace	£26,999,892	£26,999,892	£26,999,892	£26,999,892
Existing aircraft average fleet size	19,024	19,024	19,024	19,024
Hand Held Devices Sales price	£62,500	£62,500	£62,500	£62,500
A- Penetration 1% or 190 units - with 30% retained margin	£3,562,500	£3,562,500	£3,562,500	£3,562,500
B- Penetration 2.5% or 475 units-with 30% retained margin	£8,906,250	£8,906,250	£8,906,250	£8,906,250
C- Penetration 5% or 951 units-with 30% retained margin	£17,831,250	£17,831,250	£17,831,250	£17,831,250
D- Penetration 7.5% or 1426 units-with 30% retained margin	£26,737,500	£26,737,500	£26,737,500	£26,737,500
E- Penetration 10% or 1902 units-with 30% retained margin	£35,662,500	£35,662,500	£35,662,500	£35,662,500
Opex	£1,000,000	£2,000,000	£2,000,000	£2,000,000
AA- EBITDA	£5,604,156	£4,604,156	£4,604,156	£4,604,156
BB- EBITDA	£13,614,562	£12,614,562	£12,614,562	£12,614,562
CC- EBITDA	£27,872,874	£26,872,874	£26,872,874	£26,872,874
DD- EBITDA	£39,445,780	£38,445,780	£38,445,780	£38,445,780
EE- EBITDA	£62,037,392	£61,037,392	£61,037,392	£61,037,392

Schedule 3 – Technology Schematic & Handheld mock-up



HER MAJESTY'S SENIOR CORONER
FOR THE COUNTY OF DORSET

CORONER: SHERIFF S. PAYNE

ASSISTANT CORONERS: Brendan J. Allen
Richard T. Middleton
Stephen J. Nicholls

Cannons Law Practice
Aviation Lawyers
11 Somerset Place
GLASGOW G3 7JT

16th February, 2015

Our Ref: SSP/LJ/1004/12(W)
Your Ref: FC/WestR0101

Dear Mr Cannon,

RE: Richard Mark WESTGATE Deceased

I am pleased to enclose copies of letters I have sent to BA and the CAA together with the Report to Prevent Future Deaths. I will of course advise you of the outcome.

Once again I would like to thank you for the manner in which you have put together your dossier and submissions and also for supplying the memory sticks and three copies of all relevant documents.

Yours sincerely,

Sheriff S Payne
H M Senior Coroner

THE CORONER'S COURT STAFFORD ROAD BOURNEMOUTH DORSET BH1 1PA
Telephone: 01202 310049 Fax: 01202 780423 Britdoc: DX 156942 Bournemouth 3
email: coroner@bournemouth.gov.uk

Chief Executive
British Airways
Waterside
PO Box 365
Harmondsworth
UB7 0CB

16th February, 2015

Our Ref: SSP/LJ/1004/12(W)

Dear Sir,

Re: Richard Mark WESTGATE Deceased

I enclose:

1. A Regulation 28 Report to Prevent Future Deaths.
2. A Schedule of the documents supplied to me by Frank Cannon an Aviation Lawyer acting on behalf of the family of Richard Mark Westgate.
3. A USB memory stick containing the documents on the schedule.

I shall be holding an Inquest in due course into the circumstances of Mr Westgate's death and am treating your organization as an interested person. This entitles you to legal representation at the Inquest.

I shall be holding a Pre-Inquest Review at this Court at 11.00 a.m. on Wednesday the 25th March 2015. Please let me have details of who will be representing you so that I may forward an Agenda to them prior to the hearing.

Please note that not all of the documents are relevant to or will be used at the Inquest hearing.

Yours faithfully,

S S Payne
H M Coroner
Encs

Chief Operating Officer
Civil Aviation Authority
CAA House
45-59 Kingsway
LONDON WC2B 6TE

16th February, 2015

Our Ref: SSP/LJ/1004/12(W)

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Re: Richard Mark WESTGATE Deceased

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Please note that not all of the documents are relevant to or will be used at the Inquest hearing.

Yours faithfully,

S S Payne
H M Coroner
Encs

Sheriff Stanhope Payne,
Senior Coroner for The County of Dorset

REGULATION 28: REPORT TO PREVENT FUTURE DEATHS (2)

	REGULATION 28 REPORT TO PREVENT FUTURE DEATHS **THIS REPORT IS BEING SENT TO:** 1. **Chief Executive – British Airways** 2. **Chief Operating Officer – Civil Aviation Authority**
1	**CORONER** I am Sheriff Stanhope Payne, senior coroner, for the coroner area of Dorset
2	**CORONER'S LEGAL POWERS** I make this report under paragraph 7, Schedule 5, of the Coroners and Justice Act 2009 and regulations 28 and 29 of the Coroners (Investigations) Regulations 2013.
3	**INVESTIGATION** On 27th December 2012 I commenced an investigation into the death of RICHARD MARK WESTGATE, aged 43.. The investigation has not yet concluded and the inquest has not yet been heard.
4	**CIRCUMSTANCES OF THE DEATH** On 12th December 2012 Richard Mark Westgate was found deceased in his room at the Bastion Hotel in Bussum, Netherlands. His body was repatriated to Dorset. He was a British Airways pilot who had been on medical leave since September 2011 suffering cognitive dysfunction, ataxia & other deficits. Post mortem examinations gave causes of death of either Pentobarbital toxicity or lymphocytic myocarditis, individually or in combination. Testing of samples taken both prior to and after death disclosed symptoms consistent with exposure to organo-phosphate compounds in aircraft cabin air. Such exposure can cause lymphocytic myocarditis.

Stafford Road, Bournemouth, Dorset, BH1 1PA
Tel 01202 454910 | Fax 01202 780423

5	**CORONER'S CONCERNS** During the course of the investigation my inquiries revealed matters giving rise to concern. In my opinion there is a risk that future deaths will occur unless action is taken. In the circumstances it is my statutory duty to report to you. The **MATTERS OF CONCERN** are as follows. – (1) That organo-phosphate compounds are present in aircraft cabin air. (2) That the occupants of aircraft cabins are exposed to organo-phosphate compounds with consequential damage to their health. (3) That impairment to the health of those controlling aircraft may lead to the death of occupants. (4) There is no real time monitoring to detect such compounds in cabin air. (5) That no account is taken of genetic variation in the human species, such as would render individuals tolerant or intolerant of the exposure.
6	**ACTION SHOULD BE TAKEN** In my opinion urgent action should be taken to prevent future deaths and I believe your organisation has the power to take such action.
7	**YOUR RESPONSE** You are under a duty to respond to this report within 56 days of the date of this report, namely by 13th April 2015. I, the coroner, may extend the period. Your response must contain details of action taken or proposed to be taken, setting out the timetable for action. Otherwise you must explain why no action is proposed.
8	**COPIES and PUBLICATION** I have sent a copy of my report to the Chief Coroner and to the following Interested Persons, Frank Cannon of Cannons Law Practice acting on behalf of the family of the deceased. I am also under a duty to send the Chief Coroner a copy of your response. The Chief Coroner may publish either or both in a complete or redacted or summary form. He may send a copy of this report to any person who he believes may find it useful or of interest. You may make representations to me, the coroner, at the time of your response, about the release or the publication of your response by the Chief Coroner.
9	**16th February 2015** **Sheriff Stanhope Payne** **Senior Coroner for Dorset**

Stafford Road, Bournemouth, Dorset, BH1 1PA
Tel 01202 454910 | Fax 01202 780423

Berrymans Lace Mawer LLP is a leading UK law firm, renowned for its dispute resolution and insurance expertise. It counts major airport operators among its transport sector clients.

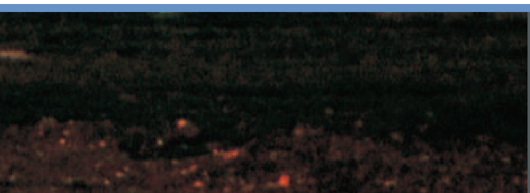
A number of toxic 'fume events' have given rise to concerns that modern airliners' air systems – which replenish the supply of air via the engines – are damaging to the health of frequent flyers and crew. In the last year in particular, reports of pilots retiring due to ill health have given credence to a controversial medical condition termed 'toxic air syndrome'. Nicola Williams, **a solicitor at Berrymans Lace Mawer LLP, addresses the possibility of future legal action brought by passenger and employees.**

Toxic air syndrome:
is there smoke without fire?

AN AIRCRAFT IS BEGINNING ITS DESCENT when the co-pilot suddenly becomes nauseous. He puts on his oxygen mask and looks to his captain, who already has his on. The captain says that he feels dizzy and groggy, and his movements are awkward and seemingly uncontrolled. These events sound like they could belong in an action film, but in fact occurred on a BAe 146-200 jet aircraft on 12 November 1999 whilst the aircraft was making its descent into Malmö airport, Sweden. The aircraft had suffered an oil leak in which more than 90 contaminants were identified as having aerosolised in the air supply. The crew were seriously incapacitated, but were able to recover, and the aircraft landed without any further incident, despite this "fume event".

The media reported another fume event on 18 February 2010, when a Boeing 757 bound from Barcelona to London was forced to make an unscheduled landing 20 minutes after take-off. The pilots had become aware of strong fumes in the cockpit and accordingly had made the decision to ground the flight. As with the Swedish flight, the aircraft landed safely and without further incident.

Notwithstanding the airline industry's proactive approach to safety, these fume events have given rise to increasing concerns about air systems in aircraft. Adding weight to the argument, a growing number of airline employees and passengers have come forward to say that they have suffered illness, ranging from minor conditions to serious neurological problems, simply as a result of breathing contaminated air on aircraft.



Of most concern are the compounds tricresyl phosphate (TCP) and phenyl-alpha-napthylamine. TCP is used in aviation fuel as an anti-wear / fire-retardant compound but is actually neurotoxic to humans, whilst phenyl-alpha-napthylamine causes skin sensitisation.

The cause

So how are jet-engine fumes getting into aircraft? Since the late 1950s, providing high-altitude aircraft with a continuous supply of pressurised air has been a challenge to engineers. Air from outside the aircraft is pumped into its air conditioning system, but given the temperature and pressure of air at high altitudes, it has to be heated and compressed first.

In earlier jet engines, on aircraft such as the DC-8 and Boeing 707, separate mechanical compressors were used to achieve this. However, it quickly became recognised that jet engines, as part of the propulsion process, heat and compress air whilst it is in the forward section of the engine, before the fuel is added and burned. This pre-heated and compressed air can therefore simply be "bled off" from the engine and pumped straight into the air cabin with negligible risks of contamination. As a result, bleed-air jets have been used in the majority of commercial airliners since the 1960s.

Obviously, bleeding air from the engine into the cabin is not risk free. Occasional seal failures can and do occur in the engines. When this happens, engine oil becomes vaporised in the bleed air and is pumped into the cabin. This results in a fume event.

Awareness of fume events is not new, and they have been recognised as far back as the late 1970s. What remains in dispute is the risks such fume events pose to the health of passengers and aircrew. To this end, many in the airline industry consider fume events to be rare occurrences, with contaminants at such low levels that they pose more of a nuisance than a safety issue. However, the evidence relating to fume events is far from clear.

There is much disparity in the data regarding the number of fume events that occur and, as a result, prevalence is greatly debated. The UK's Civil Aviation Authority (CAA) reports that approximately 500 fume events occurred on UK registered planes from 1985 to July 2006.

However, a survey by the British Airline Pilots Association (BALPA) in 2001 indicated that 96 per cent of fume events are never reported. The Global Cabin Air Quality Executive (GCAQE) agree, and state that fume events are significantly underestimated because the majority of them are seen as either "normal", or a nuisance and are consequently never reported. Australia, Norway and the USA have all officially acknowledged that fume events are significantly under-reported and all three consider this to be a major issue.

The UK Contaminated Air Database reports that 893 contaminated air events occurred on UK flights during the period of 1 January 2001 to 4 April 2006. As awareness of fume events grows, it is likely that the number of reports will continue to increase.

The effects

But what about the health risks; is there any evidence to suggest that fume events can cause health problems in passengers and aircrew? Are airlines leaving themselves open to personal injury/compensation claims?

Boeing's stated position is that "on the very rare occasions where bleed air contaminants may enter the cabin, the contaminant levels are expected to be lower than occupational thresholds established by toxicologists". The scientific community appears to agree. As recently as 2000, the UK House of Lords' Science and Technology Committee Report on 'Air Travel and Health' concluded that the evidence failed to show that there was a 'significant risk' to the health of airline passengers and crew from air contaminants.

However, as individuals continue to come forward saying that they have health problems as a result of breathing contaminated air on aircraft during fume events, pressure is mounting for an explanation. The term 'Aerotoxic Syndrome', coined in 1999 by campaigning groups to describe the symptoms, is beginning to gain credence. Some research is already suggesting that there are possible links between repeated exposure to toxic fumes on aircraft and the symptoms described by these individuals, most of whom are pilots.

The research of Dr Sarah MacKenzie Ross, a consultant clinical neuropsychologist at University College London, found evidence of 'cognitive impairment' in 27 pilots who had been referred to her. Of those individuals, 18 were classified by her as both impaired and ill. The research was independently reviewed by Professor Robin Morris of King's College Hospital, who concluded that the study could neither suggest, nor rule out a link.

However, it appears that the research was sufficient to influence the House of Lords' Science and Technology Committee, which changed its position significantly in 2007. In its updated report, the committee cited this research alongside the testimony of a number of pilots claiming ill health and the loss of their licences following fume events, and recommended that the chemicals in fume events be 'urgently' identified. They suggested it was then followed up by an epidemiological study on pilots, to ascertain the incidence and prevalence of ill health in aircrew that was associated with exposure to the identified chemicals. Cranfield University, headed by the late Professor Helen Muir, was charged with undertaking this research in a year long project, and was due to publish its findings in early 2010. At the time of writing, this report has yet to be published.

Currently, there remain genuine concerns as to the toxicity of jet fuel in fume events. Aviation fuels and oils typically contain toxic substances, such as organophosphates. Of most concern are the compounds tricresyl phosphate (TCP) and phenyl-alpha-napthylamine. TCP is used in aviation fuel as an anti-wear / fire-retardant compound but is actually neurotoxic to humans, whilst phenyl-alpha-napthylamine causes skin sensitisation.

The late Professor Muir, when speaking to the BBC on 24 September 2009, stated that whilst organophosphates will be found on flight decks, what matters is whether or not they are present in sufficient concentrations to potentially cause harm to people.

Certainly, a number of pilots and aircrew consider that they are, and say that their exposure to such fume events caused their health problems. John Hoyte, a former captain who piloted BAe 146 planes from 1989 until he stopped flying due to ill health in 2006, claims that his health progressively failed, leaving him 'a zombie like vegetable'. He claims that his memory deteriorated; he regularly suffered chronic fatigue; and his speech and thought processing abilities became so impaired he described it as feeling like he was permanently intoxicated. He claims that since ceasing to fly, his symptoms and health have dramatically improved.

Notwithstanding these types of claims, aerotoxic syndrome is yet to become a medically recognised term. In the event that scientific research establishes that there are health risks associated with fume events, it seems that this could change in future.

Industry impact

Obviously, any scientific link established between fume events and health risks is likely to have major implications for the airline industry. There are already three pending court cases in the USA, where both aircrew and passengers are suing Boeing for long-term ill health. Similar legal action is also being contemplated in the UK.

Regarding aircrew, as employees of the airlines they will be covered by the provisions of the Health & Safety at Work Act 1972 whilst the aircraft is grounded and Regulation 6 of the Civil Aviation (Working Time) Regulations whilst the aircraft is in the air.

In addition, the UK's Health & Safety Executive (HSE) has confirmed that the Control of Substances Hazardous to Health Regulations 2002 (COSHH) will apply to British aircraft and this will cover not just employee aircrew, but also passengers, who are covered by virtue of the fact that they are 'others who may be affected'.

There is no doubt that for the purposes of COSHH, bleed air contamination would constitute a 'substance hazardous to health'.

The HSE and the CAA have agreed under a memorandum of understanding, that the HSE will not intervene in health and safety matters on-board aircraft. In these circumstances it is for the CAA to both police and enforce breaches of health and safety legislation. However, the HSE does retain the right to enforce legislation whilst the aircraft is on the ground and therefore a breach of COSHH could potentially invite a criminal prosecution by the HSE for fume escapes that occur whilst the aircraft is grounded.

In the UK at least, there will be difficult hurdles for any civil actions. Litigation in respect of Gulf War Syndrome (which was claimed to have been caused by the use of chemical weapons) and for organophosphate poisoning (from use of "sheep dip") have all failed. This is largely due to the real difficulties in establishing a medically recognised condition and causation for the 'syndrome'.

Even without the results of these further studies and specifically that being undertaken by Cranfield University, the airline industry is likely to continue to be put under pressure to address these concerns. Boeing has recently launched the Boeing 787 'Dreamliner', which uses an electrical compression system and therefore does not use bleed air from the engines. It is yet to be seen whether or not other aircraft models will follow suit. What is clear is that there is a growing number of calls for airlines to take action, in the form of putting filters on bleed air feeds; by fitting toxic fume detectors; and by removal of organophosphates from jet engine oil.

This is going to have a huge impact on airlines in the coming years, as the modification and replacement costs are likely to be vast. It will probably be a number of years before existing airline fleets can be replaced or modified. Should a causal link be found between fume events and aerotoxic syndrome, airlines will have to take steps much more quickly to avoid potentially significant litigation costs.

"What is clear is that there is a growing number of calls for airlines to take action, in the form of putting filters on bleed air feeds; by fitting toxic fume detectors; and by removal of organophosphates from jet engine oil. This is going to have a huge impact on airlines in the coming years, as the modification and replacement costs are likely to be vast."

Nicola Williams is a solicitor at national law firm Berrymans Lace Mawer LLP having left a career as a research chemist. Nicola can be contacted at nicola.williams@blm-law.com

January 7, 2010

Rulemaking Directorate
European Aviation Safety Agency
Postfach 10 12 53
D-50452 Cologne
Germany

Submission by Susan Michaelis (Capt): To accompany all sections of A-NPA comments made by EASA CRT, 8/1/10

RE: A-NPA No. 2009-10 'Cabin air quality onboard large aeroplanes'

Dear Sir / Madam:

I am a former Australian commercial pilot and have researched the aircraft contaminated air issue for 13 years since 1997, since having to cease flying and having my medical removed by CASA after repeated contaminated air events. Since this time I have published numerous papers, made presentation internationally, am the head researcher for the Global Cabin Air Quality Executive (GCAQE) and am the author of the only collated source of data on this issue: Michaelis S. (2007) Aviation Contaminated Air Reference Manual. ISBN 9780955567209. I have recently submitted a PhD thesis on this issue, specifically related to contaminated bleed air systems.

While I am pleased that EASA is at last taking some interest in the contaminated air issue, the content of the A-NPA is of concern as it shows an appreciable lack of understanding of the currently available data on the subject and a significant industry bias. Given that contaminated air is an airworthiness issue, this of course is a major area of responsibility for EASA.

Acute and chronic symptoms caused by exposure to pyrolyzed engine oil on aircraft have been recognized since the 1950s,[1] With one exception,[2] airlines, aircraft/component manufacturers, aviation regulators, and government sponsored committees have made little effort to systematically investigate these smoke/fume events and the associated reports of ill health,[3,4,5,6,7,8,9] instead describing them as 'anecdotal' and similar. Therefore the flight safety issues have been overlooked with contaminated air events deemed a nuisance rather than a flight safety hazard.

I feel I more than qualified to offer my expertise on this issue based on my extensive research covering the flight safety aspects as well as the short and long-term health implications. My 844 page fully sourced reference manual and recently submitted thesis in addition to my global awareness of the available data and thinking supports this of course. I would be more than happy to brief EASA at a suitable time in the near future on my latest research and PhD findings at a suitable time.

I have sent EASA by courier a copy of my reference manual listed above along with selected other material and trust this will be carefully reviewed. The reference manual is seen as Ground breaking and seminal work by the RAAF in Australia. Many other published papers can be found at: http://www.aopis.org/ScientificReports.html

It is not possible to cover the whole issue of aircraft contaminated air in one document here. It has taken me 13 years of solid research to amass this knowledge. However while I support the GCAQE submission of course and share it's concerns, I will briefly address the 4 questions EASA has posed in the A-NPA.

A. WHAT CONTAMINANTS ARE RELEASED TO THE CABIN AND FLIGHT DECK, AND IN WHICH QUANTITY?

The vast majority of air quality monitoring has been carried out on aircraft in normal conditions of flight without any reported fume events.[10,11,12,13,14,15,16,17,18,19,20] These aircraft sampling projects and many others were not designed to capture air supply contamination events.[10,21]

A few aircraft sampling studies with very small sample sizes were intended to investigate bleed air contamination on commercial [8, 22,23,24, 25] and military[26,27] aircraft. Reported levels of airborne contaminants were stated to be below the occupational exposure limits for the limited number of chemicals for which limits have been published. Data subsequently revealed a leading manufacturer cabin air study had found TCP above it's manufacturing plant allowable limits, however this information was withheld from the published reports.[8,28,29,30,31]

However, occupational exposure standards do not apply to aviation.[8,28,32,33,34,35] Also, even if occupational exposure limits did apply to a confined space at altitude that transports members of the general public, few of the chemicals identified in oil-contaminated cabin air[10] have occupational exposure limits to which to compare. Further, passengers are not 'healthy workers' and are not covered by exposure standards, chemicals are present as mixtures and not in isolation, all aircraft occupants are exposed in a reduced pressure environment, and crewmembers can be assigned to work shifts that are 14 hours or longer, all factors that must be accounted for.[36] The ACGIH does not recommend exposure standards to be applied above 5000 feet.[37]

While engine oils are made up of a number of substances, it is the degraded or pyrolyzed substances from the heated lubricant that is of prime importance in a reduced pressure environment. However, the composition of the oil additive tricresylphosphate (TCP) in a given engine oil is an important factor when attempting to define the toxicity of a given oil. However the isomeric blends of TCP in commercial aviation engine oils are proprietary. As background, there are ten chemical variations ('isomers') of tricresylphosphates (TCPs), some or all of which are added to most commercial aviation engine oils.[38] This is relevant because the toxicity of the various TCP isomers is not uniform, and the tri-ortho isomer is neither the only, nor the most, toxic. The chemical constituents of some pyrolyzed oils have been defined,[39,40,41,42,43] but a complete analysis of the TCP isomers has not been possible because chemical standards have not been available for all isomers. Recent military studies have reconfirmed that virtually all of the ortho (TCP) isomers are in the mono form, which are the most toxic and that the various isomers are identifiable despite the standard remaining confidential.[44]

Exxon-Mobil has confirmed that oil fume contamination of the aircraft air supply system does not constitute 'normal' usage,[45] yet the MSDSs only cover normal usage. However Mobil has asserted that it's published and internal risk assessments indicate such exposures are safe and the only recognized risks are gastrointestinal effects and OPIDN, organophosphate Induced delayed Neurotoxicity, yet such effects could not occur in the aircraft cabin.[45,46,47,48] However such assertions are inappropriate for a variety of reasons including:

1. The majority of symptoms reported by crew and passengers exposed to oil fumes indicate central nervous system (CNS) damage (e.g. headache, difficulty concentrating, memory problems, slowed mental processing and response time, balance problems, depression, and visual irregularities).[2,23,49,50,51,52,53,54,55,56,57, 58,59,60]
   The fact that there are no published animal data on CNS toxicity of inhalation exposure to TCPs (whether the six ortho isomers or the remaining four meta/para isomers that dominate TCPs in engine oils) does not mean that TCPs do not damage the CNS. The more subtle but significant symptoms of CNS damage reported by exposed crewmembers are not possible to assess directly in animal studies, and post-mortem brain analyses of structures or regions involved in cognition or emotion have not been funded. A neurotoxic effect of exposure to meta/para TCP isomers has been suggested because the results of experimental studies cannot be explained by the presence of the ortho-isomers alone.[61] Using neurotoxic esterase enzyme activity as an endpoint, an oil manufacturer identified low, but consistent, neurotoxicity in formulations derived almost entirely of meta/para isomers that it had expected to be inactive.[62] 1964 US Navy studies found it 'highly suggestive' that components other than ortho isomer groups of the triaryl phosphates have significant toxicity or are capable of synergizing or potentiating other triaryl phosphates.[63]

2. Even if the ortho isomer content in aviation engine oils is lower than some decades ago, an association with reported peripheral nervous system damage cannot be ruled out for the following reasons: there is no defined 'safe' exposure level for inhaling mixed TCP isomers; there are defined genetic, endocrine, and environmental factors known to influence an individual's ability to metabolize organophosphates;[64,65,66] there is a dearth of exposure data from the aircraft cabin/flight deck; and there is no information on the health impact of chronic exposure to low-levels of pyrolyzed engine oils. One study assessed symptoms of peripheral neuropathy in hens orally dosed with engine oils containing TCPs. The authors reported an 'unexpected high neurotoxic potency of the aviation engine oil containing 3% TCPs and less than 0.02% of TOCP.'[67] These TCP contents are comparable to aviation oil products used industry-wide today. Administering heated oils to test animals via inhalation (instead of unheated oils orally) would be expected to increase the observed neurotoxic impact[61,68] and would better reflect exposures on commercial aircraft.
3. The oil MSDSs do not indicate there is no hazard and prior to 2004 the MJO II and 254 MSDS warnings and oil can labels reported: *'Overexposure to TCP by… prolonged or repeated breathing of oil mist… may produce nervous system disorders including gastrointestinal disturbances, numbness, muscular cramps, weakness, and paralysis….'*

TCP, the synthetic lubricant additive has been found in aircraft on numerous occasions including; RAAF (1988/2005), Honeywell (1997,2000) Lee, Qantas, CAA (2004), Van Netten (2005/2006), NIOH, Muir (2008), GCAQE (2009), TNO (2009), OHRCA (2009) and WDR (2009)[),8,,22,24,25,26,27,28,29,30,69,70,71,72,73,74,75,76,77,78.] In summary TCP has been recorded in at least 15 studies including military and civilian aircraft studies since 1988. These studies include TCP being found in cabin air, bleed air, filters, aircraft ducting and swab sampling of filters (flight deck, HEPA filters and interior cabin walls). 75 out of 88 (85%) swab samples for TCP have positively identified TCP. Therefore exposure to TCP in the passenger cabin is occurring and the isomers can be accurately identified to correspond with the unique TCP isomer formulation used in jet engine oils.[44,79] TCP has also been found in crew member's blood following contaminated air events.

Even if the inhalation toxicity of all 10 TCP isomers were addressed, TCPs are not the only candidates in pyrolyzed engine oil that could be responsible for the symptoms reported by exposed crewmembers and should not be considered in isolation.[61] Hundreds of chemicals have been identified in the supply air of commercial aircraft contaminated with engine oil [8,]10[,24,25,28,29,30,40,43] and others, like the neurotoxin trimethylolpropane phosphate (TMPP), have been proposed as a potential exposure risk when ingredients in the engine base stock react with TCPs at elevated temperatures.[80] TMPP formation has been recorded at temperatures as low as 250ºC,[81] which is within the range of an operating aircraft engine which can range from 300 to 650 °C in the high stage compressor section to between 50 and 300 °C in the intermediate (low stage) compressor.[82,83] A US Navy research team reported that such high levels of TMPP were generated when Exxon 2380 (now marketed as BP2380) engine oil was heated that it recommended that the product be banned on US naval vessels.[84] The research team attributed the high levels of TMPP to the trimethylolpropane phosphate (TMP) base stock reacting with the TCP additives. Most aviation engine oils contain pentaerythritol ester (PE) base stocks which are not associated with TMPP formation. Some engine oils may contain a combination of TMP and PE base stocks. Despite the recognized potential for the formation of high levels of TMPP, BP2380 is widely used on the commercial fleet globally. The study also recommended that that all polyol ester based synthetic oils in the U.S. Navy inventory should be tested for the production of TMPP and that *'research should be initiated for overall toxicity of combined, combustion byproducts rather than for any individual combustion product present.'*[84]

Trying to identify a single contaminant that is responsible for the diverse neurological and respiratory symptoms reported by exposed aircraft occupants, and to define a 'safe' level for all occupants is an impossible task for the reasons stated above. The use of the traditional dose response rationale ignores the following factors: the potential for either an additive or a synergistic response to a mixture of chemicals;[34,85,86] the impact of exposure to chemicals (especially carbon monoxide) in a reduced pressure environment;[87] the potential health impact of repeated exposures and chronic low-level exposures;[57,88,89] and the other factors referenced here that influence individual susceptibility to organophosphates and other chemicals such as pyrethroid insecticides.

Some parties consider that if aviation regulations are met then the aircraft supply air will be clean and safe. EASA requires that aircraft manufacturers design air supply systems to provide 'enough fresh air… to enable crewmembers to perform their duties without undue discomfort or fatigue' (CS 25.831(a)) and that the 'crew and passenger compartment air be free from harmful or hazardous concentrations of gases or vapours' (CS 25.831(b)). The US Federal Aviation Administration (FAA) has published similar design standards (14 CFR 25.831(a) and (b)). The terms 'undue discomfort or fatigue' is subjective and even 'harmful or hazardous' may be open to interpretation. As such the term harmful relating to adverse effects ought to be the determining factor or the use of correct application of the hazardous substance regulations. Still, there are many documented examples of pilot impairment caused by oil fumes (described in the next section) that would meet even the most conservative interpretation of these terms. In those events then, at a minimum, these aviation regulations were not met. In 2002, the FAA acknowledged that '[no] present airplane design fulfills the intent of 25.831 because no airplane design incorporates an air contaminant monitoring system to ensure that the air provided to the occupants is free of hazardous contaminants.'[90] Still, to date, no aviation regulator requires airlines to install and operate either bleed air monitoring or bleed air cleaning systems, despite the many recommendations on the subject.[2,6,9,26,91,92,93,94]. At present, neither EASA nor the FAA requires air quality monitoring so there is no guarantee that the airworthiness regulations (FAR/CS 25.831 a/b are being met at all times.

The FAA requires that maintenance work restore the aircraft to its original (i.e. design) condition (14 CFR 43.13 (b) and (c)). This concept of 'continuing airworthiness' is recognized globally.[95] However once gain there is ample evidence to support that continuing airworthiness related to contaminated air is not being met at all times. Additionally the application of MELs is not appropriate for contaminated bleed air supply as such incidents are in fact airworthiness / safety issues (as per FAR/CS 25.831) for which MELs must not be applied.[35,96]

B. WHAT IS THE EFFECT ON FLIGHT SAFETY?

More than 30 years ago, a published case study of a healthy 34-year old flight navigator exposed to oil fumes inflight described 'disturbance in [his] mental and neuromuscular function' and noted that 'by the time the plane could be landed, he had difficulty standing'.[58] The 1977 investigation and subsequent report found oil fume reports were not uncommon and that the toxicity of the synthetic jet oils was 'definitely warranted.' A review of 89 incidents of smoke/fumes in the flight decks on military aircraft from 1970-80 described 'incapacitating central nervous system dysfunction and mucous membrane irritation' and concluded that 'smoke/fumes in the cockpit is not a rare event and is a clear threat to flying safety because of acute toxic effects.'[57]

From 1979-81, 10 turboprop aircraft, all equipped with the same Garrett engine, crashed, leaving 38 fatalities. Oil residues were identified in the engines from one of the aircraft that had been retrieved from the bottom of a lake. The US National Transportation Safety Board (NTSB) initiated an investigation into whether a cracked engine oil seal might allow 'toxic or anaesthetic byproducts of the oil to enter the aircraft's environmental system.'[97] The NTSB noted that, if identified, such exposures could compromise flight safety and could be a risk on all bleed air aircraft. The NTSB partnered with the aircraft engine and oil manufacturers, introducing a known quantity of oil into the compressor section of a Garrett engine and measuring the bleed air contamination downstream. In most of the trials, liquid contaminants were removed with a glass wool filter prior to the sampling port, even though the bleed air on the crashed aircraft had not been filtered. The researchers concluded, based on the gaseous contaminants that they measured in the filtered air, that the 'hypothesis concerning subtle pilot incapacitation due to engine oil contamination of the bleed air supply… is completely without validity.' However, a companion study published by the FAA acknowledged the possibility that 'with an unfiltered [bleed air] line, a significant toxicity could be associated with breathing the oil mist.'[98]

In 1999, the Australian Transport Safety Bureau (ATSB) issued a report of an oil fume event inflight where the pilot 'suffered from a loss of situational awareness.'[99] Upon approach, 'his control inputs had become jerky and he began suffering vertigo.' The incident was attributed to oil fumes in the flight deck air (based on mechanical records) but the pilot in command had reported that no smoke or fumes were present so he did not use the smoke removal checklist and none of the three pilots donned their oxygen masks.

In 2000, an Australian Senate inquiry into oil contaminated bleed air summarized a series of pilot-reported incapacitation events. Upon exposure to oil fumes, pilots reported 'difficulty in concentrating on the operation of the aircraft' and 'a feeling like drunkenness [resulting in] difficulty lining up the aircraft for landing.'[2]

Since 2000, the UK Civil Aviation Authority (CAA) has issued four bulletins to airlines that warn of the risk of pilot incapacitation caused by exposure to toxic oil fumes inflight and recommend procedures to protect against pilot incapacitation.[100,101,102,103] The agency notes that 'reducing occurrences of oil contamination will also reduce the risk of flight crew incapacitation.'[101]

In 2001, the CAA initiated a research program into aircraft air quality in response to the increase in reported smoke/fume events, including a small number of events where 'flight crew have been incapacitated to a greater or lesser degree.'[101] The published research report concludes that 'engine oil fumes were the most likely cause' for the acute symptoms and found no evidence of other causal factors.[5]

In 2001, Swedish air safety investigators published a report regarding a smoke/fume event on a commercial aircraft during which the captain was 'having difficulty with physiological motor response, simultaneity, and in focusing.'[23] The contaminated flight deck air was attributed to an engine oil leak. The investigative report stated that subsequent air sampling by the aircraft engine manufacturer did not identify the cause of either pilot's symptoms, but the air sampling data released years later cited the presence of a wide range of contaminants, including tricresylphosphates and triphenylphosphate, specific to oil contamination.[24,25]

In 2004, the FAA issued an Airworthiness Directive (AD) requiring BAe146 operators to prevent the accumulation of oil residue in the air supply system ductwork.[104] The FAA stated that these procedures were necessary 'to prevent impairment of the operational skills and abilities of the flightcrew caused by the inhalation of agents released from oil or oil breakdown products, which could result in reduced controllability of the airplane.' The FAA had issued this AD in response to a service bulletin published by the aircraft manufacturer which stated that oil leaks and odors 'must be regarded as a potential threat to flight safety.'[105] Prior to this time the manufacturer acknowledged that oil fumes had been seen as a nuisance.[105] Other regulators had issued similar ADs regarding oil fumes on the BAe 146 prior to the FAA action, all indicating oil fumes are regarded as a flight safety risk.[106,107,108,109,110,111,112,113]

Also in 2004, the UK Air Accidents Investigation Branch (AAIB) reported an incident of oil fumes in the airliner flight deck in which the 'first officer's condition began to decline to an extent that he had difficulty in concentrating… The commander also felt light-headed and had difficulty in judging height and in the ensuing approach and landing.'[114] The report concluded that there was ‘circumstantial evidence’ that the flight crew had been affected by exposure to oil that had contaminated the APU.

In 2006, the Swiss Aircraft Accident Investigation Bureau published its investigation into a report of oil fumes in the flight deck.[115] The report concluded that ‘the serious incident is attributable to the fact that on approach… the cockpit filled with fumes which caused a toxic effect, leading to a limited capability of acting of the copilot. These fumes were caused by an oil leak…’

In 2007, the AAIB reported another incident of oil fumes in the flight deck.[94] The report identified 153 other smoke/fume incidents and concluded that 40 of them had involved ‘adverse physiological effects on one or both pilots, in some cases severe.’ The report recommended that EASA and the FAA require flight deck detection and warning systems for oil smoke/mist. The same call for detection systems was repeated in 2009 by the AAIB.[93]

These are just a few examples of industry acknowledgement that oil fumes pose a threat to flight safety. There is a vast amount of supporting evidence showing impairment is occuring in flight not on an infrequent basis. Recent research has found that of 1050 contaminated air events in the UK, 32% recorded crew impairment in flight, while 20% showed at least 1 pilot was impaired in flight with 9% of events showing both pilots impaired in flight ranging from mild to incapacitation.[116] A host of other flight safety issues were demonstrated including the low use of oxygen by pilots during contaminated air events.[116,117] In fact oxygen was used by 1 pilot during 4% of contaminated air events and both pilots in 12 % of such events.[116]

3) CAN IT INDUCE A HEALTH CONCERN?

The acute health risks outlined in the response to the previous question describes crewmembers’ reports of acute symptoms inflight, with a focus on neurological symptoms which are the primary complaint. Exposure to synthetic jet oils have been acknowledged within the aviation industry to cause a variety of short term symptoms also highlighted on a typical jet oil MSDS.69[,118,119,120,121,122,123,] The NTSB recognized in 1983 that *‘There are certain instances in which chronic or repeated exposure may sensitise a person to certain chemicals so that later concentrations in the ppb may later illicit an acute hypersensitivity type reaction.’*[124] A UK Government report found that acute effects due to contaminated air exposures were ‘plausible’,[3] while the Executive Director of the Aerospace Medical Association reports that exposure to VOCs used in aircraft operations can cause skin rashes, pulmonary and CNS symptoms ranging from mild to severe.[33] SAE stated in 1981 review of bleed air and synthetic oils that at *‘temperatures above 320C this oil breaks down into irritating and toxic compounds’*.[125] Many other industry bodies have acknowledged that exposure to synthetic jet engine oils is hazardous including Rolls-Royce.[126],[127] Selected other examples include :

- BAe Systems: **‘***With the weight of human evidence and suffering, which is quite clear, there must be something there’*… *‘There is absolutely no doubt in our mind that there is a general health issue here’*[128]
- CASA:*’Mobil Jet Oil II- Known to be harmful’*[129]
- UK Government:*’The inhalation of mist (containing tricresylphosphate) which can be produced by high pressure systems, or direct contact with the skin, would be hazardous.’*[130]

- FAA: *'JAR-E includes a unique hazard, `toxic bleed air''*[131]
- German Government: *'Does the German Government believe that inhaling of heated engine oil fumes is harmless for the health of crew and passengers?'.* Answer *'No'.*[132]
- German Regulator: *'Oil leakage… and oil residues… may lead to harmful contamination of the cabin air and cause intoxication of the flight crew.'* [133]

As to chronic effects, the primary symptoms reported and documented by exposed crew and passengers indicate central nervous system (CNS) damage (e.g. chronic headaches, difficulty concentrating, memory problems, slowed mental processing and response time, balance problems, depression, and visual irregularities).[2,23,49,50,51,52,53,55,56,59,60,]77[,123] Chronic neurotoxicity and autonomic nervous system damage have also been reported.[61,134,135]

A proportion of the crews and passengers exposed to oil fumes have reported symptoms consistent with peripheral nervous system damage (e.g. paraesthesias, tremor, abnormal gait). These symptoms are consistent with exposure to the six 'ortho' isomers of TCP (of which the tri-ortho isomer, TOCP, is one) which have been affirmed as being highly toxic to the peripheral nerves in animal studies, both by a German toxicologist in the late 1950s[136] and the worlds' leading aviation engine oil manufacturer, Mobil Oil (now Exxon-Mobil), forty years later.[62] While TOCP has received almost all the research attention over the decades, it has been long known that the mono- and di-ortho isomers of TCP are five to 10 times more toxic than TOCP, TOCP has been (incorrectly) assumed to be a suitable surrogate.[137]

In addition to the neurological symptoms described above, damage to the upper airways and lungs have been reported and documented,[49,50,51,52,53,54,60,77,123,138,139,140,141] causing symptoms including chest tightness, difficulty taking a full breath, wheezing, coughing, and shortness of breath. As well, some crewmembers report symptoms such as skin rash/sensitization, gastrointestinal upset, muscle weakness, and joint pain,[49,51,52,55,,60,]77[,123] and psychiatric symptoms such as depression.[,49,]77

Other conditions have been reported by crew and their physicians that are reported in published literature including alzheimers, Parkinsons, Grade 4 GBM, MND and MS.123.[142,143,144] Chronic effects have been recognized elsewhere.[32,123,145,146]

My recent research of BAe 146 pilots and B757 pilots has highlighted significant short and long-term health effects that show a strong temporal association with contaminated air. While the research is a part of my thesis and will be available fro review later this year, previously published preliminary data shows that of approximately 300 pilots surveyed to date, in excess of 85% acknowledged they were aware of the contaminated air; 65% reported some degree of adverse symptoms (short, medium or long-term) and an oil fumes exposure history; around 30% showed medium to long-term adverse effects of a similar pattern; with in excess of 10% of those surveyed medically retired, retired then suffering ill health of a similar nature with all having a long history of exposure to oil fumes. I have since identified a smaller subset with well known chronic disorders inn association with a strong history of oil fume exposure. [123,147] This research is supported by previous research I have undertaken.[52,55]

NYCO, a French producer of synthetic jet engine oils and a significant supplier of such oils for the military market, has revised their MSDS for TURBONYCOIL 600. The new MSDS incorporates risk phrases Xn 62.F3 (harmful: Possible risk of impaired fertility.) and Xn 63.G3 (harmful: Possible risk of harm to the unborn child). The changes were based upon NYCO sponsored research undertaken at the University of Washington investigating selected neurotoxicity of various organophosphate additives including TCP and TIPP. Both additives were found to produce 'a non-negligible potential' of neurotoxicity, while the newly discovered NYCO proposed alternative OP additive is claimed to a significant improvement in term of neurotoxictity and this matter should be fully investigated and supported by EASA to further reduce the health and safety risks associated with inhalation and dermal exposure to pyrolised/heated synthetic jet engine oils.

4) WHAT IS THE FREQUENCY OF THIS KIND OF EVENT?

It has been widely recognized that the incidence of smoke/fume events varies according to aircraft type, engine type, and maintenance practices,[2,3,9,148] but no current aircraft type or airline is immune.[116,149] The Boeing 787 aircraft scheduled to enter commercial service in 2010 should not be subject to bleed air contamination with oil because the supply air is processed in electrically-generated compressors independent of the engines.

In the absence of a reliable reporting system or air quality monitoring requirements, it is difficult to estimate the frequency of smoke/fume events on commercial aircraft. Still, there are sufficient data to conclude that smoke/fume events are not rare. This has been clearly acknowledged within the aviation industry as shown below and in my research.[116]

Based on data from three United Kingdom (UK) airlines, a government sponsored committee estimated that pilots experience oil smoke/fume events on 1% of flights and that maintenance identifies the smoke/fume source on 0.05% of flights.[3] One explanation for the discrepancy is that engineering faults can be difficult and time-consuming to identify. Mechanics routinely release aircraft with some version of 'no fault found, return to service,' only to sometimes divert with smoke/fumes on the subsequent flight.[116,117,149]

A review of publicly available smoke/fume event data for the US fleet over an 18-month period identified a daily average of 0.86 documented smoke/fume events involving oil or hydraulic fluid, considered an underestimate for reasons provided.[83] The primary data source for these events was Service Difficulty Reports (SDR) that the FAA requires airlines to submit for reports of all smoke/fume events inflight and any such ground-based events that may compromise flight safety. Frequency estimates from three Canadian airlines range from 0.09 to 3.88 events per 1,000 flight cycles depending on aircraft type and airline.[9] Australian operators reported oil fume events as often as once in every 66 flights or 1.5% of flights, while the manufacturer stated the following clearly identifying a design issue that is part of the way oils seals operate:

- *'The air supply is protected from contamination by seals, which achieve maximum efficiency during steady state operation. However, they may be less efficient during transients (engine acceleration or deceleration) or whilst engine is still achieving an optimum operating temperature.'*[150]

However, the true frequency of oil fume events may be much higher than what is documented. Aviation regulators in many countries have issued reporting requirements for smoke/fume events, but there is evidence that compliance is lacking. Also, the regulators need not share the data publicly.

For example, in Europe, aviation authorities in member states must require pilots, airlines, manufacturers, and other parties with knowledge of an occurrence involving 'smoke or toxic or noxious fumes' to report to their respective aviation authority.[151] However, one survey of commercial airline pilots in the UK reported that less than 4% of suspected oil fume events were reported at all.[55] Only a small proportion of events that even get reported to the airlines are actually reported to the authorities, as required.[116,117]

In the US, the FAA requires airlines to report 'each failure, malfunction, or defect concerning an aircraft component that causes accumulation or circulation of smoke, vapor, or toxic or noxious fumes in the crew compartment or passenger cabin during flight' (14 CFR 121.703(a)(5) and 12 CFR 125.415). Airlines must also report ground-based events if flight safety is or may be endangered (14 CFR 121.703(c) and 14 CFR 135.415(c)). However, the FAA recently reported that numerous airlines may not have reported smoke/fume events as required,[153,154] and there is no published evidence of improved reporting since then.

In Australia, the Civil Aviation Safety Authority (CASA) requires each pilot in command to enter all defects of which they are aware on the aircraft maintenance release (technical log) at the termination of each flight, and the airline must conduct a 'suitable' investigation (CAR 248, 50, 51). Since 1992, CASA has classified 'smoke, toxic or noxious fumes inside the aircraft' as a major defect,[155] (previously CAO 100.8) which means that maintenance workers must report them to the airline, and the airline must report to CASA within two working days (CAR 51, 52A).

Crewmember underreporting of fume events has been noted both in military[32,57] and civil aviation. [2,]49[,116,117,153,154]**Error! Bookmark not defined.** The Australian Senate summary of its inquiry into air safety and cabin air quality specifically noted that pilots were reluctant to report fume events because doing so could jeopardize their flying license.[2] The Australian ATSB found that *'smoke and fume contamination of cabin air is neither a new phenomenon nor a particularly rare event and that over time, it has been experienced in many aircraft types.'*[156] The FAA has acknowledged the reluctance of pilots with ill health to voluntarily remove themselves from flying[157] and the US Air Force has noted the difficulty in acquiring complete and accurate medical information from pilots with a profession, hobby, or aircraft investment to protect.[158,159]

There is little doubt that the majority of fume reports are related to oil leakage. In 1990 Rolls-Royce stated that *'The approach adopted some years ago by Rolls Royce was to recognize the fact that in the majority of instances where cabin air contamination was a problem, it was mostly associated with small leakages of synthetic lubricant from bearing seals etc.'*[162] The fact that fumes are predominantly associated with oil leakage ahs been acknowledged by regulators, airlines and manufacturers over the years along with the recognition that oil fumes are part of the design factor of using bleed air for the cabin air supply in addition to maintenance issues.[69, 150,164,165,166,167]

In addition to country or region-specific reasons for underreporting fume events, it is worth noting that all of the available smoke/fume data have been reported by crewmembers who were not trained to recognize or respond to oil or hydraulic fluid fume events, specifically.

CONCLUSION:

The issue of aircraft contaminated air has remained ongoing for several decades and has remained unaddressed and seen as outside the scope of the aviation regulator. Inhalation or exposure to oil fumes and other fluids in flight is a serious safety hazard and both short and long-term effects have been clearly identified, The aviation industry has to date not dealt with the issue appropriately at all and based on conduct documented, the term reprehensible conduct[168] (ICAO) is warranted and must be addressed.

RECCOMENDATIONS
Urgently required research includes:

- Synthetic jet engine oils and other fluids should be assessed for overall toxicity of combined pyrolysis by-products rather than individual chemicals in a manner in which exposures mostly occur, that is via inhalation. Research should also focus on specific areas such as TCP biomarkers and polyol ester based synthetic oils should be assessed for toxic by-products creation such as TMPP, inhalation toxicity of other TCP isomers (non ortho) and similar;
- Establish standards for all contaminants suitable for the cabin air environment and the heated mixture of contaminants, rather than individual ground based standards;
- Better designed engine and APU oil seals and bleed air systems that do not allow oil to leak;
- Development of effective bleed air filtration or bleed air cleaning systems should be introduced on current non ‘bleed free’ aircraft;
- Installation of effective bleed air detection (real time monitoring) systems identifying suitable markers to detect contaminated air should be introduced in each bleed supply line. This will alert crews when contamination is occurring and aid engineering with subsequent fault diagnosis;
- Research should be undertaken into the health effects associated with contaminated bleed air using case control studies and expertise free of industry/Government alliances.

Urgently required actions include:

- TCP should not be used as a substance in synthetic oils. Use of less toxic oils and fluids should be developed, mandated and introduced;
- Information on jet oils should be revised to accurately advise users of the true nature of hazards to exposure to jet oil and fluid mists, fumes and vapours and how these hazards can be controlled and prevented;
- Appropriate engineering practices should be introduced to ensure leaks are addressed in a manner that ensures further contamination cannot occur when reported. MELs should not be applied where downstream contamination will have occurred;

- As clean air is an airworthiness issue, ongoing defects addressed through service bulletins should be made compulsory by way of airworthiness directives or alternatives;
- Clean air under FAR / CS (EASA) 25.831 ‘a’ and ‘b’ must be immediately regarded as part of the ongoing aircraft certification requirements as was originally intended. This must address all contaminants using standards suitable for the cabin air environment and the heated mixture of contaminants, rather than individual ground based standards;
- All suspected contaminated air events must be reported as an aircraft defect to the regulators and be made available to crew and the public. The appropriate aviation legislation must then be adhered to and enforced;
- The industry should stop trying to rationalize the extent of the contaminated air problem in terms of the number of bleed air reports as the reporting system is not working;
- Crews must use oxygen whenever contaminated air is suspected;
- Education for the entire industry that exposure to contaminated bleed air is a flight safety hazard and health issue;
- Organizations within the airline industry must accept their OH&S responsibilities under the legislation with clearly identifiable appropriate systems to ensure the legislation is met;
- Risk assessments must be inclusive of workers and passengers rather than excluding such vital data;
- Aviation regulators and OH&S regulators must both use their expertise to address the bleed air issue and must not defer responsibility to the other without suitable expertise;
- Workers who report adverse effects from bleed air should be appropriately investigated;
- Individuals who have been exposed as crew or as passengers should be made aware of this fact. Details of the chemicals they have been exposed to should be provided to them so as to enable their physician to be able to treat and monitor their health appropriately;
- Health systems should be developed to identify and treat people exposed to contaminated bleed air and treat them with respect;
- International utilization of the FAA funded OHRCA medical protocol should be introduced while further research takes place;
- Establishment of an international database to report adverse effects of exposure to assist with international research to better understand the diversity of illness associated with contaminated bleed air; ‘Aerotoxic Syndrome’;
- Establishment of an international database to record contaminated air events to assist with international understanding of the issue and required actions;
- Better systems should be identified to monitor, detect, diagnose, treat and compensate affected workers; Those affected to date require industry level compensation, rather than individual legal actions that fall prey to the issues identified in this thesis;
- EASA should adopt the ICAO resolution that protects passenger and crew health.[173]
- All future aircraft should be designed in a ‘bleed free’ manner as is the case with the Boeing 787 Dreamliner.

Please do let me know if I can be of further assistance in helping EASA to identify the true extent of this issue and means to address it. I am currently based in the UK and would be pleased to brief EASA in further detail at a suitable time.

Sincerely,

Susan Michaelis (Capt)
susan@susanmichaelis.com

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