Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A08C0237

LOSS OF CONTROL AND COLLISION WITH TERRAIN

SKY NORTH AIR LIMITED
BEECHCRAFT A100 C-FSNA
GODS LAKE NARROWS, MANITOBA, 5 nm NW
22 NOVEMBER 2008

Canada

Aviation Investigation Report

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Summary

The Sky North Air Ltd. Beechcraft A100 (registration C-FSNA, serial number B-227) operating as SN683 departed Runway 32 at Gods Lake Narrows, Manitoba, for Thompson, Manitoba with two pilots, a flight nurse, and two patients on board. Shortly after takeoff, while in a climbing left turn, smoke and then fire emanated from the pedestal area in the cockpit. The crew continued the turn, intending to return to Runway 14 at Gods Lake Narrows. The aircraft contacted trees and came to rest in a wooded area about one-half nautical mile northwest of the airport. The accident occurred at 2140 central standard time. All five persons onboard evacuated the aircraft; two received minor injuries. At approximately 0250, the accident site was located and the occupants were evacuated. The aircraft was destroyed by impact forces and a post-crash fire. The emergency locator transmitter was consumed by the fire and whether or not it transmitted a signal is unknown.

Ce rapport est également disponible en français.

Other Factual Information

Environment

There is no weather reporting service for Gods Lake Narrows. The closest weather observation taken near the time of the accident was reported by Island Lake, approximately 50 nautical miles (nm) south at 2200.[1] The weather was reported as: wind 160° true (T) at eight knots, visibility 15 statute miles, a few clouds at 900 feet, ceiling overcast at 1600 feet, temperature -7°C.

The sun had set at 1607 and the moon was not visible at the time of the accident. The flight was conducted in total darkness. The topography beyond the departure end of Runway 32 at Gods Lake Narrows is lake and bush, and devoid of any light or feature that could assist in discerning the horizon. Darkness, cloud cover, and absence of visual cues lend themselves to the black hole illusion, which can influence a pilot's perception of the aircraft's position and movement. In some instances, pilots may believe that they are at a higher altitude.[2]

The Flight

The aircraft departed on Runway 32. Shortly after rotation, smoke and then flames emanated from the pedestal near the horizontal stabilizer pitch trim position indicator. The aircraft was in a climbing left turn approximately 400 feet above ground level (agl). With the possibility of the fire worsening, the captain, who was the pilot flying, chose to continue the turn back towards the airport and land on Runway 14. The first officer called the bank angle at 30° and approaching 60°. The captain called for the landing gear to be lowered; the aircraft stall warning commenced as the gear extended. The captain rolled the aircraft hard to the right and applied full power. The stall warning sounded continuously as the wings levelled and the aircraft descended and collided with trees. The aircraft came to rest approximately one-half nm northwest of Runway 14 at Gods Lake Narrows. The wreckage path was approximately 240 feet in length and was aligned 140°.

Briefings and Evacuation

The time between the appearance of smoke and flames in the cockpit and the collision with the trees was 22 seconds. There was no opportunity for the pilots to advise the flight nurse and passengers that there was a problem and that they were returning for landing.

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[1] All times are central standard time (Coordinated Universal Time minus six hours).

[2] *Human Factors for Aviation* (TP 12863), Transport Canada, page 84, figure 22

After the aircraft came to a stop, the captain left his seat and told the passengers and flight nurse to leave the aircraft. The pilots did not encounter flames as they climbed out of their seats and over the pedestal during egress. The captain proceeded to the door with the infant patient and opened it. The door came to rest on trees and opened approximately one-half of the normal travel. While the slack cables of the door slightly impeded evacuation, all five occupants were able to exit the aircraft. During evacuation, there was no time to retrieve the survival gear or first aid kit. The first officer was able to retrieve a winter jacket that was subsequently used to keep the infant passenger warm. The group moved rearwards over fallen trees until they were a safe distance from the aircraft, which was by then engulfed in flames.

Search-and-Rescue and the Emergency Locator Transmitter

Search-and-rescue (SAR) activities were initiated shortly after the non-arrival of the aircraft at its destination.

The emergency locator transmitter (ELT) was removed from the wreckage and forwarded to the TSB Laboratory for analysis. The ELT was too badly damaged by fire to determine whether it was armed and functioning.

A signal from the ELT would have been generated from the time of the accident until it was destroyed. It could not be confirmed whether a signal was generated or not. If it had been generated, the duration of the signal would not have been long enough to be received by the search-and-rescue satellite (SARSAT) system or over-flying aircraft. No signal was evident when the military SAR Hercules aircraft searched for the accident site.

Pilot Qualifications and Experience

The flight crew was certified and qualified for the flight in accordance with existing regulations. The captain had approximately 3200 hours of total time, of which 1850 hours were on Beechcraft 100-series aircraft. The first officer had approximately 1000 hours of total time with 500 hours on the same series.

The crew's flight and duty times were in accordance with existing regulations. The crew had approximately 12.5 hours of rest prior to being on duty for seven hours at the time of the accident. The flight crew's work/rest schedules were not considered contributory to the accident.

Company Pilot Training

All flight training was conducted in company aircraft with a training pilot providing instruction and acting as the pilot not flying (PNF). During flight checks, the training pilot acted as the PNF while an authorized check pilot administered the flight test from the cabin. For emergencies that could occur at low altitude, such as engine failures and fires after takeoff, the operator's pilots practiced drills at higher altitudes where the height of the ground would be simulated. This permitted the practicing of critical emergency procedures at safe altitudes. For engine failure during takeoff, the standard operating procedure (SOP) [3] directs pilots to climb straight ahead to 1000 feet agl prior to completing any checklist items. There was no such direction in response to electrical fires.

With respect to in-flight electrical fires, the Sky North Multi-Crew SOP manual does not differentiate between those that might occur at en route altitudes from those that might occur at lower altitudes. The operator's crews were not trained to respond to electrical fires at low altitudes. The company did, however, train its crews to maintain control of the aircraft and climb straight ahead to 1000 feet agl prior to accomplishing any checklist items.

Simulator training was not provided for Sky North pilots, which is quite typical of operators of this category of aircraft. However, crews trained in a simulator can be exposed to a wider range of emergency situations than those trained solely in aircraft. Another added benefit of simulator training is that the pilots are trained as a crew, rather than with a training pilot in an aircraft.

Operating Procedures

Generally, in the event of any emergency, the SOP directs pilots to:

> i) Fly the aircraft
> ii) Silence any aural warning
> iii) Re-set/re-arm aural warnings
> iv) Identify the emergency or abnormal condition
> v) Confirm emergency is identified correctly
> vi) Take appropriate action [4]

With respect to electrical smoke or fire, subsection 7.23 of the SOP provides the following expanded checklist:

> Electrical smoke or fire can quickly overcome a crew and incapacitate them. It is essential that well rehearsed and decisive actions be taken to secure the source of the smoke or fire quickly, followed by an expeditious landing at a suitable aerodrome.

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[3] SOP 7.6, Engine failure during takeoff and SOP 9.9, Profile.

[4] This is a list of items condensed from the SOP manual, subchapter 7.3 (b).

ELECTRIC SMOKE OR FIRE

Gang Bar [5]……………………………….DOWN [6]

This step should be taken only if flying during daylight since once the gang bar is used, all cockpit lighting will be extinguished.

WARNING
Cabin will depressurize, electrically driven Flight Instruments will become inoperative.

Oxygen Control…………………….........ON
Oxygen Mask…………………………….DON

The PF should remain in control and direct the PNF to don his/her mask, and then once he/she has completed this, the control of the aircraft can be passed to the PNF and then the other pilot can don his/her mask.

All Electrical Switches………………….OFF
Battery and Generator Switches……ON
Essential Elec. Equip…………………..ON INDIVIDUALLY

Observe the ammeter and watch for large deflection that may indicate a short in that system.

Oxygen…………………………..………AS REQUIRED

NOTE
Opening the cabin pressurization dump valve and the storm window (if depressurized) will facilitate smoke and fume removal.

The manufacturer's AFM provides an emergency checklist. Sky North also provides an emergency checklist for use in the cockpit that is similar to that of the manufacturer. A comparison of these checklists and the expanded checklist in the SOP shows subtle differences. The preface to the GANG BAR DOWN item in both the AFM and cockpit emergency checklists states that action to be taken "must consider existing conditions and equipment installed."

The expanded SOP first states "Electrical smoke or fire can quickly overcome a crew and incapacitate them. It is essential that well rehearsed and decisive actions be taken to secure the source of the smoke or fire quickly, followed by an expeditious landing at a suitable aerodrome." In addition, this SOP cautions pilots to turn electrical power off only during daylight conditions.

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5 The gang bar consists of a spring-equipped metal plate that permits the selection of the generators and battery switches to the OFF position in one motion.

6 Items in bold depict mandatory memory items—actions that must be committed to and performed by memory.

Absent from all checklists, however, are explicit procedures to be followed in the event of an electrical fire shortly after takeoff, in darkness.

Aircraft Flight Instrument Systems

The occurrence aircraft was manufactured in 1976. As was typical of the time of manufacture, the Beechcraft A100 had two sets of flight instruments where the captain's (left side) instruments were electrically powered and the co-pilot's were pneumatically powered.

The captain's instruments receive 28-volt DC power from the #1 Avionics Bus. In the event the crew detects electrical smoke or fire, the first checklist item calls for all electrical power to be turned off. Doing so de-energizes the captain's flight instruments and all cockpit lighting. In instrument meteorological conditions (IMC), control of the aircraft would be transferred to the co-pilot who would refer to his or her pneumatic flight instruments if there was sufficient ambient light to read them. In this occurrence, the captain did not turn the electrical power off.

Oxygen mask and goggles

The aircraft was not equipped with quick-donning, full-face masks, nor were they required by regulation. The aircraft was equipped with oxygen masks and eye goggles that were sealed in individual plastic bags and stowed in pouches in the back of each pilot's seat. The mask and goggles were designed to ensure an effective seal of both units when worn together. To activate the oxygen mask, the oxygen system control must be pulled to the ON position and the connector for the mask supply tube inserted into an oxygen outlet on the cockpit wall adjacent to the instrument panel. The smoke that developed during the in-flight fire did not hamper visibility and did not detrimentally affect the pilots' ability to breathe. Neither of the pilots donned oxygen masks.

Fire Extinguishers

The cockpit was equipped with a fire extinguisher that was secured beneath the captain's seat. A second fire extinguisher was mounted at the left front of the cabin on a divider located between the cockpit and the cabin. The fire was momentary in nature and the crew did not need to use the fire extinguishers to put out the fire.

Redundant Aircraft Electrical System

The electrical power distribution for the Beechcraft A100 aircraft provides power from the left and right generator belly busses to the number one (No. 1) and number two (No. 2) subpanel feeder busses, respectively.

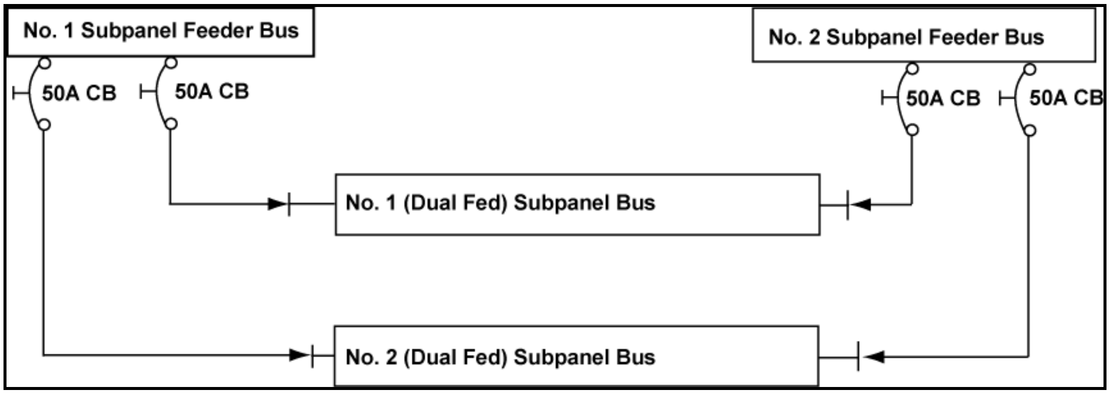

Figure 1. Simplified electrical power distribution to subpanel busses.

As shown in Figure 1, the No. 1 subpanel feeder bus provides power through a 50-amp subpanel feeder circuit breaker and a subpanel feeder diode to the No. 1 (dual-fed) subpanel bus. That same No. 1 subpanel bus is provided a second source of power from the No. 2 subpanel feeder bus through a separate 50-amp circuit breaker and diode circuit. The No. 2 subpanel bus is similarly arranged.

For either of these dual-fed subpanel busses, if the power supplied by one subpanel feeder bus fails, the alternate subpanel feeder bus will continue to provide power to the subpanel bus and all components and systems powered by that bus will continue to operate normally. No warnings or failure indications are available in the event of a single-supply failure. The four subpanel feeder circuit breakers are located in the pedestal circuit breaker panel at the aft end of the cockpit pedestal. The four subpanel feeder diodes are mounted on a heat-sink assembly inside the front-right area of the pedestal. During this occurrence, when the smoke and flames were evident, there were no warnings or indications to suggest what systems or components had failed.

Post-Occurrence Inspection and Analysis of Arced Wiring

The pedestal was largely destroyed by the post-crash fire. Within the remains of the pedestal area, the core wires of the electrical bundle were evident. The plastic portions of the circuit breakers and the wire insulation were burned away. Inspection of the pedestal wiring bundle revealed that several wires within the left rear pedestal area had arced and separated. The wire bundle was removed and forwarded to the TSB Laboratory for detailed analysis**.**

One of the wires that arced and separated was an 8-gauge wire, P73A8, which transfers power from the LH subpanel feeder circuit breaker to the subpanel feeder diode in the electrical circuit for the No. 1 (dual-fed) subpanel bus. A second 8-gauge wire, P84R8, also a component of the same circuit for the No. 1 (dual-fed) subpanel bus, had an arcing separation failure. Two ten-gauge wires showed evidence of electrical arc damage at one end of each wire. One of these wires could not be identified, the other is suspected to be wire P92T10, which was attached to the input side of the LH No. 1 subpanel feeder circuit breaker and provided power to the Avionics No. 1 circuit. The arc sites for all three of the identified wires were located approximately the same distance (1.5 inches) ahead of the pedestal circuit breaker panel.

It is suspected that the P73A8 wire and the P92T10 wires were installed in close proximity on the LH No. 1 subpanel feeder circuit breaker, and they extended into an area within the pedestal where there is a large amount of wiring compressed into a small area. It is likely that the unidentified 10-gauge wire, which was also arc damaged, was positioned in that same area.

The four wires showing arc damage were submitted for metallurgical examination to determine the internal and external composition of the arc sites and globules that were attached to the wires. The wires were examined in a scanning electron microscope (SEM) equipped with an energy dispersive spectrometer (EDS). SEM examinations were conducted using the back scattered electron (BSE) mode, which provides atomic number contrast. Alloys and elements derived from the SEM analysis, for the most part, were consistent with products that would result from the arcing of materials that were present within the pedestal wiring. Samples of lead, tin, antimony, and aluminum were evident in some of the analysed globules and arc sites. This would suggest that tin-coated copper wire had arced and melted. The presence of lead and tin may also have resulted from the melting of solder at or adjacent to the arc site. The presence of antimony might have resulted from the melting of flame retardant polymers in wiring insulation, melting of solder containing antimony, and/or arc involved contact with objects containing antimony. The presence of aluminum indicated that an aluminum object came into contact with the wiring during the arc event. Specific sources for the elements found in the arc sites and melt bundles could not be determined due to the post-crash fire.

Wire Inspection and Maintenance

Aircraft records indicated that the aircraft was maintained and inspected in accordance with existing requirements and approved procedures. Visual inspections of the pedestal area were conducted in accordance with the normal phase inspection process. The Phase 3 inspection, incorporating inspection of electrical wiring and equipment in the pilot's compartment, was completed one month and 21 days prior to the occurrence. The most recent inspection (Phase 4) had been completed four days prior to the occurrence.

Aging Aircraft Wiring

As aircraft age, electrical smoke and fire events have become more frequent. These events have involved aircraft ranging from large transport aircraft to those flown by general aviation. In June of 1998, the United States (U.S.) Air Transport Association (ATA) formed the Aging Systems Task Force (ASTF) to review the effectiveness of maintenance on electrical interconnect systems and to assess the condition of these systems on aircraft whose type certificates were older than 20 years. The task force was later re-chartered by the Aging Transport System Rulemaking Advisory Committee (ATSRAC) and tasked with providing recommendations to the U.S. Federal Aviation Administration (FAA). Inspection and testing was accomplished on eight models and nearly 100 airline transport category aircraft. A report was completed and conclusions and recommendations were presented to the FAA. As a result of this review, several detrimental conditions affecting aircraft wiring were identified. Most could be remedied by detailed visual inspection and appropriate maintenance action. However, it was noted that some conditions, such as progressive deterioration within electrical bundles, may not be readily identified by visual inspection. Cracked insulation, fretting wear between adjacent wires, and the initial phases of heat damage due to arcing may go undetected.

Horizontal Stabilizer Trim-In-Motion System

The aircraft was equipped with a system to produce beeps during trimming. During the playback of the cockpit voice recorder (CVR), it was noted that there were no trim beeps to indicate that the horizontal stabilizer trim was being activated even though the captain was trimming during the turn. The wiring to the horizontal stabilizer trim position indicator is contained within the electrical wiring bundle that arced.

Post-crash investigation revealed that the horizontal stabilizer trim actuator had been displaced during the occurrence and the rod that transfers actuator movement to the trim-in-motion actuator arm had failed below the upper rod end. Inspection of the fracture face indicated that the failure was overload in nature with characteristics that were consistent with the direction of displacement of the trim actuator. Post-crash fire damage precluded testing of the trim-in-motion system. Measurement of the trim actuator extension indicated that the horizontal stabilizer was in a normal operating range and consistent with the operation of the aircraft at the time of the accident.

Cockpit Voice Recorder

The aircraft was equipped with a Universal CVR120 CVR. The unit was removed from the aircraft and sent to the TSB Laboratory for analysis. Recorded information was retrieved; however, the hot-mic [7] recording function had not recorded the conversation between the pilots. The cockpit area microphone (CAM) and the transmit channels functioned normally.

Eight months prior to the occurrence, the CVR had been functionally tested and certified as serviceable. It was reported that at the time the unit was certified, intercom communication between the pilots may have been misinterpreted to be hot-mic recording. Because the hot-mics were not being recorded, the only conversation between the pilots that was recorded was on the CAM channel. Much of that conversation was drowned out by the sounds of the engines and propellers, making the conversations difficult to hear. However, it was possible to identify application of power for takeoff, sounds of landing gear extension and retraction, and some comments made by the crew. The CVR information was useful in determining the timing of events from the takeoff to the crash.

In the medevac configuration, the aircraft carried fewer than six passengers. As such, the *Canadian Aviation Regulations* do not require the aircraft to be equipped with a CVR. The CVR was installed as an after-market item and was not part of the aircraft manufacturer's original type certificate. The Province of Manitoba does not require medevac aircraft be equipped with a cockpit voice recorder.

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[7] Pilot headset microphones that allow for continuous recording of voice communication between flight crews.

Analysis

Pedestal Electrical System

The aircraft electrical distribution system functioned as designed. When an arcing failure isolated power from one end of the No. 1 (dual-fed) subpanel bus, the bus continued to be fed electrical power from the No. 2 subpanel feeder system. The No. 1 subpanel bus continued to supply power to the aircraft systems and components on that bus. Because of this redundancy, there were no warnings or indication in the cockpit. Their absence precludes useful input into pilot decision making.

Electrical Fire

The flames in the cockpit were momentary and consistent with an electrical arc and flash event. The level of smoke in the cockpit did not worsen and the flame subsided, indicating that the source event was over, the circuit breaker had popped, or the separation of the wires due to arcing stopped the current flow.

Routine visual inspections, conducted in accordance with the manufacturer's inspection timeframes, did not reveal indications of electrical problems. The occurrence aircraft, manufactured in 1976, was 32 years old. The detrimental effects of aging on the wires involved may have been a factor in this electrical arc event.

Effects of Flight Crew Training and Reaction

Without the flight simulator training, crews did not have an opportunity to train realistically for emergencies, such as an in-flight fire at low altitude immediately after takeoff. The operator conducted its training in-flight and its pilots were trained to climb to a safe altitude to conduct other emergency drills.

In the event of an in-flight electrical fire, the Beechcraft A100 manual directs crews to turn the master switch (gang bar) off and an accompanying warning advises that electrically driven flight instruments will become inoperative. Similarly, the operator's SOP also calls for the master switch to be turned off; however, there is a caution to only do so in daylight conditions. Neither manual provides guidance on how crews should manoeuvre the aircraft in darkness without electrical power. Removing electrical power from the captain's flight instruments in dark or IMC conditions requires transfer of aircraft control to the first officer.

The captain continued to fly the aircraft and the electrical system was not turned off. Transferring control or merely climbing straight ahead at this phase of flight in darkness would have been challenging, but it would have allowed a safe altitude to be achieved and the opportunity to accurately assess the severity of the fire (which by that point would have gone out).

Attempting a turn visually while in darkness without adequate visual cues allowed the bank angle to increase. This resulted in a loss of control at an altitude from which a recovery was not possible.

Fire Extinguisher Availability

The original configuration for the aircraft was with a fire extinguisher under each pilot seat. Section 523.851 of the *Canadian Aviation Regulations* requires one fire extinguisher in the cockpit and one in the cabin. The occurrence aircraft was equipped with a fire extinguisher under the captain's seat and one on the cabin side of the dividing wall between the captain and the cabin. The first officer's access to either of these fire extinguishers is hampered in the event of a fire in the cockpit pedestal. The captain would have had to transfer control of the aircraft to the first officer to access the fire extinguisher beneath his seat. If the fire in the pedestal had flourished, the first officer would not have had access to either of the fire extinguishers without leaning or climbing over the burning pedestal. In this case, the fire was momentary in nature and neither pilot was required to use the fire extinguisher to put it out.

Oxygen Mask and Goggles

The smoke and fumes that developed were not sufficient to cause a significant reduction in visibility and neither pilot had difficulty breathing. Therefore, neither pilot elected to don the oxygen masks as directed in the emergency procedures for an electrical fire. Although the mask and goggles met regulatory requirements, the process of donning requires transferring control of the aircraft, retrieving the mask from the back of the seat, taking it out of the plastic protective container, pulling on the oxygen supply, plugging the supply tube into the appropriate outlet, and securing the mask in place. Use of the oxygen mask and goggles would have been time consuming at a critical stage in the flight and may have influenced the captain's decision to not initiate the Electric Smoke or Fire Checklist.

The following TSB Laboratory reports were completed:

LP 029/2009 – Wiring Analysis

LP 165/2008 – ELT Analysis

These reports are available from the Transportation Safety Board upon request.

Findings as to Causes and Contributing Factors

1. An electrical short circuit in the cockpit pedestal area produced flames and smoke, which induced the crew to take emergency action.

2. The detrimental effects of aging on the wires involved may have been a factor in this electrical arc event.

3. The crew elected to return to the airport at low level in an environment with inadequate visual references. As a result, control of the aircraft was lost at an altitude from which a recovery was not possible.

Findings as to Risk

1. The actions specified in the standard operating procedures (SOP) do not include procedures for an electrical fire encountered at low altitude at night, which could lead to a loss of control.

2. Visual inspection procedures in accordance with normal phase inspection requirements may be inadequate to detect defects progressing within wiring bundles, increasing the risk of electrical fires.

3. In the event of an in-flight cockpit pedestal fire, the first officer does not have ready access to available fire extinguishers, reducing the likelihood of successfully fighting a fire of this nature.

4. Sealed in plastic containers and stored behind each pilot seat, the oxygen masks and goggles are time consuming to access and cumbersome to apply and activate. This could increase the probability of injury or incapacitation through extended exposure to smoke or fumes, or could deter crews from using them, especially during periods of high cockpit workload.

Other Finding

1. A failure of the hot-mic recording function of the cockpit voice recorder (CVR) had gone undetected and information that would have been helpful to the investigation was not available.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 29 September 2009.

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