First Flight Anomalies of Recent First Article Manned and UAV Aircraft

The purpose of this paper is to offer a review of past anomalies that have occurred during flight test first flights of recent manned aircraft and unmanned air vehicles (UAV). Such a review should allow for future flight test teams to avoid similar anomalies during test planning and build up to their respective flight test first flights. The specific aircraft involved have been purposely kept vague with emphasis applied to the specific anomaly.

Foreign Object Damage (FOD).

During the taxi tests prior to first flight of a large bomber aircraft, a system heat exchanger began to overheat. The heat exchanger was designed to flow fuel to carry heat away from other systems. Post taxi inspection showed the heat exchanger flow of fuel was being restricted due to buildup of lint in the filter system. Subsequent inspection found that the source of the foreign object lint was from special coveralls that were worn by manufacturing personnel while working inside the fuel tanks during final fuel tank manufacturing and inspection. The short term solution, for aircraft already built, were to do a series of taxi maneuvers to slosh the fuel in the tanks followed by fuel filter inspection. This procedure was repeated until no lint was detected within the fuel filters. Long term solution was to replace the manufacturing personnel coveralls with a material that would not cause foreign object material within the fuel tanks.

Following a successful and uneventful first flight of a home built amphibian single engine aircraft, the second flight resulted in engine failure during climb out causing a fatal aircraft crash. Post accident inspection showed excessive manufacturing debris in the engine feed line fuel filter causing restriction of fuel flow to the engine. The fuel filter had not been inspected for debris following the first flight.

Following successful airborne launch of a tactical cruise missile, the telemetry indications in the control room were that the missile was functioning normal with full power being applied to allow for missile acceleration. However, subsequent control room indications from telemetry within the missile were that the missile Mach number was not accelerating. A call from the chase aircraft pilot indicated that the missile was actually accelerating to higher than planned Mach number. Immediately after the chase call, the missile began to violently pitch oscillate. The UAV operator deployed the emergency parachute and the missile was successfully recovered. Post accident analysis showed that immediately following airborne launch and subsequent short term zero G flight, manufacturing debris had drifted up and shorted out the electronic air data transducers. Thus, the last input into the vehicle management engine control computer was the post-launch Mach number at the time of transducer failure. Acting on this last known Mach number value, the engine control computer continued to apply full power to achieve vehicle acceleration. With the flight control gains operating at the false low Mach number value, and with the actual vehicle accelerating to a high Mach number, the vehicle over-reacted in pitch attitude causing the onset of violent pitch oscillations. As a side note, range radar data did show the actual aircraft flight conditions, but this data was not incorporated for use by the test team.

Lesson Learned: Foreign Object Damage can occur in many forms and may be destructive, especially during the first flights of aircraft. Be conscious of fuel contamination issues caused by aircraft manufacturing debris. Also, be aware that manufacturing debris may cause insidious failure of electronic sensor inputs into computer control systems that may result in the flight control computers continuing to act on the last known input prior to the sensor failure. Also, be aware that failed vehicle sensor information, from within the aircraft system, may result in telemetry information into the control room displays that is not necessarily an accurate indication of actual aircraft system operation. Consideration should be given to use of independent range radar data to monitor test aircraft flight parameters in case of telemetry failure.

Telemetry

A prototype aircraft had under gone extensive aircraft systems checkout on the ground, prior to first flight, using a low wattage transmitter for sending of telemetry information to a control room environment. The test site restricted the use of high wattage transmitters during ground operations. However, a higher wattage transmitter was to be required for in-flight operations during the first flight. The conversion from low to high wattage transmitter was to be accomplished through use of the aircraft weight-on-wheels sensor. However, this was not adequately tested during ground systems checkout. Subsequently, during takeoff of the aircraft's first flight, the telemetry system converted to the high wattage transmitter which immediately shorted to the aircraft structure and failed. Consequently, this prototype aircraft's first flight was accomplished with no telemetry into a control room.

During takeoff of a UAV, the control room experienced a momentary loss of TM. The Abort Command was not sent because prior testing using a surrogate manned vehicle, replicating the UAV command and telemetry systems, had characterized the airspace and found the locations of possible frequency interference, including a portion of the planned takeoff environment. Continuing the UAV takeoff, the telemetry returned just like had been shown with the surrogate manned aircraft testing.

Lesson learned: Current aircraft flight test is often supported by extensive telemetry of aircraft systems monitoring into a control room environment. To insure proper operation, a through ground system checkout of the telemetry system is required including replication of the aircraft into an in-flight environment prior to the actual first flight. First flight test planning and test team training should incorporate test procedures to be used in the event of telemetry failure. Such procedures could incorporate use of information from chase and range radar data information.

Communications

During ground checkout of a bomber aircraft, prior to first flight, the instrumentation engineers needed an antenna to allow for transmitting of telemetry systems information to control room environments. The aircraft configuration had a communication system that automatically transferred control of aircrew communications through an antenna at the top of the aircraft for ground operations. So, the instrumentation engineers disconnected the aircrew communication capability through the lower antenna, and used that antenna for telemetry operations. However, upon first flight takeoff activation of the weight-on-wheels sensor, the aircraft communication system, by design, automatically transferred aircrew communication to the lower antenna, which had been disconnected by instrumentation engineers. Consequently, the test pilots lost communication with control agencies or chase pilots. The test aircraft had been configured to allow pilot cockpit communication to be heard by the control room through telemetry downlink, but no communication was available from control room to test pilots without going through external radio communications. After a period of in-flight researching the issue, the test pilots overrode the automatic antenna switching feature and manually commanded voice communication go through the upper antenna, which reestablished test pilot communications to external agencies.

For first flight of a fighter aircraft, a test team decision was made to takeoff in the opposite direction of normal airport traffic to allow for an extended lakebed runway overrun feature that was available for that runway. Also, two chase aircraft were to accomplish an airborne pickup on the test aircraft for this first flight. To minimize radio transmissions on the UHF tower control frequency, a test team decision had been made to communicate among the test pilot and chase pilots on a separate VHF radio mission frequency. A pilot, knowledgeable in the first flight takeoff plan, was deployed to the airport control tower to assist tower operators in understanding the intricacies of this first flight takeoff plan. For this first flight operation, all went according to plan with no issues.

Subsequent flights of this particular test aircraft used normal runway airport operations. However, a second prototype aircraft was to accomplish its first flight a couple months later. Since this second prototype aircraft used a different engine configuration, the test team decided to repeat the opposite direction takeoff method to allow for the extended runway capability in case of emergency abort. A pilot was **not** deployed to the control tower to assist tower operators for this first flight takeoff operation of this second prototype aircraft. Consequently, when the chase aircraft took off and turned out of traffic to accomplish their airborne pick up, the control tower did not realize that the test aircraft was still on the opposite direction runway awaiting takeoff when the chase aircraft returned. The tower operator turned attention to another aircraft in the traffic pattern awaiting clearance to do an approach to the normal runway. Tower cleared that aircraft for approach to the normal runway. As the airborne pickup of the test aircraft was accomplished, on VHF frequency, the test aircraft took off resulting in a near miss head-on with the opposite direction approaching aircraft. Subsequent aircraft maneuvering allowed for this incident to be a near miss and not an aircraft midair collision.

Lesson learned: Aircraft first flights require communication between test pilot and control room, test pilot to external control agencies, test pilot to chase aircraft pilots, and intercom among the aircrew on the test aircraft. This requires a thorough first flight communication plan to include comm lost procedures for lost communication from the test aircraft during the first flight. Also, for first flights, a knowledgeable pilot should be deployed to the control tower to insure the intricacies' of the first flight test plan are understood by the on-scene air traffic control operators. This pilot in the tower should have communication with the control room is be fully aware of test aircraft status during the taxi and throughout flight of the test aircraft.

Control room engineers and Chase pilots training

Two test site control rooms were to be used simultaneously during the first flight of a bomber aircraft. . The test sites were separated by approximately twenty miles. One of the control rooms was used for test control during taxi tests at that site. The plan was to have the second control room take over control at brake release during the planned first flight of the aircraft. This second control was located at the planned landing site at completion of the first flight. As the aircraft rolled for takeoff, the second control room, located twenty miles away, saw a telemetry dropout and called Abort over the test frequency. The chase pilot heard the call and called out “Did someone say abort?” in a questioning manner. The test aircraft was near rotation speed and continued the takeoff. Due to a test aircraft system configuration anomaly, the test aircrew lost radio communication after airborne at weight off wheels. The test aircraft aircrew had not heard the control room abort call, so the last words they heard were the chase pilots’ questioning abort call, then all external communication were lost for several minutes until test aircrew eventually restored external communication.

During airborne first flight test of a cruise missile UAV, it was the radio call from a chase pilot, that the missile was overrunning the planned flight condition Mach Number, that alerted the remote UAV operator that the UAV was flying much faster than the missile telemetry information in the control room. This aided the UAV operator to make a decision to terminate the test flight and allowed for post mission analysis of the issues involved.

Lessons Learned: During all flight tests, but especially during first flights, control room communication and chase pilot observations and communication are critical to providing accurate and timely information to the test aircrew and test team. All personnel involved must be thoroughly familiar with the test card maneuvers and immediately report any deviations from the planned maneuvers or configurations. All calls from the control room or the chase pilot should be clear and directive in nature. Consideration should be given to have a hand signal communication plan so that test aircrew and chase pilots can communicate through hand signals or other means of non-verbal communication in case of external communication failure.

In-flight System anomalies

During lift off for first flight of a new model of a fighter aircraft, the chase aircraft pilot noted that the nose gear had failed to center (cocked nose gear). The chase pilot immediately called out this anomaly and the test aircraft landing gear were left extended. The test pilot flew several mild yawing maneuvers but all failed to center the nose gear. The test pilot coordinated with the control room and all agreed for the test pilot to do a touch and go landing, keeping the nose gear in the air after main wheel touchdown, center the rudder pedals, then immediately takeoff after momentarily lowering the nose gear to the runway. After this maneuver, the chase pilot then confirmed the nose gear appeared to be properly centered and uneventful landing was completed.

First flight takeoff was normal for a new model aircraft, but after a few minutes of flying, both the test pilot and the control room noted that one of the two fuel feed tanks appeared to not be feeding correctly causing a fuel tank system disparity. After confirming that both control room telemetry and cockpit indications were both showing the same fuel tank quantity disparity, the control room simply informed the test pilot to go to Item 40 on the flight card. Item 40 was to return to base and land. In this manner, the flight test was terminated without any public awareness of any in-flight anomaly.

During first flight of a new bomber, the aircrew noted some discrepancy in some of the systems operations. However, there was no caution or warning indication of any system anomaly. First flight mission was terminated. Post mission analysis showed that there had been a failure of one of the electrical busses, but the caution light that would have alerted the crew to this failure got its electrical power source from the failed electrical buss. Thus, there was no indication of the electrical buss failure.

Following takeoff of a first flight of a new bomber aircraft, the landing gear handle was retracted but the landing gear failed to completely retract. An unsafe gear up indication was noted by the crew. The landing gear was extended and a normal gear down indication was observed. Upon landing the main landing gear tires blew out followed by tire fires, which were extinguished after the aircraft had stopped on the runway. Post flight analysis showed that the main landing gear system was designed to apply brakes after takeoff to allow for the landing gear wheels to be stopped before wheels entered the gear well. Because an anomaly in the gear retraction system failed for the landing gear system to complete its cycle and release the main gear brakes, the brakes remain applied even after the gear were fully extended. Subsequently when the landing gear touchdown occurred, the brakes were still applied by the system and the tires failed with runway contact, causing the tire fires.

Early in the first flight of a prototype fighter aircraft, one of the landing gear failed to retract. The gear handle was lowered and all landing gear extended normally. This contingency had been anticipated and an alternate gear down test mission card had been briefed. The alternate test mission was completed prior to uneventful landing.

Lessons Learned: Many new systems are being simultaneously tested for the first time during taxi and first flights of new aircraft. Each system needs to be understood by the test aircrew to the maximum extent possible. However, the system design specialists are also available, either in the control room or on call, to assist. If a system anomaly occurs, the test aircrew and chase pilot need to work closely with the control room system engineers, as a team, to come to a timely and viable solution of the effects of a system anomaly with the end result goal being a safe landing.

Lesson learned: Landing gear anomalies seem to be a prevalent issue for aircraft first flights. Gear retraction and extension test verification should be accomplished early in the mission profile to allow time to address gear anomalies. An alternate test card may be briefed to allow continued gear down flight testing.

High speed taxi/Inadvertent first flight

A new prototype fighter aircraft design incorporated use of a nose gear system from a legacy aircraft. During the high speed taxi tests buildup, the nose gear experienced a sudden shimmy onset. Post mission analysis showed that the nose gear system had been retrieved from long term storage, and the latest Tech Compliance Tech Order modifications had not been incorporated. Once incorporated, taxi tests continued with no further taxi test issues. .

A new bomber aircraft was accomplishing high speed taxi tests prior to first flight. After successfully reaching the planned max taxi speed, during the deceleration phase the aircraft began an uncommanded drift to the left. The pilot applied more right braking but the brake pedal angle in relation to the ejection seat made additional right braking difficult. The aircraft was eventually stopped at the end of the left side of the runway. The test pilot taxied onto the overrun to turn the aircraft around, but the aircraft became lodged in the soft asphalt of the overrun and was stopped. Post mission analysis revealed that an automatic flight control computer input had been incorporated to assist the pilot with crosswind taxi. But this input caused in inadvertent left drift of the aircraft during deceleration to taxi speed. The test pilots were unaware of this automatic crosswind taxi assist input from the flight control computer.

During a high speed taxi test of a new fighter aircraft prior to scheduled first flight, the test plan called for the test pilot to accelerate to near takeoff speed, apply some roll control inputs and raise the aircraft nose slightly to feel out the sensitivity of the flight control system. The flight control system was of a new design incorporating roll rate and pitch rate command from a fixed side control stick. During acceleration, as the test pilot applied the small roll control inputs with the wheels still on the ground, the roll control computer continued to apply a large movement of the roll surface in an attempt to achieve the pilot commanded roll rate input. As the nose was raised from a small pilot pitch input into the fixed stick, the aircraft achieved an airborne condition causing the aircraft abruptly achieve a right roll attitude and a left yawing condition. The pilot countered with a left roll input to level the wings but a roll attitude oscillation ensued with the aircraft slightly airborne and drifting to the edge of the runway. The test pilot quickly decided to select full power and continue the takeoff. Once airborne away from the ground, the pilot was able to stop the roll attitude oscillation and successfully complete a return to uneventful landing.

Lessons learned: Taxi tests leading to a first flight can be as hazardous as the actual first flight. Therefore, the taxi tests need to use the same test planning and test maneuver buildup and risk mitigation assessments as are applied to the actual first flight. For legacy components, need to verify that all tech order modifications have been incorporated. Consideration should be given to have a chase aircraft standing by ready to fly in case a high speed taxi test results in the test aircraft getting inadvertently airborne.

One person in charge

During early ground testing of systems checkout by flight test personnel, manufacturing personnel were still installing aircraft systems. This resulted in chaotic environment in the cockpit and around the aircraft. The solution was to have a single Test Control Engineer be assigned to organizing all work to be performed on the aircraft. Both manufacturing and test personnel had to submit their work order requirements, at meetings, ahead of time, to allow for the Test Control Engineer, on each shift, to plan out the work schedule.

During buildup ground taxi tests in preparation for first flight, numerous personnel, not directly involved in the testing, were in the control room. This resulted in extraneous conversations not directly related to the test execution. One person, A Test Director, was given authority and responsibility for insuring that only personnel required for monitoring each test were in the control room, and that communications were kept to only dialogue related the current test being conducted.

Lesson learned: At the start of aircraft or UAV ground test of an new aircraft system, one person has to be designated as having the authority and responsibility for coordinating the various activities related to work around the vehicle or in the control room to insure safe and efficient new vehicle preparation and subsequent testing.

Summary

In Summary, the purpose of this effort was to research past anomalies that have occurred associated with taxi tests and first flights of piloted and unmanned aircraft. Hopefully this information will be useful to test teams preparing for future aircraft first flights.

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