Airshow/Display Flight Guidance – considerations and recommended practices provided by the Flight Test Safety Committee

February 2020

Introduction

Flight test personnel are often tasked with performing airshow displays and demonstration flights to support recruiting, marketing and publicity efforts. An "airshow display" is just that; training or practice for a display, display qualification, or aerobatic display in waivered airspace during an airshow or other waivered event. A demonstration flight can be considered to be a flight flown with a customer or another pilot to "demonstrate" the capabilities of the aircraft or various systems. Demonstration flights do not normally take place in waivered airspace during an airshow and thus, airshow and display are the terms used in this document to distinguish between the difference in implied mission.

The majority of display flying is high risk, particularly routines that incorporate dynamic maneuvering at low altitude. The margin for error is nil or nearly so. Airshow sequences may include non-operationally representative maneuvers in developmental or operationally immature aircraft. Test pilot schools don't teach display flying as part of typical curricula. In total, test teams may be involved in the planning and execution of airshow flying without the advantage of education, training and experience. However, test organizations understand how to methodically plan and control operational risk. Display flight hazards are generally well-understood, and test teams should be acutely aware of [commonly] unique airspace constraints during planning. Despite test aircrew being recognized for conservative decision-making and precision, we have seen lapses during past events. The psychology is explainable. Introducing airshow flying into the test pilot repertoire can introduce a different mindset that can be particularly vulnerable to external pressures and machoism. Organizations considering display flights should consider accepting risk at the highest levels, understanding the financial, operational and brand reputation impacts of a tragedy. Accordingly, a disciplined plan that provides necessary training opportunities, routine refinements, and establishment of proficiency and currency baselines should be the standard approach for any display or airshow flight.

Background

In 1987, SETP formed an Airshow Safety Committee, with members Joe Jordan, Bruce Peterson, Frank Sanders, and Roy Martin, that was chartered to document lessons learned from SETP members who were experienced air demonstration pilots. The results of that committees work resulted in a 1989 paper, "Airshow Execution", by M.L. (Roy) Martin and Frank C. Sanders.

In the 1989 paper, Martin and Sanders discussed demonstration flying mishap statistics including the loss of nine society members as well as many other airmen. The risks to airshow pilots has not diminished. The following are a recent examples of airshow or airshow preparation mishaps with flight test pilots at the controls.

> June 19, 1996- Jeffery Crutchfield died while practicing airshow maneuvers in an F/A-18 near Bethalto, Illinois. The practice flight was to prepare for an upcoming airshow in the Czech Republic. A McDonnell Douglas official said the fighter had initiated a planned Reverse Half Cuban Eight maneuver but appeared to be flying lower than normal. Moments later, it crashed near the St. Louis Regional Airport. Crutchfield was a test pilot for St. Louis-based McDonnell Douglas Corp.
>
> June 1, 2008– Lake Bracciano Air Show (Italy)– Aircraft Commander Captain Filippo Fornassi was killed and co-pilot Captain Fabio Manzella was injured when their NH Industries NH90 tactical transport helicopter struck the water and sank into Lake Bracciano. The crash happened while the helicopter was diving after completing a Fieseler Maneuver (aka hammerhead or stall turn).

October 14, 2011– The fourth prototype Xian JH-7A, 814, of the China Flight Test Establishment of the People's Liberation Army Air Force crashed into a marsh near Wei Nan City, Pucheng in Shaanxi, China, while performing in an airshow associated with the China International General Aviation Convention. The aircraft came down about 1 mile (1.6 km.) from Pucheng Neifu Airport. One pilot ejected safely but the second crewman was killed.

September 24, 2017 – Capt. Gabriele Orlandi of the Italian Air Force died while performing at an air show in Terracina, Italy. The pilot was not able to recover from a loop and his plane, a Eurofighter Typhoon, crashed into the sea.

Each of these mishaps remind us airshow flying must be approached with due regard to unique hazards and residual risk. These kinds of flights can be done safely with careful planning and execution. The 1989 paper included details on planning, practicing, and performing airshows with comments from many experienced airshow pilots. It is well worth reading. **(Airshow Execution Paper)**

In 2019 the Flight Test Safety Committee began researching airshow flying recommended practices and references that could be shared on the FTSC website "**Recommended Practices**" page. These resources are intended to aid planning, workups and show execution considerations. Elements of 1989 document have been incorporated into the following text. Contemporary airshow planning information and "Wingnut's Rules" were provided by Mike Bryan, SETP Fellow and Boeing Flight Test Pilot Technical Fellow, to expand the concepts from the earlier SETP paper.

The following general considerations are provided:

Where possible, there should be two dedicated aircrews associated with an aviation display event that also plans to have airshow flight activities and "show and tell" aircraft/equipment demonstration. Plan for a primary (and possibly backup display aircrew) and a demonstration aircrew. The display aircrew should perform only those duties associated with the formal display event. Display aircrew should not be assigned to demonstration flight duties during practice, qualification, and actual display during the aviation event. The demonstration aircrew performs duties associated with demonstration flights not associated with the formal display event. The reason for this is clear. A test pilot performing both display pilot and demonstration pilot duties during an airshow or other wavered event cannot devote the time and attention/concentration necessary to perform both duties safely. Respective duties include, the mandatory scheduling events and participation in business development, public affairs, and mandatory social activities.

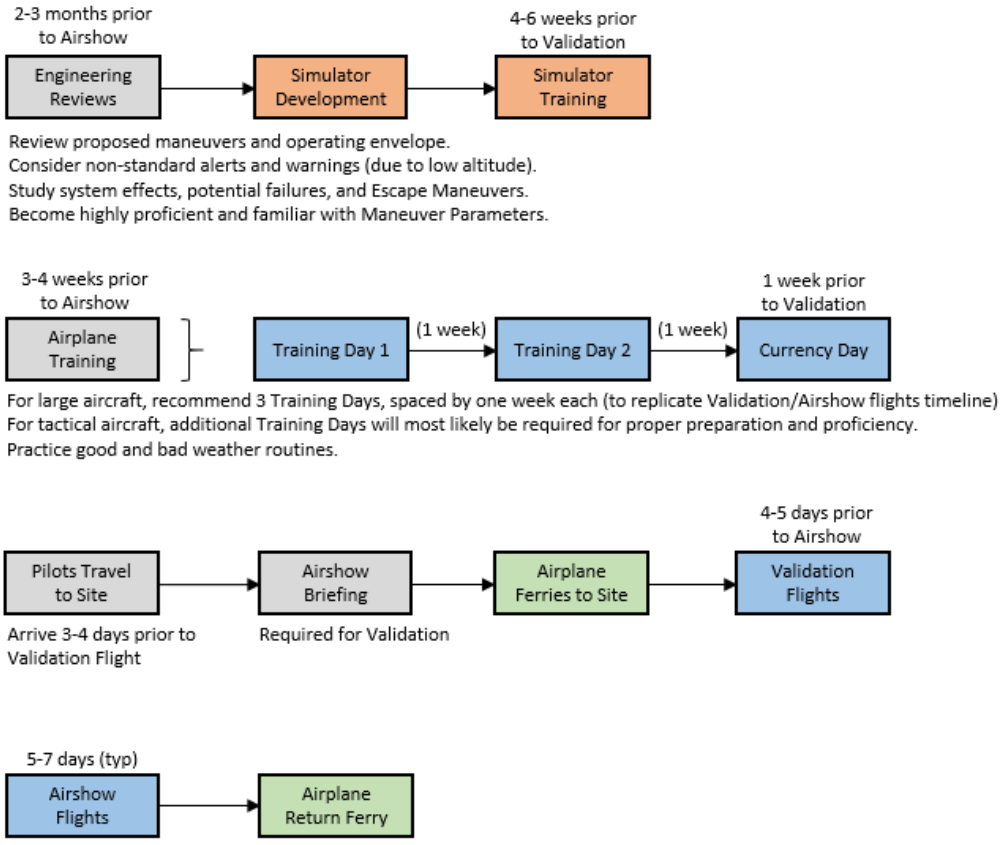
Experienced display pilots have had great success using accepted flight test protocols during display development, validation, practice and execution. Flight test engineers and flight sciences experts should be part of this development effort. Consideration should also be given to using an instrumented aircraft during development of a display routine and practice. In aircraft equipped with flight data recorders post-display review of data is highly recommended. Good data rarely lies. External and internal cameras (Go-Pro, Garmin, etc.) are particularly useful and can be mounted to record the pilot seat looking forward, record panel mounted instruments and the tail looking forward. Mounting schemes deserve scrutiny to avoid unwanted missile hazards in the cockpit. They are also especially useful in the absence of instrumentation.

Initial Display Planning

Crew, including primary and backup should be carefully selected and identified as early as possible to enable effective planning and preparation. The assigned crew begins with gaining a detailed understanding what is going to be demonstrated at the display, the constraints affecting the performance, expected aircraft system effects and warnings at low altitude, and the timeline leading to the performance. Maneuvering hazards and all relevant potential malfunctions need to be identified, and a plan formulated for handling these non-normal/emergency conditions. Examples include flap malfunctions, flight control mode reversions, unexpected IMC, takeoff aborts, and engine failures (to name just a few). An incremental

timeline needs to be established to allow for proper flight simulator training (if available), build-up and training profile flights in a representative aircraft, and currency profiles just prior to departing for the display site. This approach will require proper management support, funding, and aircraft availability (both for training and the actual airshow). It may require many weeks of preparation, planning, and training to accomplish.

Sample Timeline (International Airshow)



Understanding the airshow or demonstration guidelines:

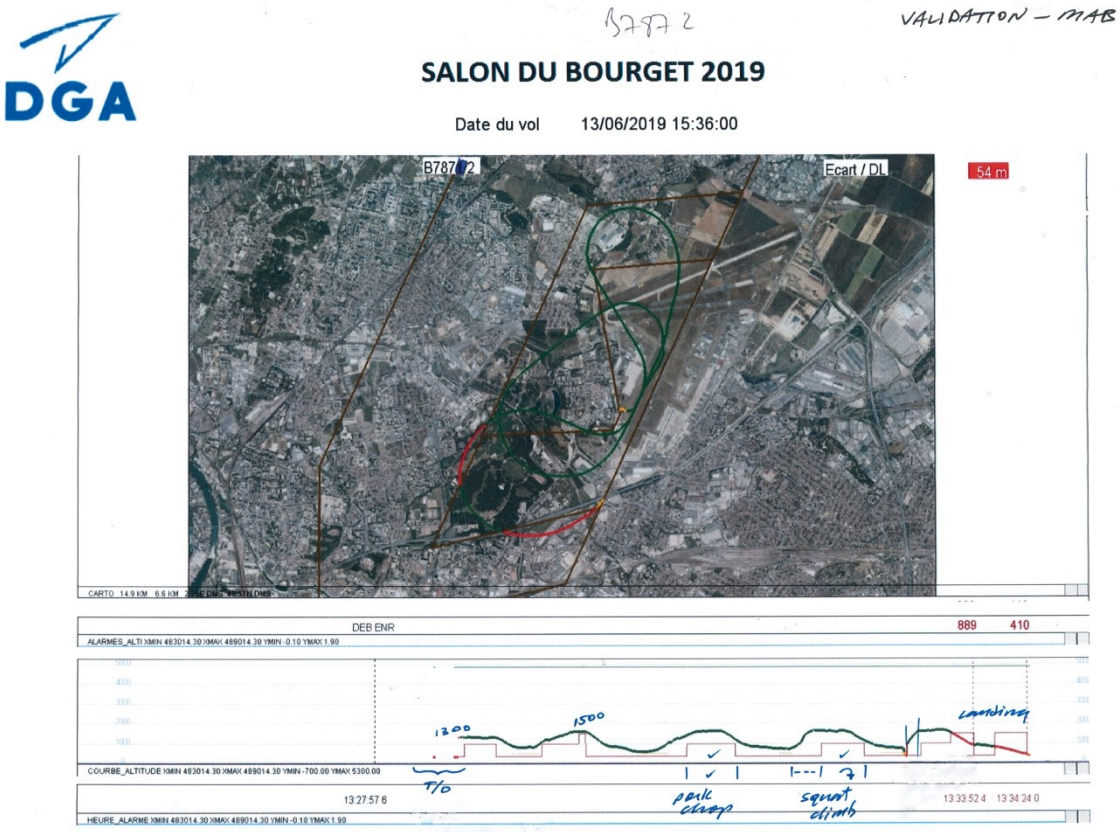
- Establish rapport with show "air boss" or liaison that can provide discreet details regarding peculiarities of the airshow including logistics, staging, airspace, timing, and weather.
- Talk to prior participants, particularly those that operate the same category of aircraft, for insider information.
- Understand show rules and due dates for participant applications and approvals.
- Understand airspace dimensions and constraints. It is not uncommon to have radar tracking systems employed at airshow events that monitor both vertical and lateral constraints for committee debriefings.
- Know the duration of the performance from takeoff to touchdown (or runway clearing time, as defined in the airshow regulations). This may affect or alter your planned profile.
- Know the show weather criteria for both high and low weather routines (as applicable to your aircraft).

Detailed Planning Items

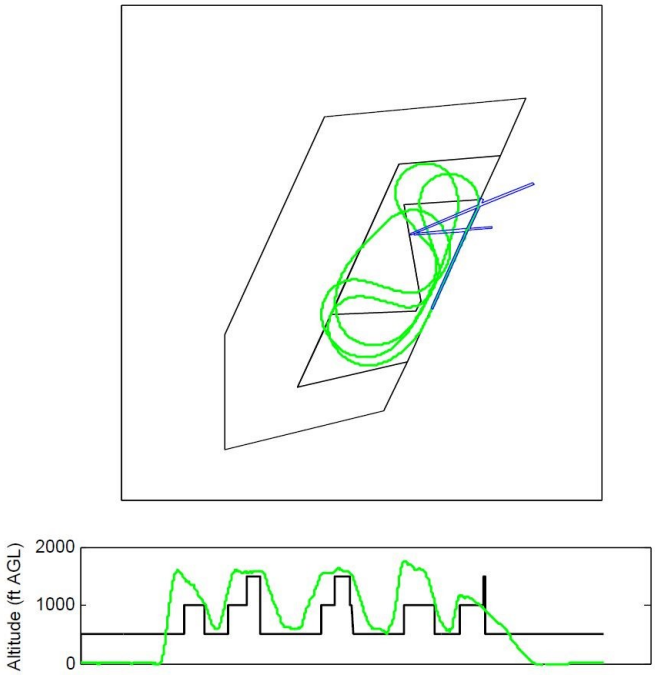
- Make an initial timeline including practice flights, transits, and demonstration flights. See the sample provide by Mike Bryan above.
- Do initial concept planning for what can be demonstrated in allotted time
    - Know the capabilities and limitations of the demonstration aircraft, including anticipated integrated system effects (i.e.: hydraulics, flight controls, electrical, landing gear, etc.)
    - Know the performance and handling qualities
    - Make a proposed sequence for further refinement
    - Make Initial risk assessments
    - Determine and provide for flight deck audio and visual recording requirements
    - Develop show airspace mockup or overlay for your practice field. It should be checked that the profile is compatible with the specific airshow limitations.
- Complete detailed individual maneuver planning to include expected parameters (airspeed, heading, altitude, bank angle, Nz, and airspace limitations). Include fully developed risk assessment and mitigations for each maneuver. Wind direction is an important issue as depending on aircraft type, the profile may need to be modified.
- Accomplish detailed initial maneuver sequence planning to include timing and transitions between maneuvers to remain in show airspace. Plan alternative direction runway contingency plans.
- Develop knock it off and maneuver escape plans.
- Determine flight deck configuration (pulled CB's, warning systems disabled, etc.). Make a kneeboard card. If possible, somebody should be in charge to monitor disabled systems: Flight Tests Engineer or Telemetry.
- Write a specifically tailored airshow checklist.
- Determine go/no-go airplane degradation (DDG/MMEL) considerations. Probably too complex and time consuming with a very long MMEL. Should be considered for key systems. In case of doubt, cancel the show.
- Develop crew rules applicable during practices and the actual show or demonstration (See Wingnuts Rules as an example on page 5.

Airshow Preparation and Training (Simulator and Aircraft)

- Use Simulators to practice to the maximum extent possible, practice unexpected non-normals and maneuver escapes. Simulator training also solidifies the cadence, timing, and parameter development checkpoints.
- Use the airshow checklist during practices
- Refine CRM with internal crew (as appropriate) and ground coordinator
- Airshow Practice sessions should use simulated boundaries and constraints emulating actual airshow airspace and constraints. Use engineering tools if available, such as Google Earth imagery of the airshow site during flight simulator training to assess lateral and vertical constraints, and flight profile compliance with those boundaries. Note that the simulator may not accurately replicate display centering. See Bryan's actual trajectorie from the Paris Airshow below.
- Study all takeoff and landing scenarios (gross weight, airspeeds, configurations, winds, malfunctions (make a checklist table for quick reference)
- Know when and how to abort a maneuver. Abort should be practiced. When you are not within a maneuver entry gate, a level pass and maneuvering return to the entry gate is always acceptable. Few people on the ground ever notice.
- Show Abort pre-plan. Whenever a display pilot does not understand something, or becomes distracted; terminate the display, call termination to the controlling agency, land and return to parking. Fly the next day.
- Practice maneuver escapes.
- Post Practice Debriefs should use a debriefing checklist to discuss individual maneuvers, timing, crew performance etc. Arrange and include post-flight debrief from a qualified ground observer.



Actual Trajectorie from the Paris Airshow (where they track you laterally and vertically).



How we approach that same measurement method through our own engineering tools (whether in the simulator or airplane).

Transit to the show or demonstration

Planning items include:

- Route planning, Special Airworthiness Certificate and Limitations (FAA), international overflight authorizations, travel plans.
- Build in crew rest and time zone accommodation. Consider pre-travel via commercial air to international sites to allow for adequate rest on arrival and risk mitigation for "last minute" airshow aircraft arrival due to unexpected delays. We recommend a four day minimum arrival time if the display pilot has not attended the airshow previously. If that is not possible, a Blue Angel or Thunderbird style advance team (can be one pilot) should be considered to validate accommodations, transport, critical event times, and infrastructure (e.g. briefing locations, parking, badging and access, schedules and meetings, etc.).
- On site Health and Welfare of the display aircrew. While subject deserves greater emphasis the following Specific planning items are included as start:
    - Display crew should have a team car and driver with appropriate flight line access credentials.
    - Display crew should have access near the aircraft to a quiet, climate controlled, phone and internet connected place to rest, mentally and physically prepare, brief, de-brief, and wait.
    - Display crew should have access to water and food near the aircraft -not the chalet or nearest food stand.
    - Display crew participation in any event or task not directly related to the display should be strictly limited and purely voluntary. This includes evening events that might potentially erode mandatory crew rest periods.
    - A personal IM SAFE checklist is beneficial should written.
        - I'M SAFE Checklist -Illness: Do I have any symptom? Medication: Have I been taking prescription or over-the-counter drugs?
        - Stress: Am I under psychological pressure from the job? Am I worried about financial matters, health problems, or family discord?
        - Alcohol: Have I been drinking within 8 hours?
        - Fatigue: Am I tired and not adequately rested? Emotion: Am I emotionally upset?

Show or demonstration site practice or validation flights, show day demonstration flights

- At major airshow events, a planned formal briefing with the airshow committee is required prior to mandatory validation flights.
- Daily airshow participant briefings for each day are also mandatory at major events
- Understand show day ground operations and expected timeline for all participants. Share with aircraft support team
- Run the I'M SAFE Checklist
- Additional crew briefings should include weather updates, runway direction and profile change options, sequence review, maneuver aborts, diverts, inadvertent IMC, etc.
- Brief Display Abort criteria.
- Debrief, document lessons learned and changes/updates to the plan going forward. Review video and/or instrumentation as needed.

The following "Wingnut's Rules" for Flying in Airshows was provided by Mike Bryan, Boeing Seattle Flight Operation's senior airshow and demonstration pilot to aid the non-full time display pilot safely fly a display routine.

1. Practice, practice, practice
2. Know your routine cold, so it becomes second nature under pressure – see Rule #1
3. Fly each maneuver to hit the "trained parameters" (airspeed, heading, altitude, bank angle, Nz)
4. The last thing I say to myself before takeoff is "hit the numbers" (fly your routine)

5. The perfect routine is when all trained parameters are hit perfectly - *not* by flying slower, faster, tighter, or lower. Minor adaptations are sometimes necessary such as bank angle and speed to cope with the wind and maintain centerpoint positioning.
6. You will *never* fly a perfect routine but that should not preclude you from trying (humility)
7. It's all about the weather - flying on a calm, sunny day is easy
8. Train for unexpected non-normals - have actions pre-defined
9. Standard "Read and Do" checklists aren't necessarily suitable to this arena – see Rule #8
10. Have an airshow checklist - train with the checklist - fly to the checklist
11. Ignore the crowd and media pressure - no one will remember your name or routine, unless you crash
12. Train in "3 Phases"
    a. Simulator – learn routine, checkpoints, and how parameter errors affect the profile
    b. Airplane – fly routine, understand differences between simulator and real life, update routine (if needed)
    c. Airplane – become proficient *and* current
13. Train in a representative airplane (gross weight, configuration(e.g. externals) and thrust)
14. Say out loud the next maneuver – this shows you are ahead of the airplane
15. If you realize you aren't saying the next checkpoint or maneuver, you *are* behind the airplane
16. Fly a currency flight one week before your validation flight – simulate the event as real
17. Allow 3 days (min) for crew rest on international travel, from arrival to validation flight
18. Don't take an unsafe airplane flying – sort out ahead of time what level of degraded airplane you *will* take flying
19. Know your diverts and Bingo fuel - have them on a handy checklist card, and have a plan
20. Know all takeoff and landing scenarios (gross weight, airspeeds, configurations, winds, malfunctions)
21. If you go IMC, the best course of action is most likely to continue your trained profile back to VMC
22. With warning systems muted or disabled, you *can* land gear up - Don't

For further reading we recommend:

- Zero Error Margin by des Barker (2003)
- Display Flying Handbook (5th European FTSW 2011)
- Airshow Accidents and Incidents 2017
- The Haddon-Cave Nimrod Report "A FAILURE of LEADERSHIP, CULTURE and PRIORITIES"