6th AIAA Aviation Technology, Integration and Operations Conference (ATIO)
25 - 27 September 2006, Wichita, Kansas

AIAA 2006-7832

Writing the Rules: An Inside Look at the AIAA Student Design/Build/Fly Competition

Christopher Bovais[1]
Naval Research Lab, Washington DC

David W. Levy[2]
Cessna Aircraft Company, Wichita, KS

Gregory Page[3]
ITT Advanced Engineering Sciences, Alexandria, VA

Stan Powell[4]
Manchester, TN

Michael Selig[5]
Univ. of Illinois at Urbana-Champaign, Urbana, Ill

and

Tom Zickuhr[6]
Cessna Aircraft Company, Wichita, KS

The Cessna/ONR Student Design/Build/Fly contest has recently completed its 10th year. The competition was founded as a "hands on" student experience to enhance their knowledge and ability to work in an industry environment after graduation. The vehicle for this experience is to design, build, and fly an electric R/C airplane to achieve a specified objective (range, payload, speed, etc). The winner is determined by the best combination of written report and flight performance, the latter determined at the competition flyoff. The initial DBF proposal was a "grass roots" effort - engineer driven by members of the AIAA Technical Committees - and it has kept this flavor throughout its history. This nature has been one of the keys to the success of the contest. Also key was the desire to keep the competition fresh, by continually challenging the students with new design objectives every year. This also requires a fresh look by the organizing committee at writing the rules, with continued attempts to learn from the previous years' experience. As always, however, the law of unintended consequences prevails, and new lessons await the students and the organizers together each year. As the Design/Build/Fly competition moves forward into its next decade, we anticipate many surprises, hopefully most of them good ones.

I. The Beginning

The Cessna/ONR Student Design/Build/Fly competition has completed its 10th year and has proven to be a very successful student outreach program of the AIAA. At this anniversary it was felt it would be beneficial to document the development and goals of the competition so that as new members enter the contest management process they will have a better understanding of where we have been and may maintain a clear vision of where they are going. While "Writing the Rules" is the fun part of the contest organization, it takes a lot more to keep the contest going and growing into the future.

[1] Aerospace Engineer, AIAA Senior Member
[2] Engineer Specialist, Sr., Aerodynamics Group, AIAA Associate Fellow
[3] Senior Staff Engineer, AIAA Member
[4] AIAA Associate Fellow
[5] Associate Professor, Dept. of Aerospace Engineering, AIAA Senior Member
[6] Engineer Specialist, Sr., Aerodynamics Group, AIAA Senior Member

The idea for a student "hands on" competition to enhance student educational opportunities had been discussed within some of the AIAA Technical Committees (TC) for several years prior to the inception of the DBF competition. It finally began to take form when the Aircraft Design TC and Applied Aerodynamics TC agreed to combine their efforts and make a formal proposal for a new student activity venue. The proposal was based on a design/build/fly format. The objective was to build an R/C electric powered airplane to carry a 5 lb payload. The aircraft must takeoff and clear a 10 foot obstacle in 300 feet and then fly as many laps of a 300 foot long circuit. Awards were based on the team's score for their written report multiplied by the number of laps completed.

The proposal was presented to the Student Activities Committee in 1995 and given a tentative approval, providing it would be staffed entirely by the sponsoring TC's and could find its own source of funding. Following some informal discussions the Flight Test TC elected to also help support and staff the contest, so the hunt for a sponsor and a place for an initial contest was on. Following the success of the first contest the Design Engineering TC offered to lend its support and assistance and became the fourth sponsoring TC.

II. Sponsors

A requirement of the Student Activities Committee was that the Design/Build/Fly competition be self supporting. To meet that goal many aerospace companies and organizations were contacted looking for a contest sponsor. A number of the companies already sponsored AIAA student paper contests and were unable to add another commitment. As time was growing short, discussions were being held with several potential sponsors in parallel. As luck would have it, two of the discussions yielded positive interest at the same time. Rather than lock out one sponsor both were asked if they would consider a joint sponsorship instead of the sole sponsorship they were initially presented, and the Cessna/ONR (Office of Naval Research) sponsorship arrangement was established. Following the initial contest the newly formed AIAA Foundation also joined in to provide financial support to the contest.

III. The Objectives

The goal for the contest was to provide students with an opportunity for hands-on engineering that was not available to many of the contest organizers when they attended university. The organizers had also noticed that many of the new graduates entering their companies had no practical experience in design to supplement their theoretical background. As their first assignment with a large aerospace company was typically a small part of the overall design, many of them worked for several years before having the opportunity to see the "big picture" view of how different design decisions interact.

With that in mind the first and foremost objective of the competition has been to become and to remain an educational tool, and not just be a "model airplane" contest.

IV. The First Two Years

With permission from the Student Activities Committee to hold an exploratory initial contest and with funding in line from Cessna and ONR one thing was still eluding our attempts to get the contest off the ground (literally), the search for a suitable flying site. Dick Bernstein, CEO of BAI Aerosystems, came to our rescue by agreeing to let the contest organizers "borrow" his private island airfield for the contest.

The rules for the first year (1996/97) were fairly simple: Carry a 7.5 pound payload for as many laps as possible, and the takeoff/landing distance requirement was 300 feet. The total score was simply computed as the written report score multiplied by the number of laps flown. A summary of the scoring formulas is presented in Table 1. To promote reasonable handling qualities, right and left hand 360 degree turns were required on the downwind leg (Figure 1), and the landing rollout had to be completed entirely within the 300 feet and remain on the runway. This was to be our first experience with the "law of unintended consequences" of the rules writing process. The rules stated that "… land within the original marked 300 ft zone", which was interpreted by contest officials that the landing had to be accomplished entirely on the runway. It turned out that several otherwise successful fights were given no score, even though they landed on the runway, but then ran off during the roll out. Most of the teams had not considered ground handling to be important.

The turnout for the first contest of 20 teams (Figure 2), while modest by current contest standards, was an overwhelming success to the contest organizers. Many of the new DBF Alumni who were present at the initial contest still speak fondly of their experiences at "the island". One special memory is the UAV "demonstration" by the professionals which crashed on launch. It provided a good lesson to the students: If you are afraid of making mistakes, come watch how the big boys do it.

The second year began the trend of alternating flyoff locations between Maryland and Wichita, Kansas, the locations of the two sponsoring companies. The flyoff was held at Westport Airport, commonly known as "Dead Cow International". The reputation for poor weather conditions in Kansas during springtime was reinforced, with high winds, cool temperatures and threatening rain. Despite the conditions, enough scoring flights were accomplished to award the top places. Some rules changes were made from the first contest, principally the addition of a "landing score" for teams that completed the entire landing rollout on the runway to a full stop. Initial touchdown on the runway was still required (no "bouncing" off was allowed). This contest also offered a tour of the Cessna production facilities, to promote further practical exposure for the students (and some faculty).

V. The Subsequent Years

In 1998/99, the third year returned to the east coast, this time to Webster field - a component of the Naval Flight Test Center at Patuxent Maryland. The facilities here were excellent, with large crossing runways and enclosed hangar space for the teams to prepare and repair the aircraft. The flyoff duration was also extended from one day to two.

The mission requirements were significantly changed. The steel payload was changed to water carried in removable polyethylene bottles. The goal of the mission was to carry as much total payload as possible over as many laps as possible. After each lap the aircraft must land, remove the existing payload, and then load new payload. The amount of payload carried per lap was left up to the teams. Changes to the aircraft limitations were also made. The battery pack weight limit was removed, and a nine foot wingspan limit was imposed. The takeoff distance requirement was reduced from 300 feet to 100 feet. A summary of mission changes is presented in Table 2.

These changes had several significant ramifications. The first, due to the payload change-out requirement, was very positive. By including more people in the student teams as part of the flight score, there was a definite increase in overall interest during the flyoff. Between each lap, there was the equivalent of a NASCAR pit stop, which was exciting to watch. The success of this change has led to including some type of payload change requirement every year since.

Another ramification, not so good this time, was the unintended contribution of pilot skill to the flight score. Although time was not directly a part of the flight score, there was an overall 10 minute limit to each mission, and the requirement to land between each lap required a competent pilot. There is a fundamental trade-off in the DBF contest where the desire to minimize pilot skill requirements has conflicted with the fundamental nature of airplane mission requirements. It is simply not possible to completely separate the two. To help teams that may not have access to good pilots in the student body, the use of a non-student pilot is allowed. There are always UAV pilots from ONR and elsewhere volunteering at the contest who are available to fly for the teams. Some DBF alumni consistently return each year using their own resources. However, teams which either have good student pilots or who can find "hired gun" pilots with time to practice with the airplane will always have an advantage.

The changes to the aircraft requirements tended to increase the overall size and cost of the airplanes. While there was no direct penalty for larger airplanes, there is a 55 pound weight limit due to Academy of Model Aeronautics rules (the DBF flyoff is an officially sanctioned AMA event). The cost of the aircraft and components continues to be a challenge for many teams. Some have found sponsors or held fundraisers while others have been very resourceful in adapting parts to their needs. This results in a range of aircraft, from sleek models made largely of carbon fiber composites to "Home Depot specials" (or the "Wing on a Stick") made partly from ladder parts (Figure 3). This gives new meaning to the phrase "commercial off the shelf".

The Fourth year (1999/2000) returned to Wichita and largely repeated the successful formula. Permission was granted to hold the contest at the Cessna East Field facility, including the use of enclosed hangar space. Warnings were posted on the website to consider the wind and weather. (It was claimed unofficially that the flyoff would only be cancelled if a tornado was actually spotted on the field.) High winds are a typical part of the contest when held in Wichita. The AMA rules call for the contest to be suspended if winds exceed 30 knots, but this has never happened. They have routinely been in the 25-27 knot range for part of the contest. But since the two day format has been used, there has always been a sufficient period when the weather is good. Flying has never been suspended due to wind, although a few hours here and there have been lost due to rain.

Changes were made to the mission and airplane requirements in order to keep the contest fresh and to reduce the advantage experienced teams may have compared to "new" teams. A battery pack weight limit was reinstated (five pounds) and the wingspan limit was reduced to seven feet. The mission alternated each lap between loaded "cargo" flights and empty "ferry" flights, thus keeping the ground crew busy. The performance and competitiveness of the teams had been improving, so the total flight score was modified to include the sum of the best three single scoring flights. By far the largest change for the year, however, was the inclusion of the Rated Aircraft Cost (RAC) model to the total scoring formula (Table 1):

Rated Aircraft Cost ($) = (A*MEW + B*REP + C*MFHR)/1000

Where:

A=	Manufacturers Empty Weight Multiplier=	$100 / lb.
B=	Rated Engine Power Multiplier=	$1 / watt
C=	Manufacturing Cost Multiplier=	$20 / hour
MEW=	Manufacturers Empty Weight =	Actual airframe weight, lb
REP=	Rated Engine Power=	# engines * 50A * 1.2 V/cell * # cells
MFHR=	Manufacturing Man Hours=	Sum of Work Breakdown Structure hours

The MEW does not include payload or batteries. The MFHR accounts for complexity due to components and systems such as control surfaces, engines, and systems. The purpose of the RAC is to encourage smaller, simpler solutions which accomplish the mission at reduced cost.

The use of the RAC continues to this day, however it provides another example of the law of unintended consequences. In subsequent years, the RAC became more and more complex as we tried to account for items such as span, chord, etc. This in turn required definitions for components that might not apply to unusual configurations. How do you measure wing root chord on a blended wing body? Is a winglet part of the wing or is it a vertical tail surface? What units are they measured in? This led to significant time spent in tech inspection determining and verifying the RAC score for each team. Finally, it led to an error in scoring that was not discovered until after the flyoff, resulting in a change in the third place winner. This experience led in the 2005/06 contest year to a drastic simplification to the RAC, defining it simply as the empty weight, including batteries. The inevitable slip toward complexity continues, however, as for the current 2006/07 contest the RAC has been expanded to include the wingspan.

After two years using water as the payload, the fifth year in 2000/01 at Webster Field we changed to a multi mission format with heavy payloads (steel) alternating with high volume payloads (tennis balls). The goal here is to push the teams into resolving contradictory requirements. As before, the payload was changed every lap. Maximum wingspan was increased to 10 feet, and the type of electric motor was restricted to brushed types only (in an effort to save costs for the teams). One of the goals of the multi-mission, multi-flight format was to promote robust designs which would be ready to fly again with minimal effort.

The students were up to the task, and the flight queue grew to be quite long (Figure 4). It was ruled that airplanes could not enter the flight queue until ready to go, and no work could be performed on the airplanes while in line. This led to difficulties and another lesson in the law of unintended consequences. The primary issue was consistent enforcement and, to a certain extent, fairness. Is hooking up a battery "working" on the airplane? If you could not even do that, then how could you make sure that batteries were well charged after a two hour wait in line? The principle of being ready to fly is a sound one, but issues with the flight queue have persisted. We have been a victim of our own success, and as the teams became more and more competitive, more have been ready to fly right away and wait times have grown to be quite long sometimes.

The flight initial queue on the second day of the contest was another concern generated by the growth of contest. Is the initial Sunday morning queue the same as the queue at the close of Saturday's flying? What about teams that weren't in the queue Saturday due to damage but want to fly early (and often) on Sunday? The organizers have left the resolution of those questions to the students and despite the competitive nature of the situation and accompanied the expected grumbling, the students, to their credit, have sorted out the situation. The organizing committee will take a more active role in managing the queue for the 2006/2007 contest. That will also make the enforcement of the intent of the rules easier and less subjective.

In 2001/02 at Cessna Field, the mission was redefined so that it was more closed ended. The mission had three defined segments: Position, Passenger (Softballs) delivery, and return. (The mission was modeled after a typical fractional share ownership flight.) To facilitate more flight attempts, the mission time was factored into the total flight score. This approach was used for several years, and it did help to reduce queue times somewhat. But it had another, undesirable effect: It promoted the importance of pilot skill. Since the time did not stop until the airplane was stopped on the runway, the better pilots learned how to get the airplane down quickly (still in one piece, of course) while lesser skilled pilots would waste valuable time, sometimes having to go-around.

In 2002/03, a new requirement was added: It must be possible to disassemble the aircraft so that it could fit into a 2x1x4 foot box. The time required to assemble the aircraft and make it airworthy was added to the flight mission time for the total flight score. This "packaging" requirement was in the spirit of many typical UAV missions. Both internal and external payloads were required. The external payloads were simulated sensor package (six by six by twelve inch box, five pounds) had to be remotely deployed. In the spirit of the 100th anniversary of powered flight, the takeoff distance was specified to be 120 feet, the distance of the first controlled powered flight by the Wright Brothers.

A special note is required to recognize the "extra" level of support from the AIAA foundation in the year following the 9/11 attack. The contest host site for that year was the Office of Naval Research, which would normally host the contest at Webster Field. With the increased security concerns following 9/11 we were rapidly approaching the contest date and could not be assured that we would have access to the Webster facilities on the contest date as security threat levels were then changing almost daily. The AIAA Foundation stepped forward and provided the facilities funding required to allow the contest to be held at the airfield at Ridgely, Maryland.

For the next year, 2003/04, a completely different type of mission was used. We switched back to a more "commercial" type of mission: a water bomber. The airplanes were required to carry four liters of water and had to dispense the water through a single orifice no larger than 0.5" diameter. No pumping or pressurization was allowed – only gravity forces could be used. The water had to be eliminated entirely during the downwind portion of the course, and early or late dumping was penalized. A total of eight liters had to be dumped, spread over two flights with the reloading included in the total flight time. The aircraft were still required to fit in a box, but this part was not timed. The goal here was to force the students to design for slow flight, thus driving the wing design. Or, so we thought. Here is a case where we got clearly outsmarted by the students, much to our (reluctant) delight. Several teams reviewed their hydrostatics and found that the drainage rate was related to the head height, and so they designed extendable tubes to increase the flow rate (Figure 6). Slow flight was no longer required, and flight times were reduced.

The next year, returning to Webster Field in 2004/05, a UAV type mission was used. Three types of tasks were required: Sensor Reposition, Maximum Utilization, and Re-Supply. The "sensors" were two 12" long pieces of 3" PVC pipe, which were required to be mounted both in internal and external positions. The external mounting was to be within 3" of the wing tip, and be remotely deployable. During the Sensor Reposition mission, the airplane was to fly a sequence of one lap with the sensors mounted, land, remotely deploy the sensors in two separate locations, then fly an empty lap, land, then remount the sensors and fly another lap. At the end of the mission, the aircraft had to be disassembled to fit in the box as part of the overall mission time. Many of the teams found that the hardest part of the mission was to taxi the aircraft after deploying one of the sensors with the significant lateral weight imbalance. Clearly, more testing would have been helpful to uncover this unforeseen element.

The tenth anniversary contest in 2005/2006 continued the multi-mission, multi-payload requirements. Payloads varied from two, two-liter bottles of water, 48 tennis balls, to a four by four by twelve inch wood block. A major change in the RAC formula was instituted, described above. Despite being in Wichita, the weather was excellent, and the readiness of the teams was the best ever. As mentioned above, the long queue times were a significant issue, and have prompted a revision in the procedures. We will find out how good of a job we did next year.

VI. Observations

It bears repeating that the primary objective of the DBF competition was to become and to remain an educational tool, and not just be a "model airplane" contest. To promote that goal, and described above, the founding premise of the contest was to change the design objective for each year to give each new team an opportunity to experience a complete design cycle from initial concept exploration, through initial and then detailed design, and finally to fabrication and flight testing to prove out their design decisions. These changes in missions from year to year are summarized in Table 2. This has been both the best and most difficult aspect of the competition over the years. As more years go by it has become increasingly difficult to come up with a new design goal that is challenging enough to tax the most experienced teams while still providing a fair footing for new teams to compete and "get on the board". One aspect that has proved to be helpful is having multiple design missions so that teams can choose which ones they are best able to design and compete for. The multi-mission aspect also deeply ingrains the requirement for design trades and compromises that are the real challenge in production aircraft design.

As the years have gone by, many schools have incorporated the DBF into their design curriculum, which we wholeheartedly support. The emphasis for different schools has ranged from the high end of using the contest as the primary project for capstone design contests, down to an extracurricular club activity with no credit, to bare acknowledgement that some of the students have entered the contest. The range of financial support is similar. The amount of emphasis has a direct impact on the amount of time the students spend on the contest, and to a large extent, how well they do. A continual challenge for the organizers has been to specify missions that still challenge the better teams but do not discourage the newcomers. The multi-mission format has helped here. We always have at least one mission that is relatively straightforward so that teams with lesser experience can "get on the board." However, there are always teams each year that work countless hours and travel untold miles to the flyoff but do not get a successful flight off. We can only hope that they learn from the experience. It appears that they do, as many will return the next year and do better.

The range of abilities of the different teams has promoted a degree of sportsmanship that has delighted us. Many more experienced teams have lent expertise, moral support, and sometimes hardware to less fortunate groups, helping them to learn and succeed. Other teams have crashed and then rebuilt the airplane to fly again with the help and donations from students (competitors) they had never met before. Over the years, as the contest has become more tightly competitive, some of this has dropped off. But the willingness of the teams to help others is still there and is still rewarding to the organizing committee.

Another key aspect of the competition has been to provide equal emphasis on the flight performance results and the design process documentation report. As a teaching tool the "how and why" are just as important as the final results. The ability to explain and to sell their designs will enable the students to prosper once they are working within industry. Many of the reports are simply excellent, with sections that show the students clearly understand what had to be done and then they do a good job of documenting it. The top reports for each year are published on the contest website: http://www.ae.uiuc.edu/aiaadbf. Others are quite lacking, unfortunately, with whole sections completely missing. Judging the reports has provided other lessons in the law of unintended consequences. Seemingly clear rules on the number of pages, font sizes, figure sizes, etc. have turned out to be more subject to interpretation than we would like. One special item of note is the requirement to get the reports in by a specific time. This also applies to the entry declaration by email. We consistently must deny entry or acceptance of a report merely because they are late. Students (and faculty) do not realize that a deadline is a deadline, especially when it is well publicized. To be fair, we must turn these reports down. We cannot accept one late report when fifty other teams have respected the deadline. Strict enforcement of the deadlines is also good preparation for the "real world" where deadlines are deadlines and are not negotiable.

Over the years, contest participation has risen steadily (Figures 6 and 7). It has progressed from the first two years of a relatively few teams and marginally performing entries, to approximately 500-600 attendees annually and very stiff competition. The sheer numbers of students, faculty, parents, and friends coming to the flyoff has presented logistical challenges to the organizers. As the number of competitive teams has increased it has come to the point where it is impossible for all teams to use all of their potential flight attempts, but no contest has ever been cut short to the point where all teams have not had a fair chance to fly. In 2003/04 in Wichita, Saturday morning was lost to rain, and the afternoon presented high winds. Not many chose to fly then, but several did and some crashed. Sunday presented fine weather, and in the afternoon many teams approached us saying we should limit the number of flight attempts by each team. We refused, citing the empty flight queue for most of the previous afternoon. One team, from Italy, did complete all five of their allotted attempts, scoring each time. Two were made in the high winds.

Another surprising aspect of the contest has been the international participation. Almost from the beginning, teams from Canada, Turkey, Italy, and Israel have participated, many for several years in a row. These teams obviously have put in a good bit of time, effort, and finances to travel all that way to the DBF flyoff, and we are honored that they choose to participate. Their reports have usually been very good, too, despite English not being their first language.

VII. The Organizers

The core operation of the Design/Build/Fly contest that many think about is the small group of TC members and past members that organize the contest and write the rules, but to reach and maintain the current level of success the contest relies on the support of many, many individuals. The flight-day operations enlist the help of about two dozen volunteers from the sponsoring TC's and the hosting sponsor organizations. To judge the written reports requires the time and effort offered by an additional 30-40 volunteers drawn exclusively from the sponsoring TC committees. Without the effort of all of these individuals the contest would not be possible.

The rules for each years contest are drafted by a small group (primarily, the authors) which has recently been officially chartered as the DBF Governing Committee. The Governing Committee is composed of past and present representatives of the four sponsoring technical committees. Creating the rules is an iterative process that begins during the previous years contest fly-off as we try to note what is working well and what in the contest structure could be improved. That is also the time when the organizing committee discusses what the students have taught us. During several months of e-mail traffic the outline for the next years contest rules begins to take shape and finally reaches a final consensus. The "consensus" rule is a key aspect of the operation of the committee and to date has proved to be the best method of melding many disparate ideas and personalities into a cohesive force carrying the contest forward. To provide more stability to the rules process we have established a formal rules release date of 15 August.

VIII. The Teams

The Design/Build/Fly competition is run for the students, and without their willingness to provide many, many hours of work would never have gotten a start. The contest has grown to include the participation of over 600 students each year. We the organizers are very grateful that they have a love for aircraft and are willing to spend their time in learning the intricacies of aircraft design.

IX. The Future

The 2004/05 contest was the first year that participation in operation of the contest from former DBF student participants was actively sought. The response from the former students was excellent and speaks well for the future of the competition as they will become the nucleus and future Governing Committee members to carry the contest into the future. We encourage all former contest participants to remain active in the AIAA as professional members and to apply for membership to the sponsoring Technical Committees to continue their participation in the DBF experience as part of those who are "Writing the Rules".

The 2005/06 contest was the last year in which the Office of Naval Research acted as co-sponsor. The authors wish to thank them for their generosity in funding and facilities. After careful consideration of several bids for sponsorship, Raytheon Missile Systems in Tucson, AZ, has been selected as the new co-sponsor. Cessna will continue their role as co-sponsor, including hosting the flyoff every other year. The 2006/2007 flyoff will be held in Tucson, AZ.

As the Design/Build/Fly competition moves forward into its next decade, we anticipate many more surprises, hopefully most of them good ones.

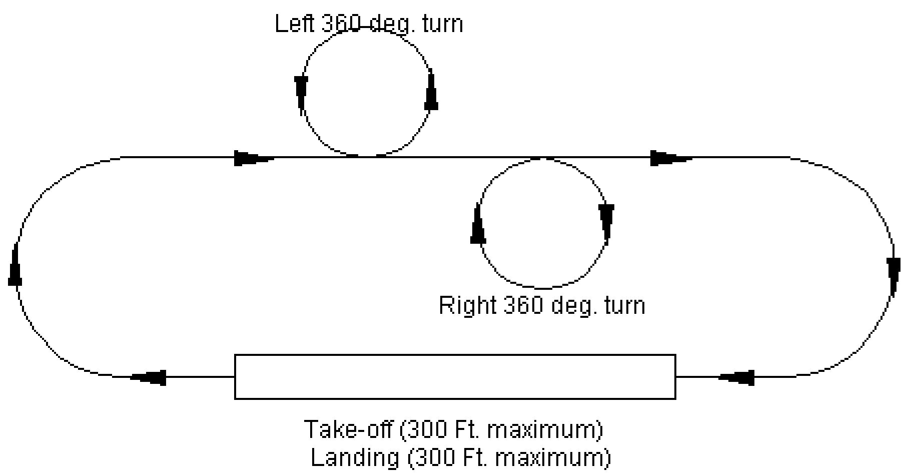

Figure 1. Flight Profile (After 1998, Only One 360 was Required).

Figure 2. DBF Inaugural Competition, Ragged Island, MD, 1996-97.

Figure 3. Large Range of Modeling Techniques at the Third Contest.

Figure 4. Wait Time in the 2000/01 Flight Ready Queue Sometimes Grew to be Quite Long.

Figure 5. Several Teams Applied Basic Hydrostatics to their Advantage in 2003/04.

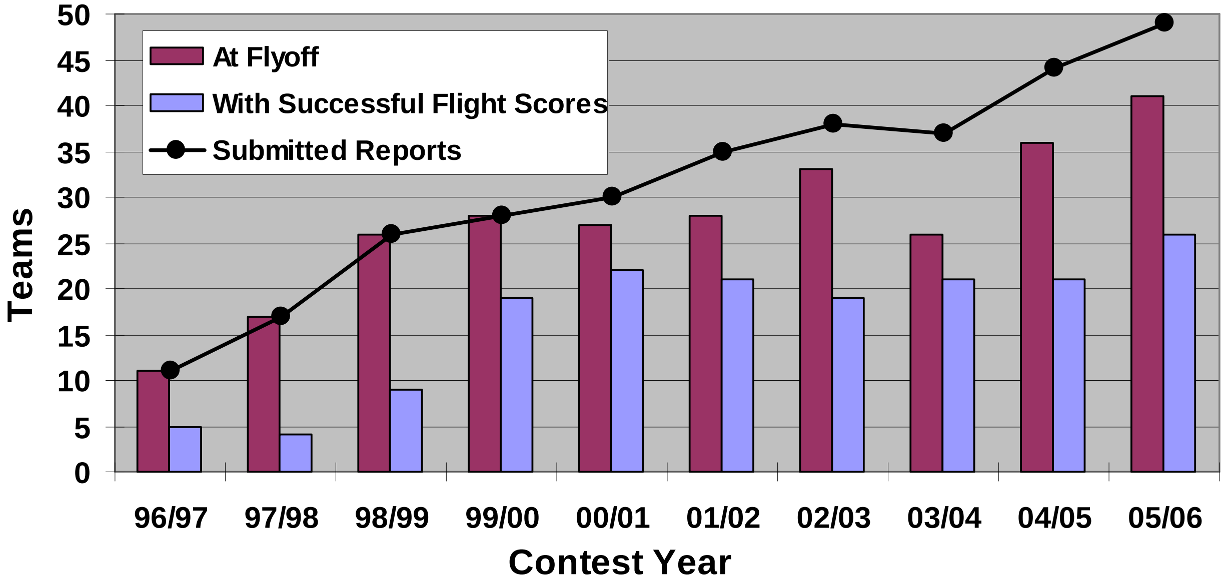

Figure 6. Contest Participation.

Figure 7. 2003/04 Flyoff in Wichita, KS.

Table 1. Scoring Formula Evolution

Year	**Scoring Formula**
1996/97	Written Report * Number of Laps
1997/98	Written Report * (Laps + Landing)
1998/99	Written Report * Total Weight Carried
1999/2000	$\frac{\text{Written Report}}{\text{Rated Aircraft Cost}} \sum_{i=1}^{3} (10 * \# \text{ bottles})$
2000/01	$\frac{\text{Written Report}}{\text{Rated Aircraft Cost}} \sum_{i=1}^{3} (\# \text{Heavy} + \# \text{Light}/5)$
2001/02	$\frac{\text{Written Report}}{\text{Rated Aircraft Cost}} \sum_{i=1}^{3} \frac{(\# \text{Laps} + \# \text{Balls})}{\text{Total Mission Time}}$
2002/03	$\frac{\text{Written Report}}{\text{Rated Aircraft Cost}} \sum_{i=1}^{2} \frac{\text{Difficulty Factor}^{*}}{(\text{Flight Time} + \text{Assembly Time})}$
2003/04	$\frac{\text{Written Report}}{\text{Rated Aircraft Cost}} \left[\frac{2}{\text{Time}_{\text{firefight}}} + \frac{1}{\text{Time}_{\text{ferry}}} \right]$
2004/05	$\frac{\text{Written Report}}{\text{Rated Aircraft Cost}} \left[2(12 - \text{Time})_{SR} + (\# \text{laps})_{MU} + 1.25(12 - \text{Time})_{RS} \right]^{\dagger}$
2005/06	$\frac{\text{Written Report}}{\text{Rated Aircraft Cost}} \left[\left(\frac{10 * \# \text{laps}}{\text{Load Time}} \right)_{CF} + \left(\frac{150}{\text{RAC}} \right)_{MR} + \left(1.25 \# \text{laps}^{2} \right)_{P} \right]^{\ddagger}$

* Difficulty Factors: Missile Decoy=2.0, Sensor Deployment=1.5, and Communications Repeater=1.0.
† Best two of three scores from the Sensor Reposition, Max Utilization, or Re-Supply Missions.
‡ Best two of three scores from the Cargo Flexibility, Minimum RAC, or Incremental Payload Missions.

Table 2. Year to Year Mission Change Summary.

Year	Payload	Battery Wt (lb)	Field Length (ft)	Mission/Restrictions
1996/97	Steel, 7.5 lb	2.5	300	Maximum number of Laps
1997/98	Steel, 7.5 lb	2.5	300	Added landing credit
1998/99	Water	none	100	Change payload each lap, 9 ft wingspan limit
1999/2000	Water	5.0	100	Multi-mission Cargo/ferry format, 7 ft wingspan limit, added RAC
2000/01	Steel / tennis balls	5.0	200	Multi-cargo format, 10 ft wingspan limit, RAC
2001/02	Softballs	5.0	200	Multi-mission Position/Passenger Delivery/Return, Timed mission, RAC
2002/03	6”x6”x12” Box, 5 lb	5.0	120*	A/C must disassemble to fit in box, multi-mission Decoy/ Deployment/ Repeater, timed mission, RAC
2003/04	Water	5.0	150	Multi-mission fire bomber/ferry, box disassembly, timed mission, RAC
2004/05	12”x3”dia PVC, 3lb	3.0	150	Multi-mission Sensor Reposition/ Max Utilization/ Re-supply, box disassembly, timed, RAC
2005/06	Variable**	3.0	100	Multi-mission Cargo Flexibility/ Minimum RAC/ Incremental Payload, box disassembly, timed, New RAC

*Distance selected to honor the 100th anniversary of powered flight
**12”x4”x4” 5lb wood block, 48 loose tennis balls, 2x2liter pop bottles