Camberline

Newsletter of the UIUC Low-Speed Airfoil Tests • University of Illinois at Urbana-Champaign • No. 4, Sept. 1996
Michael Selig • Christopher Lyon • Philippe Giguère • Cameron Ninham • Andy Broeren • Ashok Gopalarathnam

What's New

From Selig . . . More milestones and more plans. We have completed our second book of airfoil data and taken data for the third, and we are currently writing the third book and planning for the fourth with testing to start at the beginning of next year. Our accomplishments and plans to date include:

- Completed tests on over **80 model airplane airfoils** for R/C sailplanes, power planes, free-flight models and pylon racers. We have probably taken more airfoil wind-tunnel data than anyone since the landmark efforts of Wortmann and Althaus (Stuttgart) and before that the NACA.
- Published **two airfoil data books**: *"Summary of Low Speed Airfoil Data – Vol. 1"* by Selig, Guglielmo, Broeren, and Giguère (292 pages), and *"Summary of Low Speed Airfoil Data – Vol. 2"* by Selig, Lyon, Giguère, Ninham, and Guglielmo (251 pages). Under a special arrangement with SoarTech Publications (Herk Stokely) part of the proceeds will be used to continue the testing. Airfoil performance data disks are also available from SoarTech Publications. (See page 3)
- Developed a **World Wide Web homepage** for those with access to the internet. All the wind tunnel data and airfoil coordinates are freely available on the internet through a Web browser such as Netscape or Mosaic. Note that the data for *Vol. 2* is not yet on the Web but should be available soon. See `http://www.uiuc.edu/ph/www/m-selig`. The Web page includes an interactive airfoil design interface (PROFOIL) with a Web User's Guide. The page can be used to design airfoils for educational purposes (high school and college). (See page 8)
- It should be mentioned that the airfoils and resulting data have been placed in the public domain under the **GNU General Public License** that allows people to freely copy the data and distribute it to others. Also, the data can be included in commercial products (software and airplanes), but the vendor cannot place restrictions on the data under the General Public License.
- Many **model airplanes** have used the new airfoils designed and tested as part of this work. Performance improvements indicated in wind tunnel tests and have been confirmed by flight tests. More widespread use of the new airfoils and performance data is anticipated. This process is facilitated by model design and airfoil plotting software that makes use of the data.
- Added pitching moment measurement capability to the experimental setup. Pitching moment data will appear in the next airfoil data book (*Vol. 3*).
- Improved the measurement and data reduction techniques. (See page 4)
- Currently writing *"Summary of Low Speed Airfoil Data – Vol. 3"*, which should be available around January 1997. Airfoils to appear in this volume include the PT 40, Trainer 60, Avistar, Falcon, Ultra Sport 1000, Ultimate, S8036, S8037, DH4009, E472, S8052, ESA40, S6063, E231, SD7037, RG14, E387, Clark-Y, Göttingen 417a (curved flat plate), BW-3, and more! (See page 4)
- Planning for Test Series #4. We plan to focus on airfoils for **R/C soaring airfoils**, but as always there will be a mixture. Tests will begin around mid-January 1997. (See page 5)

This impressive list of what we have done so far and what we plan to do would never have happened without the generous support of many individuals, clubs, organizations and businesses. We'd like that to continue! If you would like to make a donation to the UIUC LSATs Program, it can be sent to:

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Please make checks payable to the "University of Illinois, AAE Dept." Also, include on the check "Selig – Wind Tunnel Testing/AAE Unrestricted Funds."

Table 1: The top 20 finishers at the 1996 AMA/LSF Nationals in Unlimited Thermal Soaring

Place	Name	Score	Sailplane	Airfoil	Radio
1	Aaron Valdes	10946	Arianne	SD7037	Futaba 9 ZAP
2	Arthur Markiewicz	10939	Prism	SD7037	Airtronics Vision
3	Russel A. Shaw	10908	Viper	SD7037	Ace Micropro 8000
4	Joe Wurts	10863	Sapphire	SD7037	Airtronics Stylus
5	John Hauff	10751	Milineam (Waco)	Waco 6%	Airtronics Vision
6	Daryl Perkins	10717	Maverick	RG15 (mod)	Airtronics Stylus
7	Mike Fox	10668	Scorpion 112	SD7037	Ace Micropro 8000
8	Phil Barnes	10648	Merlin	WA001	Futaba
9	James H. Bonk	10628	Victory C	SD7037	Airtronics Vision
10	Louis J. Glaab	10617	Magic	WA001	Airtronics Vision
11	Gordon H. Jennings	10477	Blackhawk (Kevlar)	S9000	Airtronics Stylus
12	Thomas E. Kallevang	10406	Thermal Eagle	RG15	Airtronics Infinity 1000
13	Anthony H. Matyi	10365	Esteem	SD7080	
14	Terry Edmonds	10361	Genesis	SD7037	Airtronics Vision
15	James D. Frickey	10325	Super V (2M)	SD7037	JR783
16	Ronald A. Scharck	10268	Sapphire	SD7037	Airtronics Stylus
17	Charles F. Anderson	10221	SPICA	SPICA	
18	J. Shape	10169	Super V (114")	SD7037	Airtronics Vision
19	Michael Selig	10160	Blackhawk (Carbon)	S9000	Airtronics Stylus
20	Robert J. Massmann	10105	Falcon 880	S3021	Airtronics Vision

Donations and in kind gifts (models and equipment) have supported the bulk of the program since it started nearly 2-1/2 years ago. Hopefully, we can continue the work for at least another 2-1/2 years! Donations have, however, been declining in the past several months. Yearly contributions from a large number of people could support the program for many years. Purchasing a book (*Summary of Low-Speed Airfoil Data*) or a t-shirt are other ways to financially support the airfoil tests.

Contest Survey: 1996 AMA/LSF Nationals. Our interest in finding out what airfoils were used at the AMA/LSF Nationals prompted us (Michael Selig and Cameron Ninham) to perform a survey. We asked those competing in the Unlimited Thermal Soaring competition (July 31 – August 1) what sailplane they were flying as well as the airfoil and the radio. Of the approximately 110 flyers, we were able to reach 101 of the flyers for the survey. Sometimes the data was incomplete, for example, missing radio data. Although our main interest was to see what airfoils were being used on what aircraft, we have included here additional information for those interested.

Table 1 shows the top 20 flyers together with their aircraft flown and radio information. It is quite interesting to see that among the sailplanes flown there is no dominant design. This same trend is seen on the entire fleet of sailplanes given in Table 2. Of the top 20 flyers, 10 use the SD7037 and 12 use either the Airtronics Stylus or Vision computer radios – a trend consistent with Tables 3 and 4 that list all of the airfoils and radios used. Over 70% of the airfoils were Selig/Selig-Donovan designs and most used computer radios.

We plan to include more contest surveys in this newsletter to track what airfoils seem most popular, and we will use this data in the process of developing the wind-tunnel test plan. We plan to report on contests that we attend; however, if we are supplied with data from other contests, we will include that as well.

A New UIUC LSATs T-Shirt (1996 edition). Cody Robertson of Flagstaff, AZ has designed a second T-shirt exclusively for the UIUC Low-Speed Airfoil Tests. You can receive this white short-sleeve shirt (Hanes Beefy-T brand/100% cotton) for a suggested donation of $18 – $15 for the shirt and $3 for mailing in US, Canada, and Mexico. Other countries should include $7 for mailing. Proceeds will be used to help support the project by sending your check payable to "University of Illinois, AAE Dept." Please write on the check "Selig – Wind Tunnel Testing/AAE Unrestricted Funds." Shirts can be obtained from the UIUC LSATs coordinator:

Chris Lyon

Table 2: Unlimited sailplanes flown at the 1996 AMA/LSF NATS

No.	Sailplane	Airfoil
5	Peregrine	SD7037
5	Thermal Eagle	RG15
4	Esteem	SD7080 (mod)
4	Super V	SD7037
3	Alcyone	SD7032/SD7037
3	Blackhawk	S9000
3	Grand Esprit	Grand Esprit
3	Merlin	WA001 (9%)
3	Pulsar	S3021
3	Sky Hawk	SD7037
2	Condor	SD7037
2	Duck	S3021
2	Duck	SD7037
2	Falcon 880	S3021
2	Prism	SD7037
2	Sapphire	SD7037
2	Scorpion 100	SD7037
2	Super V (114”)	SD7037
1	Arianne	SD7037
1	Banshee	E387
1	Bird of Prey	SD7037
1	Calypso	RG15
1	Cumic	E205
1	Desperado	RG15 (mod)
1	Eagle	SD7080
1	Esteem 118	SD7080 (mod)
1	F3B Eagle	RG15
1	Genesis	SD7037
1	Gentle Lady	E205
1	Grand Esteem	SD7080 (mod)
1	Gypsy Queen	SD7037
1	Heatseaker	K3311
1	Magic	WA001 (9%)
1	Mako	SD7037
1	Maverick	RG15 (mod)
1	Merlin	WA006
1	Meteor	E205
1	Milineam (Waco)	Waco 6%
1	Olympic II	Olympic II
1	orig design (Circlet)	E193
1	orig design	HN 227
1	orig design	S4233
1	orig design	SD7032/SD7034
1	orig design	SD7037
1	orig design	SD7037
1	orig design (Shrike)	SD7037
1	orig design	SD7080
1	Osprey 2M	S3014
1	Paragon	Paragon
1	Phoenix	S4061
1	Pulsar 2M	S3021
1	Saturn 2.9T	HQ 2.0/8-9
1	Scorpion 112	SD7037
1	Shadow	SD7037
1	Sky Hawk	S7012
1	Spectrum	SD7037
1	SPICA	SPICA
1	Spirit 100	SD7037
1	Super Spook	S3010
1	Super V (100”)	SD7037
1	Super V (2M)	SD7037
1	Swan	SD7080
1	Swift 2M	RG15
1	Victory C	SD7037
1	Viper	SD7037
1	Vulcan 2M	S7012
1	Windsong	E214

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Summary of Low-Speed Airfoil Data – Vol. 2, from Herk Stokely, May 1996 The second installment of the wind tunnel work that Michael Selig and his graduate students have been conducting at the University of Illinois, may now be ordered. This work is titled *“Summary of Low Speed Airfoil Data – Vol. 2.”* Twenty five airfoils were tested, many with a variety of flap and turbulator configurations. Continuous improvement of the wind tunnel and data reduction system has resulted in better accuracy and reliability in the data. The team is still working to improve these systems. In the next series increased accuracy and the addition of airfoil pitching moment data may be expected.

Volume 2 is based on the second series of wind tunnel tests at UIUC. A third series of tests have now begun (*MSS: now finished*), and we expect that some time before the end of 1996, *Volume 3* will also be published.

“Summary … Vol. 2” is 251 pages of narrative and

Table 3: Airfoils flown at the 1996 AMA/LSF NATS

No.	Airfoil
40	SD7037
8	S3021
8	RG 15
6	SD7080
4	WA001 (9%)
3	E205
3	Grand Esprit
3	S9000
3	SD7032/SD7037
3	SD7080 (mod)
2	S7012
2	RG 15 (mod)
1	E193
1	E214
1	E387
1	HN 227
1	HQ 2.0/8-9
1	K3311
1	Olympic II
1	Paragon
1	S3010
1	S3014
1	S4061
1	S4233
1	SD7032/SD7034
1	SPICA
1	WA006
1	Waco 6%

data much like Michael's previous works *"Summary of Low Speed Airfoil Data – Vol. 1"* (1995) and *"Airfoils at Low Speeds* (SoarTech 8 – 1989). This book is similar in content and organization to *Volume 1*, and is similar also to the material in *Airfoils at Low Speeds*. We've set the price at $25 in the USA – which includes postage.

All of the actual tabulated data and airfoil coordinates (but none of the narrative or illustrations) in the book are available on-disk in ascii text files. There is no program for use of these files included on the disk. These are provided for those who wish to use the data in their own programs. By formatting the data properly, their use can make manual re-entry of the data unnecessary. The price for the data disk in the USA is $15 including postage.

When ordering the book from outside the USA, add $4 to the basic US price for international surface mail. For Air Mail to the Western Hemisphere add $6 to the basic US price. For Air Mail to Europe add $13, and for other parts of the world add $17. For disk orders from outside of the USA add one dollar to it's price.

Table 4: Radios used at the 1996 AMA/LSF NATS

No.	Radio
37	Airtronics Vision
14	JR 388
9	Airtronics Stylus
8	ACE MicroPro 8000
4	Futaba
4	JR x-347
3	Airtronics Infinity
3	Futaba 9ZAP
2	Airtronics
2	Futaba Attack
2	JR783
1	Airtronics 4CH
1	Airtronics 4CH Vangard
1	Futaba 7UGFS
1	Futaba Super 7
1	Hitec Prism JX
1	Hitec Spectra

A significant portion of the price received from all book and disk sales will be returned to UIUC to provide part of the continuing support for Michael's ongoing test program.

"Summary ... Vol. 1", and SoarTech 8 are both currently available also. The price for *Volume 1* is the same as for *Volume 2*. SoarTech 8 has a base price in the USA of $20 and the international surcharges are the same as for *Volume 1* and *2*. Data disks are also available for *Volume 1* and SoarTech 8. The SoarTech operation is not big enough to handle credit card orders. Please feel free to question me directly by email, (*herkstok@aol.com*) or send regular mail to SoarTech Publications, 1504 N. Horseshoe Cir., Virginia Beach, VA 23451 U.S.A..

When ordering, PLEASE provide a check or money order in US Dollars which can be paid at a US bank. U.S. cash is also accepted. Residents of Virginia should add the state 4-1/2% sales tax to the above rates.

Herk Stokely
May 1996

Highlights from Test Series #3. Test series number three that was completed this past spring proved to be our busiest to date. For starters, we used our new lift balance, which eliminated down time between runs. In doing so, we were able to take more data during a given time frame. The other major change made, and perhaps the most exciting aspect of test series three, was the addition of a moment balance. While doing so added more complexity to the LSATs hardware and data acquisition codes, the information gleaned from the moment data well outweighed the extra effort it involved.

As if changes in the hardware weren't enough, we also decided to change our focus a bit. As mentioned in the previous newsletter, this test series centered on power airfoils. These relatively unexplored types of airfoils had many surprises in store for us, not the least of which were violent oscillations that at times threatened the integrity of our setup. As they say, however, "The show must go on," so methods were devised to reduce or circumvent the violent nature of many of these airfoils, and we continued to take data. Again, our troubles did not go unrewarded as many of the power airfoils exhibited remarkable behavior.

The most time consuming aspect of test series three was the extremely extensive boundary-layer trip study we performed. Among the trip geometries tested were multiple trips, zigzag trips, hemispherical trips (bump tape), riblet material, and the effects of surface abrasion. While many of these had been tested before, never had anything been performed to the extent of which occurred during test series three. We feel this data will help to dispell some common misconceptions about boundary-layer trips and also serve as a guidebook for those modelers who use airfoils that might benefit from them.

Coming unexpectedly out of this trip study were some rather definitive and beautiful surface oil-flow visualizations. In general, surface flow visualization on the model produces streak patterns which, when interpreted correctly, indicate laminar, turbulent, and separated flow regions. This flow viz in addition to performance data taken on a new and very accurate E387 (built by Jerry Robertson) compared very well with NASA Langley data. This validation test gave us further confidence that the accuracy of our data is top notch. Details of these tests will be included in *Summary of Low-Speed Airfoil Data – Vol. 3,* which is currently being written.

Plans for Test Series #4. For our fourth test series, we plan to focus mainly on topics dealing with R/C sailplanes (but as is typically the case the data will have wider application). In particular, some of our plans include so far:

- *Tests on a series of airfoils designed around the SD7037.* A part of this work is motivated by the trend toward reducing the airfoil thickness. We plan to design a series of airfoils (three) with the thinnest one being 4%. We also plan to design a thinner lower-lift version of the SD7037 — a tip airfoil – for use in combination with the SD7037 or the newer thinner versions. Also, two lower lift versions of the SD7037 will be designed. From the contest survey, there is a clear trend that the SD7037 and S3021/RG15 bound the desired performance range. Thus, lower lift seems like the logical direction to go, but we expect the slightly lower lift version (the one most similar to the SD7037) to be the favored of the two.
- *Blended airfoil tests.* Since several airfoils are used in combination with other airfoils, we plan to test an intermediate airfoil, e.g., an airfoil between say the SD7037 (root airfoil) and SD7032 (tip airfoil). The particular intermediate airfoil that we test will likely be one based on the SD7037 (root airfoil) and one of the newer airfoils (tip airfoils) to be used with the SD7037.
- *The effects of using a leading edge flap together with a trailing edge flap.* Launch height is driven largely by efficiency at high lift. Can the leading edge flap together with a trailing edge flap lead to higher launch heights? Joe Wurts has offered to construct the wind tunnel model, and it should be mentioned that this idea was his.
- *Gap seal thickness effects on the SD7037.* We plan to test the SD7037 with and without an upper surface gap seal to determine the drag increment associated with leaving the gap open. We will also test different thicknesses of gap seal. Should only a thin gap seal be use?
- *Performance data for small flap deflections.* During the last test series, several airfoils were tested with flap deflections of 5 and 10 deg. Since often a flap deflection of near 3 deg is used during thermaling, we will test the same airfoils at 2.5 and −2.5 deg (two settings currently possible with the rig). The −2.5 deg case will simulate the reflex position used for cruise.
- *Lift data for large flap deflections.* During the approach, large flap deflections are used. Also, when the glider is heavily loaded, large flap deflections are needed. We plan to test several of our flap models with flap deflections up to 40 deg (the maximum currently possible with the rig).
- *Elevator performance tests.* Not all models use a full-flying stabilator. Data will be taken on an elevator type model (flapped section) to compare with the stabilator.

- *Airfoils with turbulators.* After we complete our review of the data on the tripped airfoils taken during the last series, we might decide to do more. Based on results shown in *Summary of Low-Speed Airfoil Data – Vol. 2* it is clear that trips help the SD8020 when used as a stabilator. We might do more tests along these lines, particularly with the new S8025 tail airfoil.

- *Airfoils for flying wings/reflexed airfoils.* We want to test 2–3 reflexed airfoils, but we are not sure of which ones to test. Any advice we receive will be appreciated . . . as well as an offer to build the model!

- *Wing tests with external flap control linkages.* Is it worth while to build a fairing around the control horn linkages? To find out, we plan to test a wing with an external flap control linkage as well as one that is faired and compare both against the clean wing.

Low-Speed Airfoil Aerodynamics. In the first bulletin, we listed twenty things a knowledgeable modeler interested in airfoils ought to know something about. So far we have answered four, here we answer four more.

"What is the effect of laminar separation bubbles on airfoil performance?"

Laminar separation bubbles affect airfoils in two general ways. First, the presence of a laminar bubble leads to higher drag over a non-bubbled airfoil, with the higher drag region typically occurring near the middle of the drag polar. As the angle of attack is increased, free transition takes place ahead of the bubble, thereby eliminating it, and the drag returns to normal values. This drag effect is mostly of concern to sailplane pilots. The second effect is a change in the lift characteristics of the airfoil. In a very loose sense, the presence of a laminar bubble is equivalent to a change in the geometry of the airfoil. The change being most similar to the addition of camber near the bubble and a decrease in camber downstream. The net effect is typically a loss in camber that leads to a lower lift coefficient than at higher Reynolds numbers. Also, the effective change in camber is not uniform over a range of angles of attack—a process that often leads to a waviness in the lift curve. Because aircraft handling qualities are strongly dependent upon the nature of its airfoil lift curve (the straighter the curve the better), any wiggle makes the aircraft utilizing it feel squirrely or unpredictable. Thankfully, this change in handling qualities is really only dominant on high-lift airfoils (S1223, E423, etc.) as any SAE high-lift competition participant will tell you.

"Why is Reynolds number (Re) so Important?"

Reynolds number is by far the most important dimensionless parameter in fluid flows (remember that air is a fluid):

Quoted from Model Aircraft Aerodynamics by Martin Simons: Experimental work by Osborne Reynolds in 1883 showed there are two distinct types of flow, laminar and turbulent. These may change from one to the other according to particular conditions. Which type of flow prevails in the boundary layer at any point depends on the form, waviness and roughness of the surface, the speed of the mainstream measured at a distance from (usually ahead) the surface itself, the distance over which the flow has passed on the surface, and the ratio of density and viscosity of the fluid. A variation in any of these factors can bring about a change in the boundary layer. Reynolds combined them all except surface condition, into one figure, the Reynolds number (Re).

The formula for Reynolds number is

$$\text{Reynolds number} = \frac{\text{Density}}{\text{Viscosity}} \times \text{Velocity} \times \text{Length}$$

Any classic textbook on aerodynamics will show that for a given airfoil the lift coefficient (C_l), drag coefficient (C_d), and pitching moment coefficient (C_m) are dependent on Re, angle of attack (α), and freestream Mach number (M). As an example the "average skin friction coefficient" (C_f) depends on Re; as Re increases the C_f decreases. Another example is that for any given airfoil the maximum value for C_l ($C_{l.max}$) typically increases as the Re increases. From this we can see that Re plays an important role in determining the attributes of an airfoil, affecting the three most important entities; C_l, C_d, and C_m.

If geometries of two flows are similar (geometric similitude), and the Mach numbers are equal, and the Reynolds numbers are also equal, then the flows are dynamically similar and the force coefficients will all be equal. The reverse also holds true. For flow past airfoils the chord length is usually given, thus we can use similar Reynolds numbers to compare flows, which implies that they are dynamically similar.

This fact leads us up to probably the most important aspect of Re. Re allows us to non-dimensionally scale the attributes of aerodynamic entities. To demonstrate this one has to consider the feasibility of wind tunnel testing wing designs or airfoils for full-size aircraft. There are very few wind tunnels in the world that are capable of testing the main wing of a full-size Boeing 747, or even the full-size airfoil at the root of the main wing. However, by calculating the range of *Re*'s at which the wing operates, taking into consideration the chord length, velocity, and kinematic viscosity of the fluid (typically air), one can emulate the same characteristics by scaling the size of the model down (e.g. decreasing the chord) but increasing the velocity and/or kinematic viscosity (changing the fluid density). This unique feature allows aerodynamicists to build smaller and more practical sized scale models that can be tested inside wind tunnels and still exhibit the same aerodynamic characteristics as the larger full-sized counterparts.

"What are the basic principles of airfoil wind-tunnel testing?"

The most basic principle of airfoil-wind-tunnel testing is to simulate the actual operating conditions in which the airfoil is used. The simplest examples are aircraft wings and tail surfaces, but of course there are several other examples, such as helicopter rotors, propeller blades, and wind turbine blades. In addition, testing the characteristics of airfoils in wind tunnels usually means that two-dimensional tests are performed. For example, there is no chord variation along the span of an airfoil model. Other measures such as the use of endplates (see *Vol. 1*) can be employed to ensure that the airflow remains approximately two dimensional.

Making sure that the operating conditions are simulated properly leads to another principle in airfoil wind-tunnel testing called similitude. The two types of similitudes that must be considered are geometric and dynamic. Geometric similitude means that the airfoil model must be a scale model of the airfoil used on the actual wing or blade section. Dynamic similitude means that the Reynolds number at which the airfoil model is tested is approximately the same as the Reynolds number at which the wing or blade operates. For example, the UIUC LSATs uses 1 ft chord airfoil models. This is usually larger than the chord on a typical sailplane wing, which means that we must adjust the airspeed in the wind tunnel to ensure that the Reynolds number properly matches the flight Reynolds number of the wing. For high-speed airfoil testing, one must also match the Mach number (ratio of airspeed to sound speed), in addition to the Reynolds number.

There are several other considerations that must be made when designing a wind-tunnel experiment. However, these become specifically related to the goal of the test. For example, measuring performance data requires much different equipment and wind-tunnel set-up than does measuring the flow velocity inside of an airfoil boundary layer.

"What is meant by inverse airfoil design?"

Figure 1: Direct design methods for which the airfoil shape is the input.

Airfoil design methods can be broadly classified into two main types—direct methods and inverse methods.

Direct methods (as illustrated in Fig. 1) are those where the designer obtains a desired velocity (or pressure) distribution by specifying the airfoil shape. The resulting velocity distribution is then used to determine the development of the boundary layer over the airfoil. Since the airfoil performance (such as lift, drag, pitching moment) are determined predominantly by the velocity distribution and the boundary-layer development, the designer has to keep modifying the airfoil shape by trial and error until the desired airfoil performance is achieved. This is, however, quite tedious and can lead to "designer burnout."

Inverse methods (as illustrated in Fig. 2) are those where the designer does not know the airfoil shape apriori. Instead, the velocity distribution is specified and the method calculates the airfoil shape resulting from the velocity distribution (subject to some constraints). Since the boundary-layer development is also dependent on the velocity distribution, it is fairly easy for the designer to specify a velocity distribution that will lead to a desired boundary layer – and therefore an airfoil with a desired performance. It is for this reason that most of the modern airfoils are designed with inverse methods. In particular, the airfoils designed as part of the UIUC LSATs program are designed by inverse methods, most notably PROFOIL.

What's Old, But Still Important

Figure 2: Inverse design methods for which the airfoil shape is not known apriori.

The Mailing List. All those who have made donations to the program are automatically on the snail-mail list for at least three bulletins. If you would to receive the e-mail version, please let us know. All past bulletins can be found at the UIUC Applied Aerodynamics Web site on the Internet. New bulletins are automatically posted to several newsgroups on the Internet. If you are on the Internet, you will probably see it.

Airfoil Data on the Web. If you are on the Internet and have access to the World-Wide Web (WWW) through a browser like Netscape, then you can:

- Keep abreast of the latest information on the wind tunnel tests.
- Download airfoil coordinates on over 1000 airfoils for all types of applications.
- Download airfoil performance data from the wind tunnel tests.
- View photos of the wind tunnel setup.
- Design airfoils using PROFOIL, which is one of a suite of design and analysis tools used by Selig for airfoil design. So far, the code is only available on the WWW.

The address on the Web is:

http://www.uiuc.edu/ph/www/m-selig

Once you find this site, if you have problems linking to some of the data it is probably because the server is a PC that runs Windows and Linux (a Unix operating system for the PC). When the PC is running in Windows mode (which is rare), you will not get to the data. Be patient, eventually (in hours) it will be back up in Linux.

Coordinates for the New Airfoils. Until the airfoils are published through SoarTech, they can be obtained from the Web site or by sending a self-addressed stamped envelope with your request to:

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Club Presentation Available. If you are interested in presenting a discussion of the airfoil test program at a club meeting, a 25-page+ presentation with an updated and detailed narrative is available for free. To receive the presentation, please send your request to Chris Lyon.

Offer to Build a Wind Tunnel Model. If you have an interest in building a wind tunnel model, please contact Chris Lyon. Please give us some idea of your interests (sailplanes, power, helicopters, etc.), and your method of construction (foam core or built-up and fully sheeted), your building skills – we dream about the perfect airfoil model, but don't expect to ever see one. We find that all composite models (blue foam, fiberglass and vacuum bagged) are best – most durable and most accurate.

The wind tunnel models should be 33 5/8 inch in span with a 12 inch chord and can either be built-up or foam core. To ensure a uniform contour, the built-up models need to be fully sheeted. The surface finish can either be fiberglass or monokote; however, we are interested in the effects of surface finish and will consider testing models with non-smooth surfaces. The models are attached to the wind tunnel balance by standard model wing rods. K&S tubing is installed in the model to adapt to the wing rods. Details of the mounting system and airfoil model dimensions are available from Chris Lyon. Standard model construction techniques should provide the necessary strength (supporting 15–20 lb of lift when pinned at both ends). The K&S brass tubing and collars for the models are supplied along with full-scale plots of the airfoil.

What is SoarTech 8? *Airfoils at Low Speeds* by M.S. Selig, J.F. Donovan and D.B. Fraser – a book with results on over 60 airfoil models tested over the Reynolds number range 60,000 – 300,000 at Princeton University. Along with the UIUC books, it has become a popular source of airfoil data for R/C sailplanes. It's almost 400 pages and a bargain at $20 in the US ($22 in Canada and Mexico, $25/$35 in US dollars for Surface/Airmail in other countries). The book is only available direct from:

SoarTech Publications
H.A. Stokely
1504 N. Horseshoe Circle
Virginia Beach, VA 23451
herkstok@aol.com

When ordering, please provide a check or money order in US Dollars which can be paid at a US bank. US cash is also accepted. Residents of Virginia should add the state 4-1/2% sales tax to the above rates. Sorry no credit card or COD orders at this time.

Your Help

All contributors to the UIUC LSATs Program are listed in two successive volumes of *Summary of Low-Speed Airfoil Data*. Have your name, organization, club or business listed there! **In the next issue of this bulletin and those following, we will acknowledge all those who have made a donation since the previous bulletin.** Be sure that get your name on the list. Finally, thank you for your support!