The Flightline

Volume 43, Issue 12 | Newsletter of the Propstoppers RC Club | AMA 1042 | December 2013

President's Message

Tinicum indoor is Friday evening December 6th and Brookhaven is Saturday December 21st please try and make time, the turnout to date has been very small, so everyone should get plenty of stick time.

The elections went well; Dick Seiwell President, Albert Cheung V. President, Dick Bartkowski Secretary, Pete Oetinger Treasurer, Ray Wopatek Membership Chairman.

I would like to welcome Al Cheung to the board and thank Jeff Frazier for a great job of V/P. He had to step down due to his new job, but he will be glad to help out on Picnics and other events throughout the year

This would be a good meeting for show & tell. We will start off with S&T and then the meeting.

The weather is bad so try and join us at the indoor meets; always warm and dry. 6:30 till 9:30.

Dick Seiwell, President

Agenda for December 10th Meeting At Middletown Library;

Doors open 6:00, meeting at 6:30

1. Show and Tell
2. Membership Report
3. Finance Report

Minutes of the Propstoppers Model Airplane Club 12th November 2013 at the Middletown Library

Call to order took place at 6:30 PM by President Dick Seiwell Roll call by membership chair Ray Wopatek showed 20 members and one guest present

Treasurer's report by Pete Oetinger was accepted

Minutes of the October meeting as published in the newsletter were accepted by the members

Old Business:

Dick Seiwell reminded members to pay their current dues. If you haven't paid for this year, you'll have to settle that before you can get next year's membership.

New Business:

Nominations for club officers were opened and nominated were:

President: Dick Seiwell
Vice-President: Al Chung
Secretary: Dick Bartkowski
Treasurer: Pete Oetinger

Chuck Kime moved that the nominations be closed and the group be accepted. The club voted in favor by acclamation.

Eric Hofberg announced that he will again hold an open house for viewing his model train displays on December 28 Saturday from 2 to 5 30 PM.

Inside This Issue

2013/14 Indoor Flying

Tinicum School gym for indoor flying.

December 6 2013	6:30 – 9:30 PM
January 3, 2014	6:30 – 9:30 PM
February 7, 2014	6:30 – 9:30 PM
March 7, 2014	6:30 – 9:30 PM

Brookhaven; Saturday nights 6:30 till 9:30 PM

Dec. 21 2013
Jan 18 2014
Feb 15 2014
March 15 2014

Calendar of Events

Club Meetings

Monthly Meetings
Second Tuesday of the month.
Middletown Library
Doors open at 6:00, meeting at 6:30 pm.
Next Meeting; 10th December

Tuesday Breakfast Meeting
Tom Jones Restaurant on Edgemont Avenue in Brookhaven. 9 till 10 am. Just show up.
Flying after in the summer at CA or Elwyn Field 10 am. Weather permitting.

Regular Club Flying

At Christian Academy; Electric Only
Monday through Friday after school till dusk
Saturday 10 am till dusk
Sunday, after Church; 12 pm till dusk
At Elwyn Field; Gas or Electric
Monday through Saturday 8 am till dusk
Sunday 12 pm till dusk

Indoor Flying See page 1

Special Club Flying

Saturday mornings 10 am
Wednesday Helicopter evening in summer
Thursday evenings in the summer
Tuesday mornings 10 am weather permitting after breakfast.
Check our Yahoo Group for announcements;
http://groups.yahoo.com/group/propstoppers/

Beginners

Beginners using due caution and respecting club rules may fly Apprentice or similar models without instructors at Christian Academy Field.
The club also provides the AMA Introductory Pilot Program for beginners without AMA insurance.

Propstoppers RC Club of Delaware County, Pennsylvania.
Club Officers

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Propstoppers Web Site; www.propstoppers.org

Show and Tell:

John Moloko showed how to vent an ammunition can to make it safe for LiPo storage by installing a blow-out plug in the lid.

John Moloko showing his ammo can LiPo charging container blow-out plugs

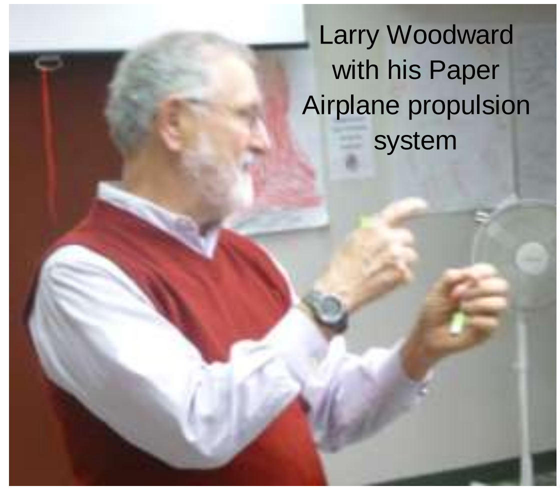
Eric Hofberg showed a small quadcopter from Tower Hobbies that has a built in camera a bug for still or video pictures. It is very small about a foot across and flies indoors or outdoors. The battery lasts about 5 minutes. He demonstrated it at the meeting. (sorry Eric, I accidentally deleted your picture!)

Eric's Tower Hobbies Quad in flight at the meeting

Mick Harris showed a 1942 old timer pylon model that here recently built. It is electric powered to meet standards for contest flying.

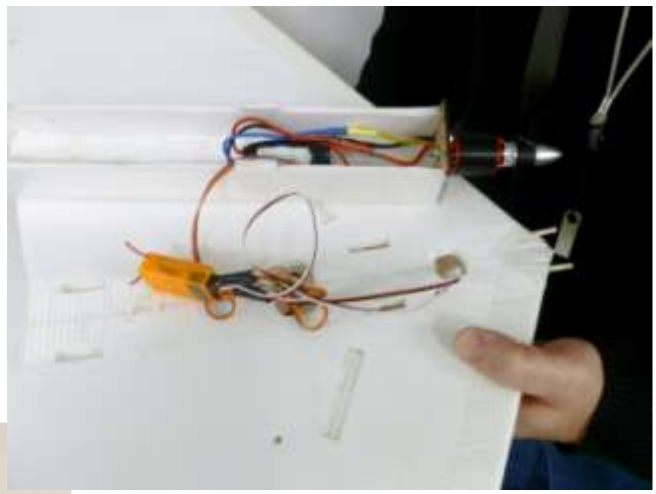
Larry Woodward showed it a motor capacitor system originally designed to fit a paper airplane. He fit it to an indoor Penney plane. He said it flew indoors for 2 minutes.

Ron Lauser showed a battery holder that fits inside an ammunition can to hold several batteries. He also showed how he uses "bread ties" on the battery leads to indicate those that h ave been charged. He also showed his flying wing FT Versawing. It is made from Dollar Store foam board and sticks and held together with tape and hot melt glue. It is electric with a power pod that can be used on several different designs. Plans and kits are available via the Internet.



Larry Woodward with his Paper Airplane propulsion system

Ron Lauser showing the ammo can LiPo charger battery insert



Newly elected club VP Al Cheung with his indoor 3D "Crack Yak"

Ron Lauser with his Dollar Store foam board Versawing

Adjournment took place at 7:45 PM

Dick Bartkowski, Secretary

Eric's Christmas Train Show ~ 28th December 2 pm till 5:30 pm.

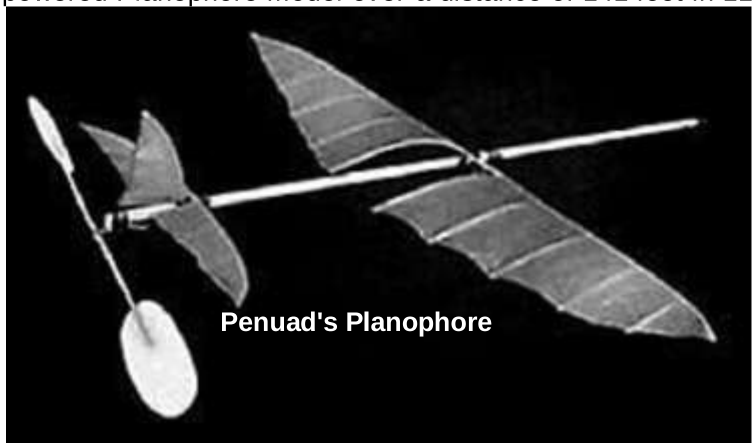
Eric Hofberg and his wife Peg will once again host a Christmas open house with his extensive and magical O gauge model train layouts.

Club members, their kids and grandkids are welcome to come and "play" engineer, take one of Eric's quizzes or just enjoy watching kids, young and old marvel at one of "our" favorite toys/hobbies.

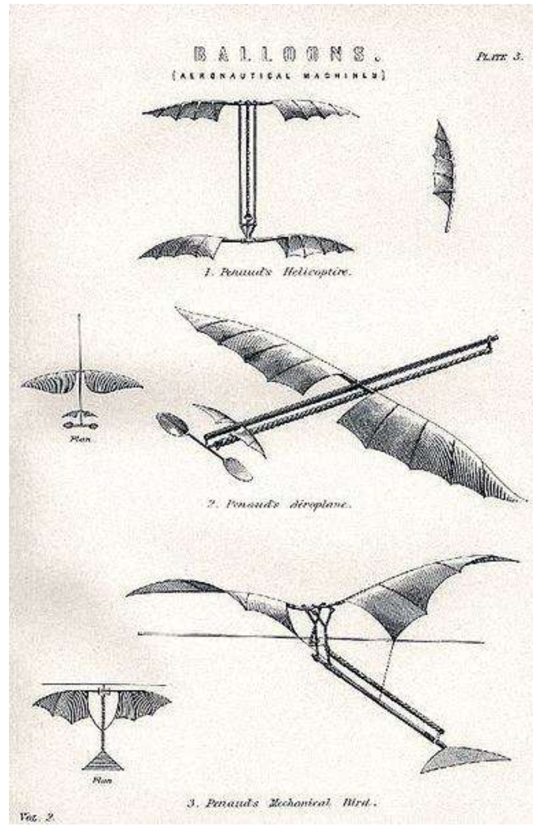
Yet another Aeronautical Challenge

For the last ten years I have been competing at the Southwest Regionals SAM contest in Eloy Arizona, about half way between Phoenix and Tucson Anyway, I just heard they are holding a special free flight event this year for Alphonse Penuad's Planophore model.

Alphonse Penaud is credited with the first successful model airplane flight when he flew his rubber powered Planophore model over a distance of 141 feet in 11 seconds in 1871 at the Tuileries Garden in Paris.

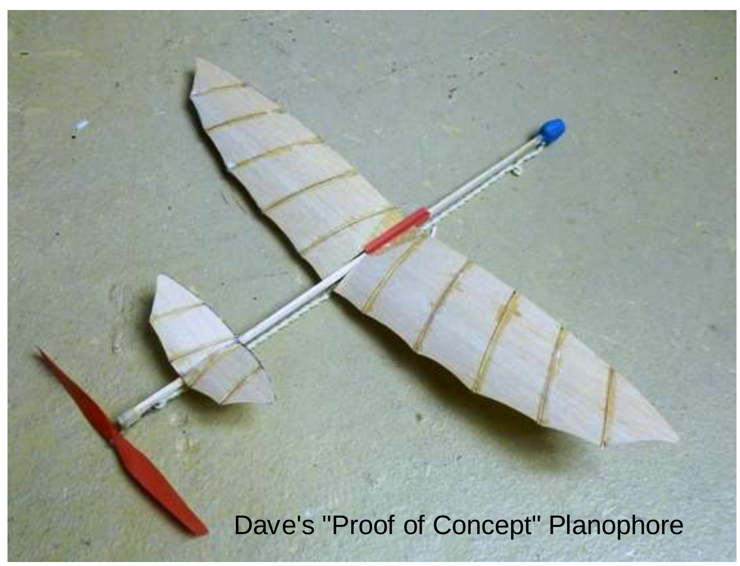


Penuad's Planophore



When I expressed interest in the event on the SAM chat group one of the members from Seattle told me he built one but couldn't trim it into stable flight. He said he thought it might be the pusher propeller. I told him pusher props are stabilizing; he was not amused!

Greg's Planophore



Dave's "Proof of Concept" Planophore

What to do? Yikes, just realized it is our first indoor meet this evening, an ideal place to try something like this. So thinking I was only building a proof of concept model (even though it had been already proven 142 years ago). It would be easy if I could make it from solid balsa and use some of the parts from one of those dime store all balsa rubber models; I have the parts. So I built it in a few hours before the meet and flew it late in the evening. At first it was way tail heavy due to the plastic prop, but adding more and more modeling clay to the nose brought it into trim and I achieved two magnificent flights. Aero design proved. Subsequent discussions with Greg revealed another fellows suggestion that he add downthrust. Sure enough, my model with the dime store prop has downthrust, well, upthrust actually, but the effect is the same. Now to build a proper one with all the original materials, balsa, bamboo, piano wire, tissue paper and cotton thread and do some more testing before launching off to Arizona.

Dave

Scale Duration Airfoils and Aeronautical Technology, a Story

When I decided to build the Antoinette for Kirby Hinson's $100 Pre 1914 Speed 400 Scale Duration event prize at the 2013 Champs I had a dilemma regarding the airfoil. The pictures I took of the one in the Paris **Musée de l'Air** showed a deeply cambered airfoil with sharp leading and trailing edges, in fact almost a symmetrical shape fore and aft.


1909 Antoinette in the Paris Musee de l'Air

Didn't seem to me that it would work very well in model scale so knowing I needed an airfoil with these general characteristics and also knowing it was somewhat similar to those used in successful free flight models I thought I would get some expert advice.

I asked Gil Morris and my friend, Boeing colleague and fellow model club member Dave Bevan.

SAM Hall of Famer and US World Champs Free Flight team member Gil you know. Dave is an absolutely top notch aerodynamicist. As a kid, hanging around the local airport, fixing and flying Cubs, BS Aeronautics for Virginia Tech and Glenn L Martin aerodynamicist where he worked with some of the famous German aviation technologists that came to the US in Operation Paperclip after WWII. Dave was the manager of the Boeing Philadelphia wind tunnel for 15 years (** see below), and a lifetime modeler; original AMA 3797.

Gil gave me some suggestions and Dave gave me a stack of old measured airfoil data and an old book I just began to read. The 1917 book is "Aeronautical Engineering and Airplane Design" by Klemin,. I began to read and slowly realized that this is a seminal work in aviation technology. I was amazed at the scope of aeronautical science at that time. Further, this particular book is an original print and was previously owned by Rensselaer Polytechnic Professor John G Fairfield, the 1916 Professor of what was then called Heat Engineering and today would have been called Thermodynamics. The next owner was Henry K "Hank" Borst, another noted aerodynamicist who co-authored the great German aeronautical engineer Hoerner's book Fluid Dynamic Lift*. Hank worked at Boeing Philadelphia in the late 1960s through early 70s. He must have then given the book to Dave.

Discussing these things with Dave he sent me the following;

Incidentally, one of the Germans I worked with from Focke Wulf was Rudolph Voigtberger. He was a contemporary of Hoerner, and arranged for me to have one of the small original copies of Hoener's "Fluid Dynamic Drag" book. Subsequently, at one point Mrs Hoerner expressed some interest in getting it back! After I left Martin, I told Hank Borst about the original book and showed it to him and told him about Mrs Hoerner and also that I had always wanted to do a similar book on Lift. Hank and I talked a lot about these subjects and eventually he rewrote Drag and put together Lift. That's all I know about that. Dave B

* From Wikipedia; http://en.wikipedia.org/wiki/Sighard_F._Hoerner

In 1945 and 1946, Dr. Hoerner prepared a manuscript for the book Aerodynamic Drag. The technical publishing houses in New York City were not confident enough to bring a book as specialized as this to the market. ***As a result, he published the book himself in 1951, using a photo-offset process and sold copies of the book by mail order from his home****.[3] The book got very good reviews and demand was steady. In 1958 it was reissued as Fluid-Dynamic Drag. With the rapid progress in aerodynamics over the years, he prepared an update to the book, which was published in 1965.[4] As before, the book was self-published by Hoerner Fluid Dynamics. This book contains documentation of the worldwide knowledge (at the time) of the sources of aerodynamic drag and the means to quantify aerodynamic drag. While substantial knowledge on this subject has been learned since 1965, this book is often the starting point in work where aerodynamic drag must be calculated.*

The US Navy Office of Naval Research gave Dr. Hoerner a contract in the mid-1960s to write a companion volume Fluid-Dynamic Lift. Co-authored with Henry V. "Hank" Borst, this book was published by Hoerner Fluid Dynamics in 1975. Unfortunately, Dr. Hoerner died shortly before publication. This book, like its companion, contains documentation of the worldwide knowledge on the generation of aerodynamic lift and is still used heavily.[5]

Klemin's 1917 book is eminently readable and although technical in nature you can follow it. The whole breadth of technology and design is covered. So here I am with this wonderful rare find and a dilemma, do I take the time to read it now, or ask Dave if I can hang on to it a while longer so I can read it when I do have the time? Well, maybe I could buy one if I can afford it, it may be expensive like Hoener's Fluid Dynamic Drag. But it turns out that Amazon has a paperback version for only $15. But wait, it is even available as an e-book online in the Google Archive where you can read it for free, or download it to read at your leisure. https://archive.org/details/aeronauticaleng00klemgoog (incidentally, Dave has kindly given the original book to me.)

Oh, what did Gil say? Well, I gave him the general shape needed to match the original; together with the expected Reynolds number for the wing loading and chord (about 70K) and he made several suggestions including the GM15. So, although it was a bit of a challenge to make the trailing edge I went with the GM15. Here is the model sitting on the El Dorado dry lake in a picture taken by Kirby Hinson. You can see the tip airfoil. Oh, it flew great.

Antoinette Scale Duration on El Dorado Dry Lake at the SAM Champs won the $100 prize.

** *The Boeing Philadelphia subsonic wind tunnel is the largest privately owned wind tunnel in the United States. The nine-blade fan (shown here), measuring 40 feet (12 meters) in diameter, Sometime, perhaps in the late 1970s Dave Bevan, arranged a free flight model airplane contest; in the return section of the wind tunnel.*

Shown here with their models are from the left; Dave Bevan, Bruce Blake (eventually helicopters technology manager), unknown young man, your editor, Dave Harding and wind tunnel mechanic Mike Drosda. My model is, what else, an Antoinette covered with Saran wrap.

Dave Bevan and Hypersonics

The other day Lockheed made an announcement that they were working on an SR-71 replacement. This announcement together with the techie stuff I have described above led me to want to re-introduce you to our club's past Vice President Dave Bevan. This is a repeat and update from a piece I wrote eight years ago.

Meet Vice-President Dave Bevan

Dave Bevan has been a Propstopper for some years although he has been a low key member until volunteering for the role of Vice President last month. I have the privilege of working with and associating with Dave for over thirty years, mostly through our work at Boeing. However, we shared a modicum of modeling during that time when we were both focused on earning a living. But I knew that Dave's lust for matters aviation and modeling had driven his earlier life so I asked him to share some of his background with the Propstoppers. Here is his "train of consciousness" biography, illustrated by "your's truly". (Dave Harding, Ed.)

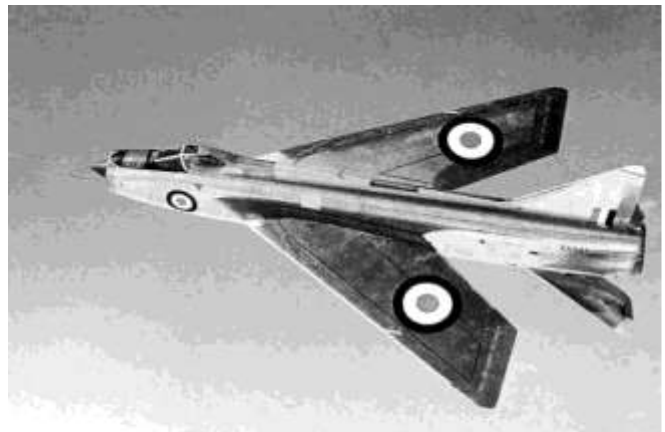
Dave; This whole thing started by building model airplanes. Around the age of eight there was a list of nearly a hundred models built. Pre-teen activity included Henry Struck's Flying Cloud Wakefield, the Buzzard Bombshell, Zilch C/L stunt, lots of Comet, Megow, Scientific, Joe Ott, etc.

A job at the local airport turned the boy into a teenage pilot and mechanic. Flew Aeronca C-3&7AC, Piper J-3, PA-16, and PA-22.

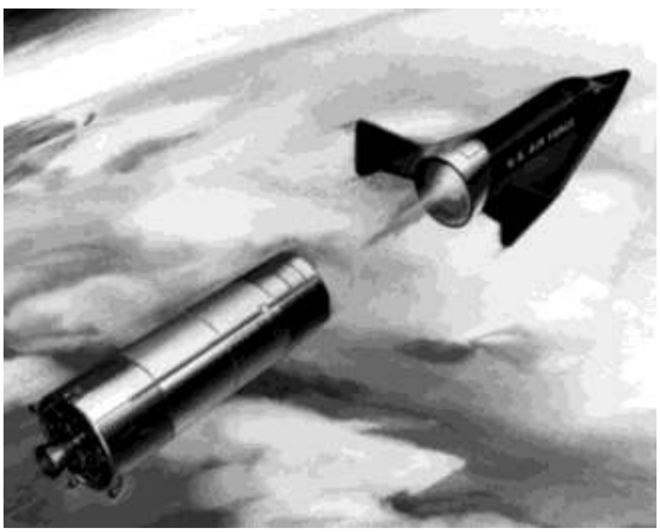
Took a BS in Aeronautical Engineering at Virginia Tech. Worked for Glenn L. Martin when he was alive, doing aerodynamics analysis, wind tunnel tests, and flight tests from Mach 0 to 22 on jets, props, rockets, air-to-air, launch vehicles, reentry vehicles, warheads, "upper atmosphere research (read spy plane)".

Cleaned up the Mach buffet, tuck and such on B-57 Canberra, and reworked the controls so we had a 54,000 lb twin-jet high-speed bomber with good low-speed maneuverability and low control forces with completely manual surfaces-no hydraulics or boost.

Worked on Variable Stability F-106, English Electric P-1B Lightning.



Hywards, Robo, Dyna Soar orbital skip gliders-(stuff that looks like the subsequent Shuttle).



Member of Baltimore Aerocraftsmen MAC, flying 1/2A, A gas and trying to get on the Nordic (FAI F1A) team.

Sixteen years later he joined Boeing Vertol as head of VSTOL Aero. Twenty eight years with Boeing brought varied assignments in R&D sales, technology manager of subway- surface railcars, and manager of the Boeing V/STOL Wind Tunnel. At retirement I managed the Aerodynamics group, the Dynamics group, Noise Control group, Flying Qualities group, wind tunnel and simulator groups -all the people others called technical weenies.

Before retiring in 1995, we conducted classes at Boeing for the Widener and U. of Penn students entering the SAE - sponsored college contest for the radio-controlled model that would take off within 200 feet with the greatest payload, but the students have to predict the takeoff distance and weight! That activity continues at Widener.

Dave Bevan

Hypersonics to Space

When preparing Dave Bevan's story I began to research some of the advanced programs Dave had been involved with at the Glenn L Martin Company. They led me to the extraordinary story of these developments and the associated organizations and men responsible.

Most developments of aeronautical interest to us modelers derive, I am afraid, from the pursuit of military advantage. Simply put, the objectives in military technology are to see further and attack further and faster than our enemies. This is true for hand held weapons like swords and lances and everything since. The first aviation applications were the use of balloons to see further, and it only took a few years following practical airplanes to recognize then develop them for military uses. Initially they were used for reconnaissance but quickly carried munitions to deliver lethal force to distances way beyond other means.

Once begun on this course, airplane development expanded enormously and engineers developed airplane technology and the means to understand it. Early in these developments the US Government chose to invest in aeronautical technology beyond the military services by organizing the National Advisory Committee for Aeronautics; NACA.

Very early in aeronautical developments Breguet developed the fundamental equation that relates an airplane's range to three specific properties of the design, indeed, it is known as the Breguet Range Equation;

The three terms; propulsive efficiency, the fraction of the weight that is fuel and the L/D (The Lift divided by the Drag, the basic aerodynamic properties of an airplane.)

All three of these elements have been at the heart of aeronautics development from the very beginning, both in industry and at NACA. And by the middle of WWII they had led to the airplanes we know and enjoy. As we also know some of these airplanes by then had the performance to dip into the region of compressible aerodynamics and bump up to the speed of sound, then jet propulsion was added to the equation and NACA began to formally add research into transonic and supersonic aerodynamics to their previous thrust in subsonics. Of course, the goals were high L/D, low weight and efficient propulsion, just like in Breguet's day, 35 years earlier.

Then, on 6th June, 1944, came the Normandy invasion and on 13th June Germany responded by launching its first "Velgeltungswaffe Ein" (or "Vengeance Weapon No. 1") missiles against England, followed by its first strike of V-2s (German Designation V-4) on London in September.

Because they flew at speeds of up to Mach 5 (3400 miles per hour), the V-2 missiles were invulnerable to interception by even the fastest fighter planes.

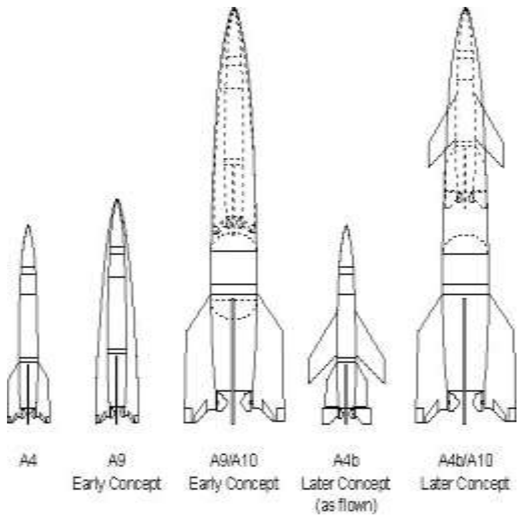
And, because they flew out of the atmosphere, on motor thrust alone, they did not behave according to the Breguet Range Equation; other factors were dominant. NACA were not working on these!

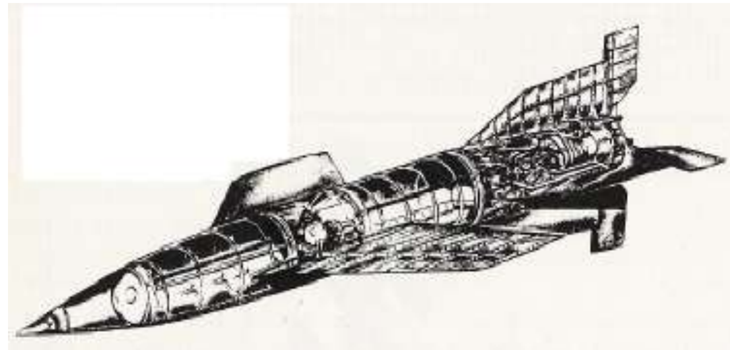
When the Allies captured the Baltic town of Peenemünde in the summer of 1945, technical experts discovered, among the various V-2 test facilities, a "super-supersonic" wind tunnel, which, though small (0.4-meter diameter), was operational-on an intermittent-flow basis-to Mach 5, as well as a larger, continuous-flow "super-supersonic" tunnel, which was under construction for a speed ten times that of sound.

Nowhere else in the world were there high-speed tunnels like these two. Nazi engineers had built them for the purpose of testing long-range ballistic missiles, two of which (the A-9 and A-10) were planned for the aerial bombardment of the eastern United States.

Here was an air vehicle which did not cruise in the atmosphere held up by aerodynamic forces of the wings. It relied on blasting out of the atmosphere using powerful rockets. More, if these rockets could achieve a velocity of 17,500 mph, then they would circle the earth in orbit, totally devoid of aerodynamic lift. Further, if the vehicle had wings it could return to the earth's atmosphere and fly to complete the mission.

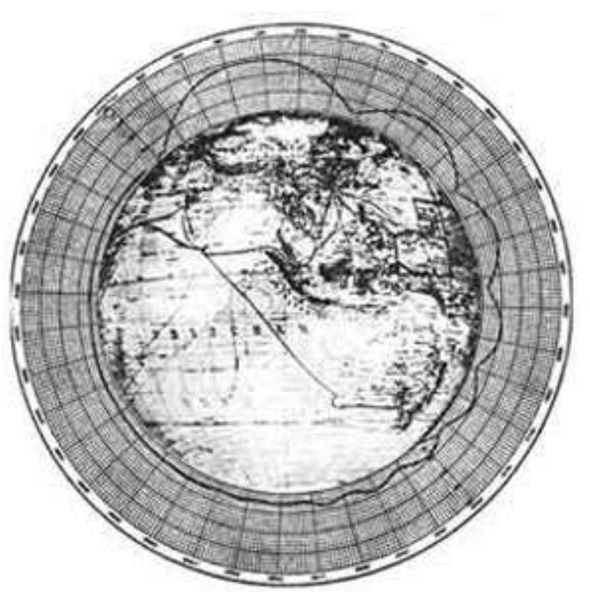
These developments were the passion of Werner Von Braun who subsequently realized them by becoming an American and leading his Huntsville team to Space. But he was not the sole German with a space technology vision. Eugen Sänger (1905-1964) and his assistant Irene Bredt had worked on the theory of a rocket-powered glider based on Sänger's Doctoral thesis from 1933. They finalized their report in the summer of 1944.





The Von Braun Glider-Missile A-9.

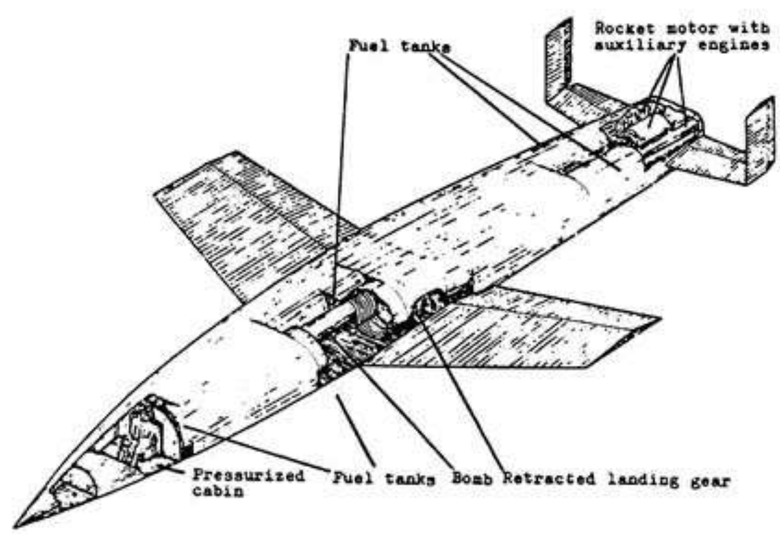
The concept was for a rocket powered glider to achieve orbit then, on re-entry, skip off the upper atmosphere to continue further, and so forth, like pebbles on a pond, until re-entry. Any craft that could convert the kinetic energy it had acquired during boost and ballistic flight into aerodynamic lift could use this for trajectory shaping and, as the end result, get an enormously increased range.



Trajectory of Global Reach Sänger-Bredt Rocket Glider-Bomber, from Sänger-Bredt report august 1944, © Irene Sänger-Bredt

This principle was, of course, apparent to practitioners like Werner von Braun and Walther Dornberger in Peenemünde, who argued that their A4, supplied with wings could attain more than double the ballistic range. Using a booster stage, the A10, the glide range would span the Atlantic.

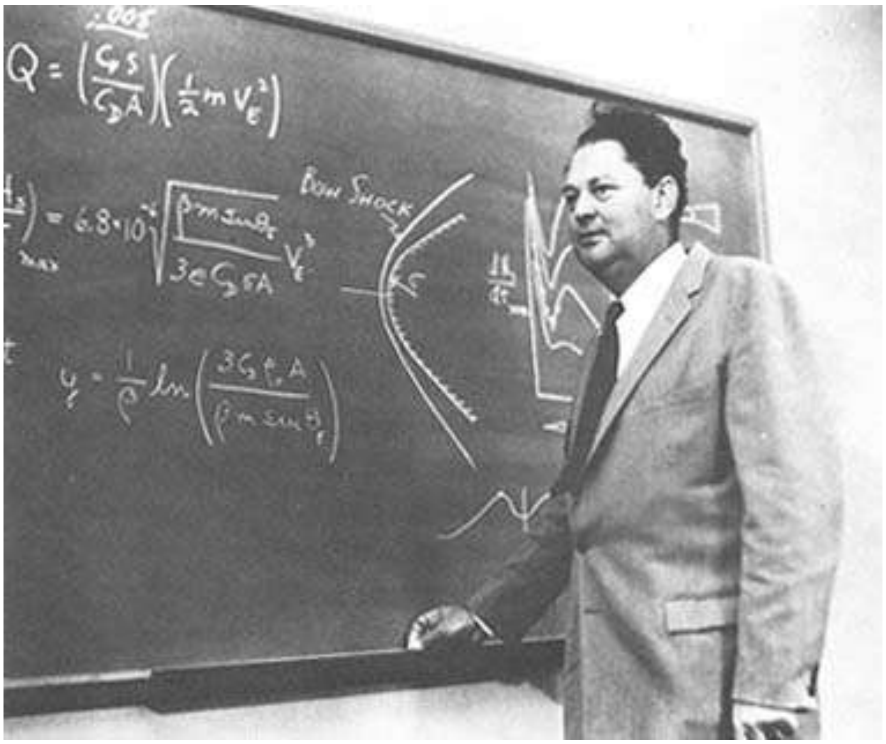
Antipodal Reach Rocket-Glider by Eugen Sänger and Irene Bredt.



Though there was early debate inside the NACA and elsewhere about whether ballistic missiles would ever amount to much. The effect of Peenemünde was for NACA Langley to organize three separate study groups.

They opined that a successful intercontinental ballistic missile would have to be accelerated to a speed of 15,000 miles per hour at an altitude of perhaps 500 miles and then guided to a precise target thousands of miles away. Sophisticated and reliable propulsion, control, and guidance systems were thus essential, as was the reduction of the structural weight of the missile to a minimum. Moreover, some method had to be found to handle the new and complicated technical problem of aerodynamic heating. As one of these missiles arched over and slammed back into Earth's atmosphere, the air around its nose - which carried the warhead - heated up to tens of thousands of degrees, hotter than the surface of the sun. The part of this heat generated outside the boundary-layer surface by shock-wave compression, and which was not in contact with the missile structure, dissipated harmlessly into the surrounding air; but the part that arose within the boundary layer, and which was in contact with the missile structure, was great enough to melt the missile. Many dummy warheads burned up because they were unprotected from the effects of aerodynamic heating.

NACA Ames Chief, “Harvey” Allen, proposed a "blunt-body" shape-familiar to us all now because of the rounded nose and bottom side of the Mercury, Gemini, and Apollo space capsules, but a strange idea at the time.



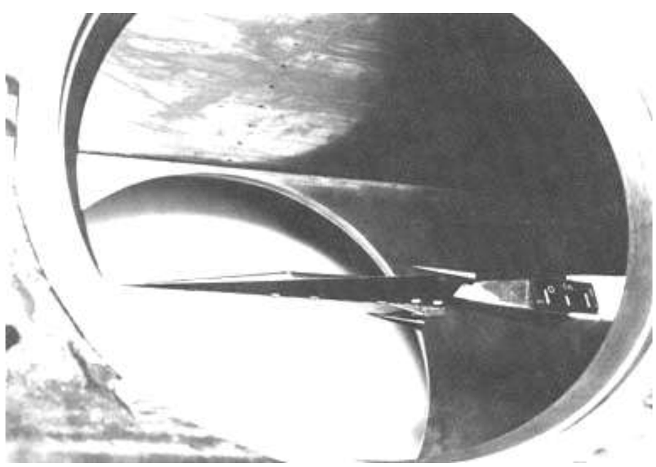
The blunt shape, when reentering the atmosphere, would force the buildup of a powerful bow-shaped shock wave, Allen predicted. The shape of this shock would deflect heat safely outward and away from the structure of the missile. However, industry did not pick up on the blunt-body idea very quickly. People accustomed to pointed-body missiles remained skeptical of the revolutionary blunt-body principle until the late 1950s, when the principle became crucial for missile design and for the design of the future blunt reentry capsules of the Mercury, Gemini, and Apollo programs.

In June 1952 the NACA Aerodynamics Committee recommended that Ames and Langley laboratories increase their emphasis on hypersonics research. Robert J. Woods, designer of the X-1, X-2, and X-5 aircraft for the Bell Aircraft Corporation, proposed that the Committee direct some part of its organization to address the basic problems of hypersonic and space flight. Accompanying his letter was a document from Walter Dornberger, formerly commander of the German rocket test facilities at Peenemünde and now employed by Bell, outlining the design requirements of a hypersonic aircraft. Dornberger was still intrigued by an elaborate concept for an "antipodal" rocket plane which had been proposed by his colleagues Eugen Sänger and Irene Bredt. The Bell engineer called for the NACA to define and seek to procure a manned research airplane capable of penetrating the hypersonic flight regime. This led directly to the X-15 program. The pioneering X-15 reentry systems, their derivatives, and the X-15's reentry flight experiences led directly to the systems and techniques employed later in the shuttle.

Project HYWARDS

Langley researchers began wind tunnel and structures testing of the X-15 in early 1956. One can imagine, then, how surprised the NACA researchers were in March 1956 when they heard rumors that the air force had established Project HYWARDS which, among other things aimed at a configuration having (1) a delta wing with a fiat bottom surface and (2) a fuselage crossing the relatively cool shielded region on the top (or lee) side of the wing. The flat-bottomed wing design had "the least possible critical heating area for a given wing loading," which translated into the need for "least circulating coolant, least area of radiative shields, and least total thermal protection in flight." Here was the first clear delineation by the NACA or anyone else of design features that could significantly alleviate the aerodynamic heating problems of hypersonic flight, "space leap," and reentry. In the future, designers would incorporate these basic features in the air force's Dyna-Soar (a program whose intent was to combine all post-1953 feasibility studies on a boost-glide research vehicle into a single plan leading to an operational USAF vehicle) and NASA's space shuttle.

In the course of supporting HYWARDS, the Langley study group became engaged in a debate with a parallel group of researchers at Ames. The Langley study shed some new and surprising light on the requirements of lift-drag ratio (L/D), an important gauge of the aerodynamic efficiency of wings at different angles of attack, for hypersonic gliders. The Langley group knew that regarding aircraft range at ordinary speeds this factor was as important as the weight and propulsion factors. But at the near-orbital launch speed required for "once-around" or global range, the group found theoretically that the glider weight would be carried initially almost entirely by the centrifugal force produced by the launch. Considering this, the group perceived that aerodynamic L/D lost most of its importance. Thus, for global range, the study showed that a certain glider design with low L/D (with a smaller and therefore lighter wing) would require only about three percent higher launch velocity than a design with L/D four times higher than called for by high-L/D designs. The Ames people seem to have accepted Becker's ideas with little question. Perhaps they realized that there were no quick and easy solutions to the enormous technical problems of heat protection in very high L/D design.



1957 Langley test of HYWARDS in the 11-inch hypersonic tunnel.

Langley and Ames had a more compelling reason, however, to compromise over their different HYWARDS glider configurations than some new technical consensus over the optimum L/D or over structural heating requirements. The first man-made satellite to orbit the Earth - the Soviet Union's Sputnik 1 - was moving overhead.

Since Sputnik was launched on 4 October Americans had been huddling near radios and televisions straining to hear the "beep-beep-beep" of the distant satellite. What they heard from the satellite alarmed them, but what they heard about the satellite bothered them even more. The Soviet achievement embarrassed American scientific and technological prestige, the politicians were beginning to say, and it posed a new communist threat to national security.[60]

Although the Main Committee took no official notice of it at its annual meeting on 10 October, Sputnik had captured the minds and imaginations of some within the NACA. Many attending Round III "felt mounting pressures" to solve the critical reentry problem of the ballistic vehicle and even to take on satellite research. Langley and Ames had been studying the problems and potentials of lifting bodies - that is, wingless bodies capable of generating lift - since the early 1950s.

Theoretical and experimental results from ICBM research demonstrated very clearly by October 1957 that ballistic operation - throwing a vehicle into the upper atmosphere or into space rather than flying it there and back - minimized both the launch energy required and the reentry heat load. High reentry deceleration rates and the necessity of an uncontrolled parachute landing still handicapped the ballistic vehicle, but at least NACA labs had found a way to greatly alleviate the deceleration problem by designing, according to Allen's blunt-body principle, a wingless body with small L/D which was capable of significant lift.

Ira Abbott of NACA headquarters declared that the NACA should immediately begin to study the satellite reentry problem for non-lifting or slightly lifting vehicles. It should be "in addition to continuing R&D on the boost-glide system, however, not it’s alternate." There was good reason for the NACA to think that its work on the boost-glide system was still, in spite of the growing reaction to Sputnik, more immediate and urgent from a military point of view than was work on satellites: after all, the air force had only two months earlier proposed Project Dyna-Soar to follow the X-15 project.

A revolution in public mentality was unfolding. Until the last ninety days of 1957, space had been a dirty word in American political arenas. Ira Abbott recalls that the NACA stood "as much chance of injecting itself into space activities in any real way [in the pre-Sputnik period] as an icicle had in a rocket combustion chamber." When he mentioned the possibilities of space flight to a House subcommittee in the early 1950s, Abbott was accused by one congressman of talking "science fiction." Space had also had negative connotations in certain NACA quarters. The NACA had taken formal notice of space flight as early as 1952, but only as a natural extension of aerodynamic flight through the atmosphere into space and return. The predominant attitude of the Committee and leaders of its research organization during the period 1952 to 1958 was to avoid "Buck Rogers stuff."

This NACA era was brought to a close following the final Conference on High Speed Aerodynamics. The organizers managed to elicit papers which summarized all the disparate work on the various challenges of space technology, and spacecraft configurations including winged, lifting body and also a new, simple, non-lifting satellite vehicle (which was to follow a ballistic path in reentering the atmosphere) by Max Faget, head of the Performance

Aerodynamics Branch of PARD. (See the picture on page 2). Faget read his paper (coauthored by Langley's Benjamin J. Garland and James J. Buglia) first. He highlighted several advantages of the simple non-lifting ballistic vehicle, a pet concept: Since it follows a ballistic path there is a minimum requirement for autopilot, guidance, or control equipment. This condition not only results in a weight saving but also eliminates the hazard of malfunction. In order to return from orbit, the ballistic reentry vehicle must properly perform only one maneuver. This maneuver is the initiation of reentry by firing the retrograde rocket. Once this maneuver is completed (and from a safety standpoint alone it need not be done with a great deal of precision), the vehicle will enter the earth's atmosphere. The success of the reentry is then dependent only upon the inherent stability and structural integrity of the vehicle.

Faget concluded that the state of the art in ballistics was "sufficiently advanced so that it is possible to proceed confidently with a manned satellite project" of the type he was proposing. He recommended specifically the design of a nearly flat-faced cone configuration, one that capitalized on Allen's blunt nose concept in the extreme; it became the configuration of the immensely successful Gemini and Apollo satellites to follow.

However, the work by NACA and their predecessors on skip gliders was not in vain, as it led directly to the equally successful Space Shuttle some years later. Although the path to an Air Force skip glider bomber program was broken by the cancellation of Dyna Soar by Secretary of Defense, Robert McNamara.

The Langley engineers flying back to Hampton after the last NACA Conference on High-Speed Aerodynamics ended in March 1958 knew that some basic, quick, and dependable vehicle like the one Faget recommended would most probably carry the first man into space.

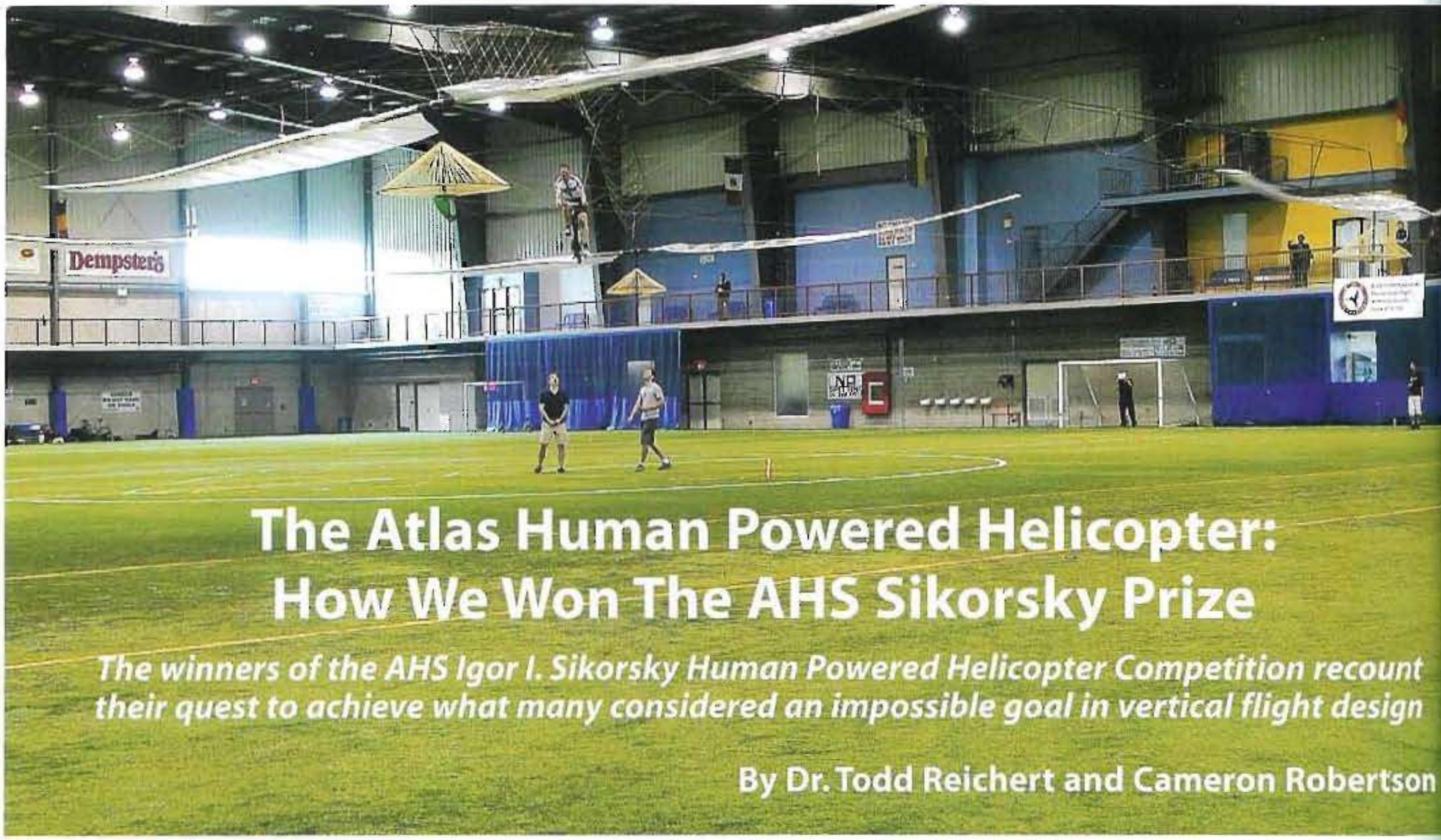
If they had known that in less than four months, on 16 July, Congress would pass the National Aeronautics and Space Act, dissolving the NACA and establishing NASA, the Langley engineers flying home from Ames might have thought back with satisfaction on the quality of the 46 papers they had just heard at the NACA conference. Their work had shifted from the traditional subsonic aerodynamics to tackle the daunting challenges of hypersonic flight and re-entry from space. It was the very foundation for the initial entry to space and the subsequent development of the re-usable Space Shuttle.

Dave Harding

From multiple internet sources, including the official NASA website;

http://history.nasa.gov/SP-4305/ch12.htm

http://www.astronautix.com/index.html



The Atlas Human Powered Helicopter: How We Won The AHS Sikorsky Prize

The winners of the AHS Igor I. Sikorsky Human Powered Helicopter Competition recount their quest to achieve what many considered an impossible goal in vertical flight design

By Dr. Todd Reichert and Cameron Robertson

Todd Reichert pilots the Atlas on its prize-winning flight on June 13, with ground crew Trefor Evans and Cameron Robertson below. (AeroVelo video image)

On July 11, AHS International and Sikorsky Aircraft presented the $250,000 AHS Sikorsky Prize to Toronto, Ontario-based AeroVelo for flying the first human-powered helicopter to meet technical requirements set by AHS more than a third of a century earlier, in 1980. – Ed.

Beginnings

In May 2011, we heard about the University of Maryland's Team Gamera conducting their first flight tests of a human-powered helicopter. The two of us had led the Snowbird Human-Powered Ornithopter Project, which in 2010 resulted in the world's first piloted, flapping-wing aircraft to sustain flight.

Passionate about lightweight engineering and design for human power, we realized that the AHS Sikorsky Prize might be an opportunity to pursue our true interest and passion again. Meeting the prize's requirements of a single flight that achieved a height of 9.84 ft (3 m), remained aloft for 60 sec and stayed within 32.8 ft (10 m) of its liftoff point also could set the stage for a career of doing what we loved to do. Todd had just finished his Ph.D. at the University of Toronto Institute for Aerospace Studies. Cameron left his position in the unmanned air vehicle industry, and we began the Atlas Human Powered Helicopter (HPH) Project.

At the outset, it looked as if Team Gamera had several years' head start. However, we had worked on the Snowbird for four years and were experts in human-powered aircraft (HPA) technology and construction. We had zero helicopter background, but surmised that this was more similar to a typical HPA than a helicopter.

Starting our initial configuration study in January 2012, we looked at the size of previous HPHs and eliminated the most obvious constraint: we would not design Atlas to fit inside a gym. Our objective was a minimum-power helicopter focused on achieving the prize flight. The flight test venue was a logistics concern for later.

Based on the simplified power estimates, we eliminated hinged main and tail rotors and further evaluated quad-rotor and coaxial, counter-rotating, and tip-propeller-driven, single-rotor configurations. We applied a basic aerostructural optimization scheme to the quad-rotor and prop-driven configurations. This showed that the optimal sizes were larger than expected (with a quad-rotor radius of about 42.6 ft or 13 m), and the powers very similar.

We selected the quad rotor for several reasons. It is inherently stable. The maximum sizes of its primary structural elements were reasonable and would minimize joints. There were economies of scale for manufacturing, with four- or eight-instance repetition of the main components. And it had heritage. We fixed the rotor radius at 32.8 ft (10 m), given that the optimum was very shallow and we had greater confidence that an aircraft of this size was feasible.

We programmed a more advanced aerostructural optimizer for design of the rotor blade. It includes a vortex-ring model that is similar to a vortex lattice but with vortex filaments from each revolution collated in a ring; this was inspired by analysis methods for bat flight. It also included a one-dimensional frame finite element analysis (FEA) with detailed composite laminate and macrostructural failure models. The vortex-ring model captured ground effect and agreed very well with models from the literature and experimental results. Another important element was a parametric mass estimation developed from the Snowbird. Our design objective was minimum power, for as much margin as possible on the prize flight – with the understanding that this would be whittled away.

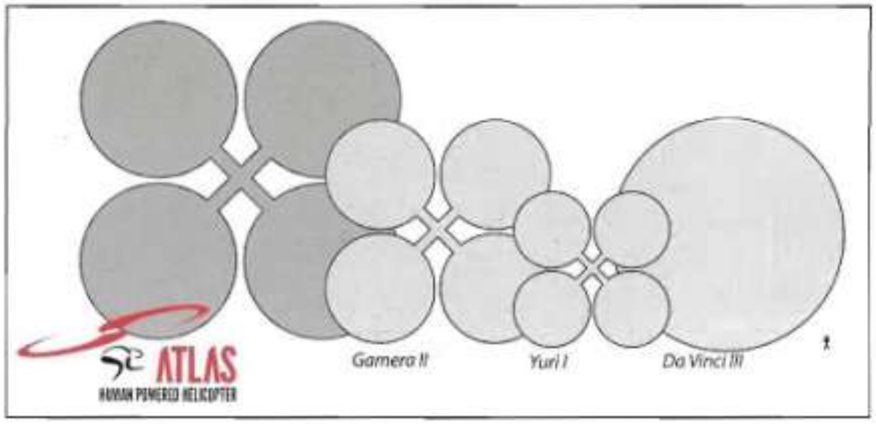
Many design decisions were based on familiarity. Given a tight timeline that aimed to win the prize by the end of August 2012, we wanted to minimize our learning curve. Plugged into the human-powered community, we made several human-engine decisions based on expert advice rather than independent study. For example, we opted for an upright bike instead of a recumbent one.

Building Atlas

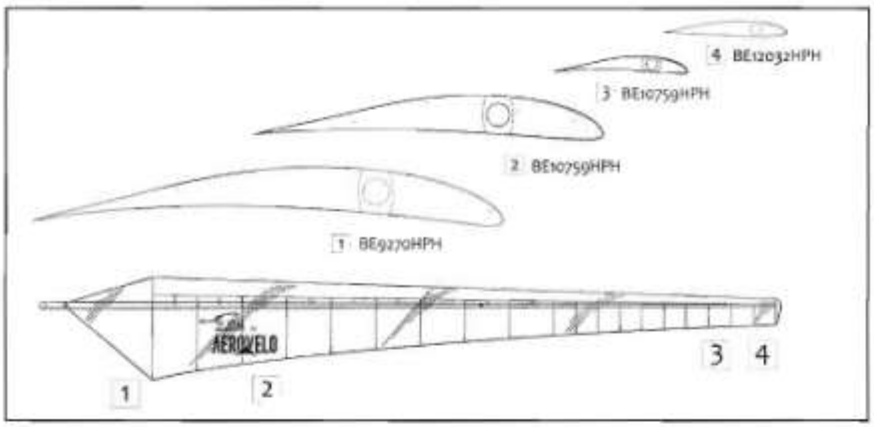
In May 2012, we recruited the eight-student summer team, made up largely of undergraduate engineering students from the University of Toronto. Our workspace was an old barn at the Great Lakes Gliding Club in Tottenham, north of Toronto. Our team lived together, biked to and from the barn, and cooked meals together. This tight-knit and focused approach was crucial to our collaborative process and passionate drive.

Light weight and creativity were prioritized during the detailed design stage. The rotor hubs were inspired by a bicycle wheel and went through five build/test cycles. The four-arm boom structure was in fact a hybrid between a truss and a wire-braced arch, designed with a gradient-based FEA optimization. A lift wire was also used for the main rotor spar, saving weight over a cantilevered spar at minimal drag penalty.

We used axially wrapped, pre-preg carbon-fiber tubes (a technique developed for the Snowbird) for the rotor spars and boom structure and a built-up rib construction for the lifting surfaces. We made few spares, reasoning that parts would be fast and cheap to repair on the field. Despite several enormous crashes, the helicopter weighed the same for the prize flight as it did when first built.



A comparison of the original size of the Atlas versus prior flying HPHs. Atlas' booms were later reduced in length by 10%, resulting in rotor overlap. (AeroVelo graphic)



Altas blade configuration. (AeroVelo graphic)

For the drivetrain, we chose a system that drove the rotors as string unwound from spools on the rotor hubs and wound up on spools connected to the bike pedals. We used off-the-shelf or modified components for the bike and mechanical elements where possible. The bike itself was suspended on lines.

We considered the control problem from the outset, contrary to nearly all other HPH designs. Our initial concept was to tilt the entire helicopter by using collective on each rotor. Each rotor's lift differential would be effected aeroelastically, with a small all-flying canard at the tip applying torque to twist or untwist the blade. This minimized the control force required and profile/induced drag penalties.

Initial Testing

We transitioned to the Ontario Soccer Centre in Vaughan, Ontario in mid-August 2012, with two weeks to do final integration and flight test. Having determined that flying outdoors would be prohibitively weight-expensive for gust tolerance, we searched for an indoor location. Of the few facilities that could contain Atlas, only the Soccer Centre was willing and able to accommodate us. Our early gambit had paid off.

Upon integrating the four boom structures and tuning the bracing lines, we found the booms were extremely flexible in torsion. Under load, they tended to twist and fall over. We supplemented the existing bracing lines with cross-bracing between the booms and additional pre-tension in the truss internal lines. These were the first of many incremental stiffening steps.

Flight test was very slow going. For one, the helicopter was stored in a 53 ft (16.1 m) trailer. Typically, 2 hours of assembly and rigging was required each morning and 45 minutes of disassembly needed in the afternoon. This left 6

Robertson and team fairing the rotor spar mandrel in their barn workshop in May 2012. (AeroVelo photo by Jake Read)

hours a day to fly. We began with ground tests, with and without canards attached, for rotor aerodynamic balancing. (Weight balance was not an issue.) Much time was spent painstakingly trimming the blades and canards. The rotors had been designed with significant negative pre-cone and minimal clearance to keep the tips in ground effect. Imbalances often resulted in tip strikes and broken blades. This dominated testing during the last week of August. We had six blade breaks. During our final flight, a control authority test resulted in dramatic imbalance of the canards on several rotors, breaking two blades upon landing after the 17 sec flight.

With the team back to class after that, the two of us focused on several experimental studies and modifications. We reduced the negative pre-cone on the rotors to improve clearance. Using in-pedal power measurement on the drivetrain, we conducted whirl-stand testing for the optimal blade and canard angles of attack as built. Improvement of the truss followed; we further tuned the bracing lines and modified attachment points for better rotor clearance. There was a fine balance between improved stiffness and reduced failure margin. (By the prize flight, several truss elements would be buckled prior to loading the pilot due to line pre-tension).

Testing resumed in January 2013; we flew roughly one day every two weeks. This model minimized disruptions of the students' academic work and allowed time to analyze data and make improvements between sessions. During these tests, we found the existing controls lacked authority, had an extremely slow reaction time and invariably caused dramatic and destructive rotor blade imbalances.

Atlas rotor spool on a test stand in the old barn in July 2012. (AeroVelo photo by Todd Reichert)

Evaluating other options, we realized the booms' extreme flexibility could be an advantage. We modified the bracing lines under the truss to connect to the bike frame, so when the pilot leaned left, right, forward or back, the lines would pull on the bottom of each rotor axle and instantly tilt the lift vector. This yielded intuitive control, instant reaction and substantial authority. We removed the canards for a 10% total weight saving and 15% drag reduction.

Going for the Prize

In March, we conducted our first prize attempt. Having made progressive flights to 1 and 2 m (3.28 ft and 6.56 ft) heights, we saw that a flight to the AHS Sikorsky Prize's required 3 m was possible, if fairly aggressive. We were prone to taking risks, cutting corners or rushing due to the race with Team Gamera. Our helicopter climbed with power margin and control, but flexibility allowed a growing "wobble" in multiple rotors. Upon starting the descent after reaching nearly 3 m, the front rotor lost lift and fell rapidly, breaking two booms. The crash damaged much of the helicopter, which required five weeks to rebuild. We addressed all possible causes of the crash, but couldn't establish definitive evidence of a root cause.

In late April, we went from re-trimming the rebuilt helicopter to making a prize attempt in one day. Again, a smooth climb to nearly 3 m ended with the front rotor in a rapid descent and a mid-air breakup. During the six-week rebuild, we re-evaluated possible causes and several outstanding concerns with the truss structure. We shortened the boom arms by about 10%, increasing their stiffness and reducing weight (and repair time). This resulted in the rotors intermeshing, but phase offset and slow rotor rpm eliminated the possibility of tip strikes. We modified the lines under the structure so the arch loads were borne by lines connecting the bottom of each adjacent rotor axle instead of those to opposing axles. This increased stiffness and substantially reduced the large oscillations resulting from inconsistencies in drive power.

We were testing again in early June. With a new full-time, summer-student team, we planned a five-day block of testing and focused on taking deliberate and incremental steps. After we made small adjustments to bracing lines and rotor angles, Atlas was finally behaving in a controlled and consistent manner. Going into the fifth day, we were able to leave the helicopter assembled overnight, pre-trimmed and in excellent shape for a prize attempt in the morning. As the primary pilot, Todd was able to take an ice bath, recover and get some rest before starting his focused warm-up routine the next day.

Top view of Altas in the Ontario Soccer Centre a few days after the first flight on August 28, 2012. (AHS photo)

On the morning of the prize-winning flight, we performed two checkout flights to roughly 2 and 2.5 m. We made final trimming adjustments and ensured that everything behaved properly as altitude and input power were increased. On the prize-winning flight, Todd shot up like a rocket, peaking at 1,100 W (nearly 1.5 hp) and clearing the 3 m mark within 10 sec. To avoid vortex-ring state (a potential cause of previous crashes), he maintained power and Atlas used the rest of the minute to descend as slowly as possible. The helicopter drifted left, but Todd leaned aggressively to the right to maintain control. Upon landing, a momentary silence was shattered by cheers and applause. In an instant, 18 months of intense focus and dedication were committed to history.

The Pillars of Success

We are often asked what led to our success. There is no single magic ingredient, but in a general sense it can be distilled into four key pillars.

First and foremost was the small, dedicated team whose members came on board with no promise of pay and worked together with passion and a common vision.

Second was a strong background and familiarity with the work of experts that had come before us. We made sure not to reinvent the wheel, and chose construction techniques that had been mastered for the human-powered AeroVironment Gossamer Albatross, the MIT Daedalus, and our Snowbird.

The third factor was seeing beyond the constraints that had held back previous designs, particularly regarding the enormous size required.

The final factor was perseverance. This project gave us an entirely new concept of persistence, challenging our drive and motivation with every setback and every crash. Needless to say, it was all worth it.

We've established AeroVelo as a design and innovation lab focused on high-profile, thought-provoking engineering projects. Our greater mission is to engage in projects that

Close-up view of the center of the Atlas trusses. (AeroVelo photo by Jake Read)

Repair of the rotor mid-spar after a September 1, 2012 impact. (AeroVelo photo by ckmmphotographic/Mike Campbell)

Two crashes from nearly 3 m in March and April 2013 were major setbacks but also the inspiration for the final winning configuration. (AHS photo)

The Atlas Team, with the primary manpower coming from undergraduate University of Toronto engineering students, celebrates at the July 11 award ceremony. (Photo by Kenneth I. Swartz, Aeromedia Communications)

Watch the record flight; http://www.youtube.com/watch?v=LEPryYsN1wY

AeroVelo Atlas Human Powered Helicopter Facts

Maximum diagonal dimension:	154 ft (46.9 m)	
Rotor area:	13,700 ft^2 (1,276 m^2)	
Maximum height:	11.9 ft (3.625 m)	
Weight (approximate)	122 lb (55.3 kg)	

Less than the weight of the air in the truck where the helicopter was stored

Weight of Powerplant (Reichert)	160 lb	(60 kg)
Power: Average	0.9 hp	(700 W)
Peak	1.5 hp	(1,100 W)

The same as a cordless drill

Construction:

- Carbon-fiber composite, including 1,500 ft (457.2 m) of carbon fiber tubes
- Balsa wood
- Polystyrene foam
- DuPont Melinex polyester film
- 3,280 ft (1 km) of Vectran line (from CSR Inc.)
- DuPont Kevlar, including 6.2 mi (10 km) of Kevlar thread
- Cervelo R5ca bike frame

Source: AeroVelo

inspire creativity and challenge the norms of conventional design, doing more with less and leading the way to a healthy and sustainable future. We've now instituted annual experiential learning programs for engineering students, providing them with the opportunity to participate in unique projects such as Atlas. These will allow them to gain hands-on experience, challenge themselves and push engineering technology to its limits. Our current focus is on human-powered land vehicles: "speedbikes" capable of nearly 80 mph (129 km/hr) on a level road.

After that, there remain two Kremer human-powered aircraft challenges … we've been told they're impossible.

About the Authors

Dr. Todd Reichert was the pilot and Chief Aerodynamicst of AeroVelo's Atlas helicopter project. Cameron Robertson was Chief Structural Engineer. Both are co-founders of AeroVelo.

Scan this QR code or go to ***www.vtol.org/aerovelo*** *for AeroVelo videos and photos.*

The barn at the Great Lakes Gliding Club in Tottenham has given birth to the world's first human powered ornithopter and the winner of the AHS Sikorsky Prize. This could be just the beginning. (AeroVelo photo by Jake Read)

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