

**Final Report for Virginia Space Grant Consortium Management of
National General Aviation Design Competition**

**National General Aviation Design Competition
Project Report**

October 1, 2000 - September 30, 2001

NASA Langley Research Center Grant #NAG1-01047

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This report summarizes the management of the National General Aviation Design Competition on behalf of NASA, the FAA and the Air Force by the Virginia Space Grant Consortium (VSGC) for the time period October 1, 2000 through September 30, 2001. This was the VSGC's seventh and final year of managing the Competition, which the Consortium originally designed, developed and implemented for NASA and the FAA. The competition is now being managed in-house by NASA.

Awards to winning university teams were presented at a ceremony held at AirVenture 2001, the Experimental Aircraft Association's Annual Convention and Fly-In at Oshkosh, Wis. by NASA and FAA officials.

The competition called for individuals or teams of undergraduate and graduate students from U.S. engineering schools to participate in a major national effort to rebuild the U.S. general aviation sector. Participants were challenged to meet the engineering goals of the Advanced General Aviation Transport Experiment (AGATE) project. For the purpose of the contest, general aviation aircraft are typically defined as single or twin engine (turbine or piston), single-pilot, fixed-wing aircraft for 2 - 6 passengers. The competition seeks to raise student awareness of the importance of general aviation by having students address design challenges for a small aircraft transportation system. NASA, AFRL and the FAA hope to stimulate breakthroughs in technology and their application in the general aviation marketplace.

National goals for revitalizing the industry offer excellent, open-ended design challenges with real world applications for the Innovative Design Category. Both individual and team submissions were encouraged. University faculty advisors and students consistently cite the value of this kind of educational experience for their engineering students. Eight proposals were submitted for the 2001 Competition for the Innovative Design Category. Eleven faculty members and 124 students participated. Since inception, more than 785 students and 60 faculty members have participated in the Competition. A review panel comprised of general aviation experts from the FAA, EAA, NASA and industry representatives reviewed the design packages and selected the winners.

The VSGC coordinated marketing of the competition to a mailing list which included selected deans and department chairs from ABET-accredited institutions, Space Grant affiliates, faculty who had previously participated in or expressed interest in the Competition, and others.

Awards were made at the EAA's Air Venture 2001 in Oshkosh, Wis. in July. Innovative Design Awards were presented to winners at a press briefing on Saturday, July 28. The Innovative Design Awardees also gave technical forums and participated in a discussion with Dr. Elizabeth Ward of NASA Langley about the future of the competition. The University of Oklahoma, the Design It, Build It, Fly It winner from 2000, was recognized at the press briefing, exhibited its seat design research in the NASA exhibition area, presented a technical forum, and also received recognition, including a \$500 check from the EAA, at a Theater in the Woods program.

Mary Sandy developed a press release on the Innovative Design category winners and assisted with development of a fact sheet on the University of Oklahoma's Design It, Build It, Fly It category award that spanned the 2000 – 2001 academic year. The NASA Fact Sheet was distributed at the EAA AirVenture 2001 exhibit.

The first place award was presented to a 19-student team from Embry-Riddle Aeronautical University, Daytona Beach, Fla. The team's design, undertaken in collaboration with several manufacturers, seeks to retrofit the popular Cessna 182 Skylane with a modern, turbocharged reciprocating diesel engine. The students hope to attain an FAA supplemental type certificate for the changes involved in the retrofit. The diesel engine is designed and manufactured by Société de Motorisation Aéronatique (SMA) in France. It runs on readily available Jet A fuel. The review panel, which was comprised of representatives from NASA, FAA, industry and academia, praised the design for its practicality. The team sought to lower costs through extended time between overhauls, increased fuel economy and decreased direct operating costs. The design provides for low emission and low noise technologies while reducing pilot workload and increasing engine reliability. A team goal was a certifiable, digital, single-lever, power control system.

The review panel of general aviation experts rated the design effort as outstanding overall. The first place award provided a total of \$3,000 to Embry-Riddle's design team members and a \$5,000 award to the university's Aerospace Engineering Program. James Ladesic and Reda Mankbadi served as the team's faculty advisors.

Second place honors went to Pennsylvania State University, University Park, Pa. The team's design, named *Defiance*, features a four-place, single engine, turboprop-powered, general aviation aircraft that was developed in a senior aerospace engineering aircraft design course. The twin tailboom, twin vertical tail layout uses both aluminum and modern composite materials, and features advanced aerodynamics, avionics and support systems. The team chose the Williams International EJ22 turboprop engine for fuel efficiency, improved performance and user-friendly engine control. The review panel was impressed with the quality of the very realistic workman-like design. The second place award provided a \$2000 prize to the 26-member student team. Hubert C. "Skip" Smith was the team's faculty advisor. The Pennsylvania State University has won a place award in every year of the competition.

The third place award went to the University of Virginia, Charlottesville, Va. for a design dubbed *Vector Evolution*. The design combined the fast, high altitude performance of a business jet with short takeoff and landing performance of a typical general aviation aircraft.

The project's six-seat aircraft features vectored thrust, ease of operation and strong aesthetics. The team's faculty advisor was James McDaniel. For third place, the 26-student team shared a \$1,000 prize.

The Best Use of Air Force-Developed Technologies award earned the University of Virginia team a separate \$3,000 award from the Air Force Research Laboratory. These technologies included: wireless flight controls, non-hydraulic, electric actuator systems, and aerogel and serrated engine nozzle edge noise reduction techniques.

Virginia Tech, Blacksburg, Va. and its collaborating international partner -- Loughborough University, Leicestershire, United Kingdom won an **honorable mention** for *Tempus*, an aircraft with a 3,600 nautical mile range. The 25-student team set a goal of efficient, affordable and comfortable transportation between international destinations. The design features an advanced composite structure and modern aerodynamics while offering comfort for passengers making transoceanic or extended flights. James Marchman was the Virginia Tech faculty advisor, and Gary Page and Lloyd Jenkinson served as faculty advisors at Loughborough.

A group of student engineers from the University of Oklahoma in Norman, OK working to create safer, more crashworthy seating for aircraft passengers, was the winner of the *Design It, Build It, Fly It* award of the National General Aviation Design Competition. The student team, working under the guidance of faculty advisor Karl Bergey, received a \$10,000 grant in 2000 to take their highly innovative seat designs through a proof of concept phase. The students also received an award of \$500 from the Experimental Aircraft Association (EAA), the award co-sponsor, upon presentation of the final results of their work at the EAA's AirVenture 2001 in Oshkosh, Wis. The award was recognized at the GA Design Competition Ceremony and also at a special EAA ceremony.

The University of Oklahoma award is the second to be made in this category. An earlier version of the seat design won the *Design with Best Retrofit Potential* award in the 1999 General Aviation Design Competition, which was sponsored by the Aircraft Owners and Pilots Association (AOPA).

Senior aerospace engineering design students at the University of Oklahoma are designing and building a four-place high performance general aviation aircraft, the BAC S28R Cougar, that incorporates a number of innovative design features and complies with current FAA requirements for aircraft certification. It is an ongoing project of the senior aerospace design program at the University of Oklahoma. Over a period of two years, twenty-two aerospace and mechanical engineering students have been involved in the project, including seven female students. The purpose of the project is to demonstrate the suitability of these features for incorporation into general aviation aircraft, either in new designs or through retrofit to the existing fleet. The energy absorbing seat design is part of the full aircraft renovation. The goal for the team's seat design is to create a lightweight and low cost energy-absorbing, crash worthy seat that would meet the lumbar loading requirements of federal aviation regulations. The seat design will help dissipate excess energy and prevent lower back and pelvic injuries.

The team used a variety of static and dynamic tests to narrow the type of material that should be used. The goal is to design the seat such that the occupant loads would be dissipated in the seat pan rather than the seat frame itself. The seat pan is made of expanded carbon steel, which has been slit and expanded or drawn into an open mesh pattern in a single operation without loss of metal. This process creates a material that is stronger per pound and absorbs impact energy through plastic deformation. The resulting material looks much like a diamond patterned chain link fence and early tests using a tapered seat pan have indicated its capability to minimize loads on a passenger's spinal column.

As Karl Bergey, Faculty Advisor, states "The purpose of the program is to provide hands-on design and fabrication experience for the student aerospace engineers. In a computer-dominated educational system, the requirements for real world engineering judgement are often neglected. The COUGAR project supplies that linkage."

Oklahoma students used the award to undertake additional testing to refine the design of the seat pan and to validate the results of their previous static and dynamic tests. Since the seat pan design was fairly well evolved, the design of the seat back will be the focus of analysis and testing for optimum configuration, design and strength.

The COUGAR seat design represents a new approach to energy absorbing seats for aircraft. It has been developed to meet the current impact requirements of CFR14, Part 23 emergency landing conditions. Part 23.562 specifies that the compression load on the spine of a 170 pound test dummy shall be no greater than 1500 pounds when the seat and dummy are subjected to an impact force of at least 19g. The COUGAR seat meets the Part 23 requirement. It is also simple, lightweight, and cheap. A prototype seat was successfully tested in the impact sled facility at the FAA's Civil Aeromedical Institute (CAMI) in Oklahoma City. It met the FAA requirement through elasto-plastic deformation of the seat pan itself. The seat structure remained intact and, along with the seat belt and shoulder harness, continued to support and restrain the test dummy. Since the energy-absorbing feature of the seat involves only the seat pan, the new technology can be applied to all seats in the aircraft, including those that may be part of the primary structure of the aircraft itself. It appears that the design approach demonstrated in the Cougar seat can be adapted to many existing GA aircraft. It will also allow those not in compliance with the current FAA impact requirements to be brought up to current certification standards at relatively low cost.

Additional funding was provided through AGATE to bring students to Oshkosh to experience advances in general aviation technology and to participate in next steps planning for the Design Competition. Dr. Elizabeth Ward of the NASA General Aviation Program Office met with faculty advisors and students at Oshkosh for a planning session and to seek their input.

Attachments include:

Copy of the NASA Press Release prepared by the VSGC

Copy of the NewsFacts Sheet co-developed by the VSGC

NewsRelease



National Aeronautics and
Space Administration

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For Release: July 28, 2001

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RELEASE NO. 01-072

University aviation design competition winners named

NASA, the Federal Aviation Administration and the Air Force Research Laboratory (AFRL) today awarded honors to four university teams for their innovative general aviation designs. The winners of the National General Aviation Design Competition were recognized at a ceremony held at AirVenture2001, the Experimental Aircraft Association's Annual Convention and Fly-In at Oshkosh, WI.

The competition calls for individuals or teams of U.S students to participate in a major national effort to rebuild the U.S. general aviation sector. Participants are challenged to meet the engineering goals of the Advanced General Aviation Transport Experiment (AGATE) project. For the purpose of the contest, general aviation aircraft are typically defined as single or twin engine (turbine or piston), single-pilot, fixed-wing aircraft for 2 - 6 passengers. NASA, the FAA and AFRL hope to stimulate breakthroughs in technology and their application in the general aviation marketplace.

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The first place award provides a total of \$3,000 to Embry Riddle's design team members and a \$5,000 award to the university's Aerospace Engineering Program. James Ladesic and Reda Mankbadi served as the team's faculty advisors.

Second place honors went to Penn State University, University Park, PA. The team's design, *Defiance*, features a four-place, single engine, turboprop-powered, general aviation aircraft. The twin tail boom, twin vertical tail layout uses both aluminum and modern composite materials, and features advanced aerodynamics, avionics and support systems. The second place award provides

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a \$2000 prize to the team. Hubert C. "Skip" Smith was the team's faculty advisor. Penn State has won a place award in every year of the competition.

The third place award went to the University of Virginia, Charlottesville, VA, for a design dubbed *Vector Evolution*. The design combined the fast, high altitude performance of a business jet with short takeoff and landing performance of a typical general aviation aircraft. The team's faculty advisor was James McDaniel. For third place, the team will share a \$1,000 prize.

An honorable mention in the General Aviation Design Competition went to Virginia Tech, Blacksburg, VA, and its collaborating international partner Loughborough University, Leicestershire, United Kingdom, for *Tempus*, an aircraft with a 3,600 nautical mile range. The team set a goal of efficient, affordable and comfortable transportation between international destinations. James Marchman was the Virginia Tech faculty advisor, and Gary Page and Lloyd Jenkinson served as faculty advisors at Loughborough.

The best use of Air Force-developed technologies award was also presented to the University of Virginia's *Vector Evolution* design. The team received an additional \$3,000 from the Air Force Research Laboratory. These technologies included: wireless flight controls; non-hydraulic, electric actuator systems; and aerogel and serrated engine nozzle edge noise reduction techniques.

The competition for the 2000 - 2001 academic year was managed by the Virginia Space Grant Consortium. The AGATE project will end in September 2001, and the new competition will be managed by the General Aviation Programs Office, NASA Langley Research Center. A preliminary announcement for the new competition is available under EVENTS on the SATS web site (<http://sats.nasa.gov>).

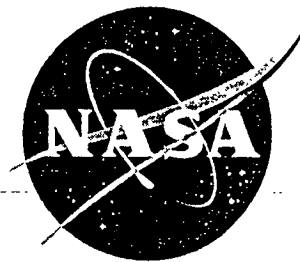
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Note: Electronic images to illustrate this story are available at <http://oea.larc.nasa.gov/designimages>

NewsFacts

National Aeronautics and
Space Administration

Langley Research Center
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July 2001

'Design It, Build it, Fly it' sponsored by NASA, FAA, Air Force Research Lab

OU team proves energy-absorbing seat concept

Last year, a team of students from the Aerospace Engineering Department of the University of Oklahoma was awarded \$10,000 to prove their concept for an energy-absorbing seat for a four-seat airplane. This year, they have completed the project. The award was granted through the National General Aviation Design Competition "Design It, Build It, Fly it" category, sponsored by NASA, the Federal Aviation Administration and the Air Force Research Laboratory. The students teamed with Bergey Aerospace Co., Inc. on the project.



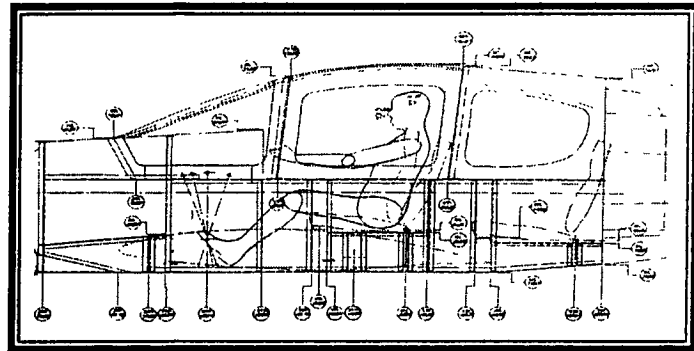
The team has been building an advanced aircraft they call "COUGAR" for the last three school

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years. The design and development of the aircraft serves as an on-going part of the senior Aerospace Engineering Design class at OU. The purpose of the competition, aside from the hands-on educational experience for the students, is to design, build and fly a general aviation (GA) aircraft that incorporates a number of innovative features, many of which can be applied to new GA aircraft or refitted to the existing GA fleet.

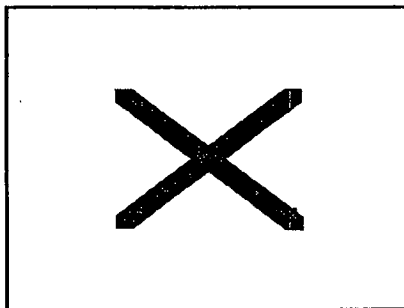
The 'Design It' award was given in summer 2000 to allow the student team to take the energy-absorbing seat to a proof of concept stage. With that task now accomplished, the team received an additional \$500 award from the Experimental Aircraft Association at the AirVenture 2001 airshow and convention in Oshkosh, Wis.

During the EAA AirVenture 2001 airshow and convention at Oshkosh, Wis., the construction of the seat will be shown in the COUGAR cabin mockup on display in the NASA building. The team will present the results of their work in a NASA Technical forum at AirVenture on Saturday, July 28 at 8:30 a.m.



COUGAR is a four-place, high-performance, single-engine aircraft. Simplicity and minimum parts-count have been guiding principles in the design of both structures and systems. An attempt has also been made to use the most appropriate materials and fabrication techniques for each of the major airframe components. Thus, the COUGAR is a combination of materials, including high-strength composites, welded steel tubing, and conventional light alloys. It uses a variety of construction processes.

The COUGAR seat design represents a new approach to energy absorbing seats for aircraft. It has been developed to meet the current impact requirements of CFR14, Part 23 emergency landing conditions. Part 23.562 specifies that the compression load on the spine of a 170 pound test dummy shall be no greater than 1500 pounds when the seat and dummy are subjected to an impact force of at least 19g. The COUGAR seat meets the Part 23 requirement. It is also simple, lightweight, and cheap. A prototype seat was successfully tested in the impact sled facility at the



FAA's Civil Aeromedical Institute (CAMI) in Oklahoma City. It met the FAA requirement through elasto-plastic deformation of the seat pan itself. The seat structure remained intact and, along with the seat belt and shoulder harness, continued to support and restrain the test dummy. Since the energy-absorbing feature of the seat involves only the seat pan, the new technology can be applied to all seats in the aircraft, including those that may be part of the primary structure of the aircraft itself.

It appears that the design approach demonstrated in the COUGAR seat can be adapted to many existing GA aircraft. It will also allow those not in compliance with the current FAA impact requirements to be brought up to current certification standards at relatively low cost.

In addition to the energy absorbing seat design, additional new technologies incorporated in the COUGAR aircraft include:

CRASHWORTHINESS:

The COUGAR incorporates structural crashworthy features, including crushable structure ahead of the cabin and a steel-tube safety cage over the top of the cabin. The forward baggage compartment, located between the firewall and the cabin, provides energy absorbing structure to reduce the impact forces acting on both the cabin structure and the occupants. An aft baggage compartment as the additional advantage of assisting the pilot in loading the COUGAR within approved center-of-gravity limits.

Along with the steel tube safety cage, the strengthened lower cabin structure is designed to provide additional protection for the occupants.

NEW DUAL-MODE EXHAUST SYSTEM

The COUGAR is powered with a Lycoming 10-540-K1G5 engine and a Hartzell tree-bladed propeller. The engine is rated at 282 horsepower at 2500 rpm. The engine exhaust system is designed to meet the flyover noise requirements of Part 36. The exhaust stacks are tuned for effective exhaust scavenging. They also incorporate a straight-through muffler system. Together, they are designed to reduce noise and improve the volumetric efficiency of the engine, thereby increasing power and reducing fuel consumption.

Performance

The estimated performance of the COUGAR is:

Max speed (mph/k)	215/187
Max CR Speed, 75%, 8000 ft (mph/K)	205/178
Max R/C, G, Sea Level (ft/m)	1600/8.1
Range, IFR, 75%, 8000 ft (st mi/n mi)	910/790
T.O. Distance, 50ft, GW, SL (ft/m)	1350/412

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Electronic images of COUGAR and seat design are available:
<http://oea.larc.nasa.gov/crashimages>