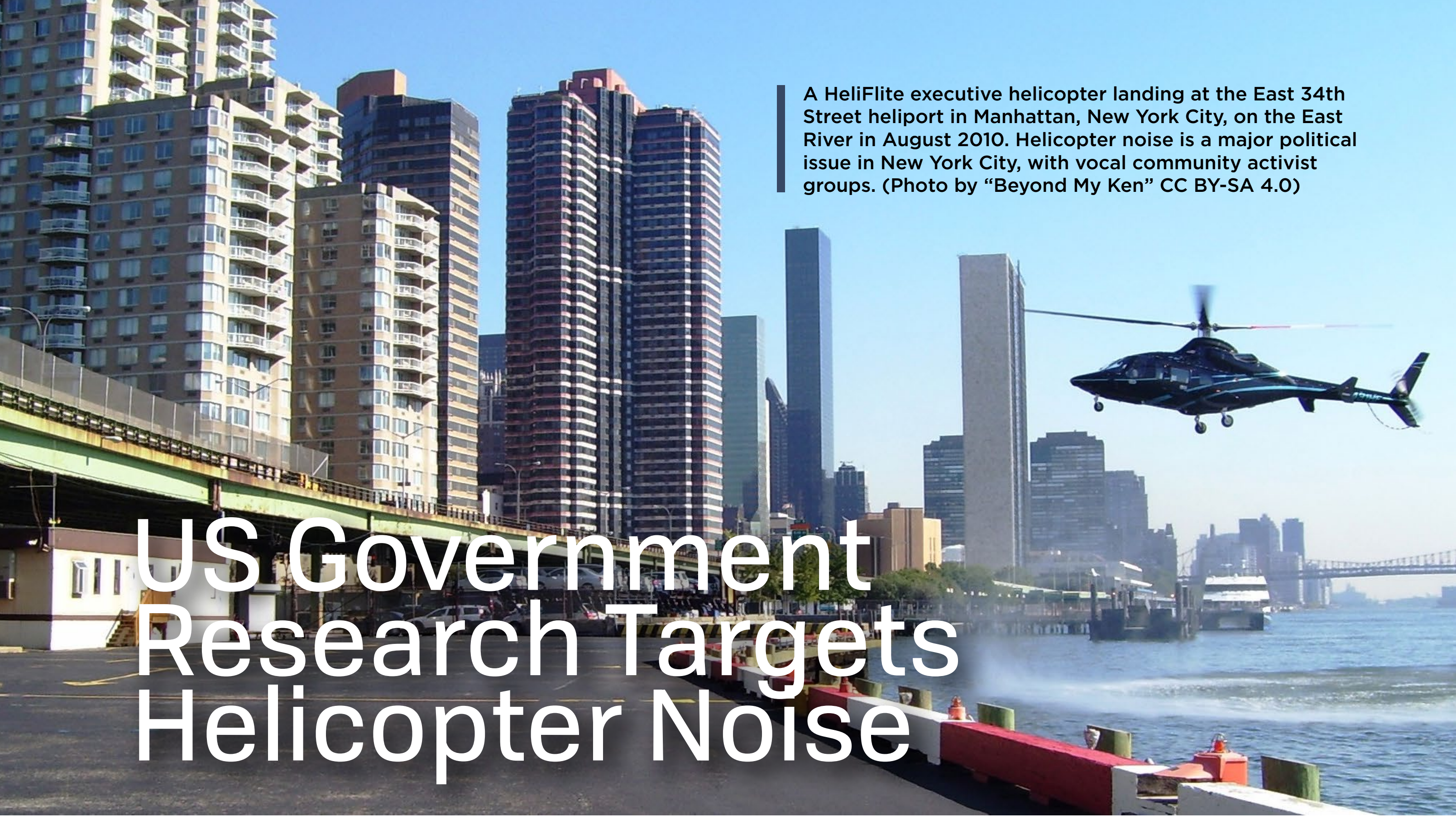


A HeliFlite executive helicopter landing at the East 34th Street heliport in Manhattan, New York City, on the East River in August 2010. Helicopter noise is a major political issue in New York City, with vocal community activist groups. (Photo by "Beyond My Ken" CC BY-SA 4.0)

# US Government Research Targets Helicopter Noise

*The FAA, Volpe, NASA and industry partner to understand and reduce noise that annoys communities.*

**By Douglas Nelms**

Nothing proves the value of the helicopter to the civilian populace more than natural disasters, and there is nothing sweeter than the sound of a helicopter swooping in to rescue someone from a flooded house or off the top of a submerged car following the latest hurricane, as recent events have hammered home.

Unfortunately, in today's world, even a helicopter's life-saving capabilities aren't enough to ensure public acceptance. There will always be individuals and communities who rise up in protest at the sound of a helicopter, regardless of how intrusive it is or isn't. Even though new technology is making the new generation helicopters quieter, a lot of communities — particularly in major population centers such in New York and the Los Angeles basin — are becoming louder in their objections to helicopter noise.

Since helicopter noise can't be totally eliminated, the question becomes: "How do we make helicopters more acceptable to the civilian community?" This question is now at the core of research being conducted by joint government, university and industry programs, sponsored by the US Department of Transportation (DOT), NASA and various universities.

Since 2013 (partly as a result of advocacy efforts by AHS International), the US Federal Aviation Administration (FAA) and NASA have invested additional funding in their helicopter noise research programs, and the two agencies have strengthened their collaborative efforts.

### AHS Community Noise Initiative

In recognition of the increasing community noise complaints and successful efforts to restrict helicopter usage, AHS International initiated an effort with HAI to help the technical and regulatory community better understand and address helicopter noise and noise complaints. Go to **www.vtol.org/noise** to learn more or to download past articles and technical reports.

## ASCENT

One of the most ambitious programs is ASCENT ("Aviation Sustainability Center"), which is the FAA Center of Excellence for Alternative Jet Fuels and Environment (**www.ascent.aero**).

ASCENT is a cooperative aviation research organization co-led by Washington State University and the Massachusetts Institute of Technology, and funded by the FAA, NASA, the US Department of Defense (DOD), Transport Canada and the US Environmental Protection Agency (EPA). It was formed from a coalition of 16 leading US research universities as well as international research programs, federal agencies and national laboratories "to create an all-inclusive research capability for whatever environmental impact obstacle the aviation industry faces." The program is aimed at the overall aerospace industry with the goal of creating "science-based solutions for the aviation industry's biggest challenges."

The ASCENT program involves 48 projects, two of which are aimed at rotary-wing noise abatement and are being led by Prof. Ken Brentner at The Pennsylvania State University. The first, now completed, was primarily aimed at noise abatement through operational procedures while maintaining safety and mission completion. The second consists of studies meant to measure noise levels under specific conditions through modeling, and then to validate the findings.

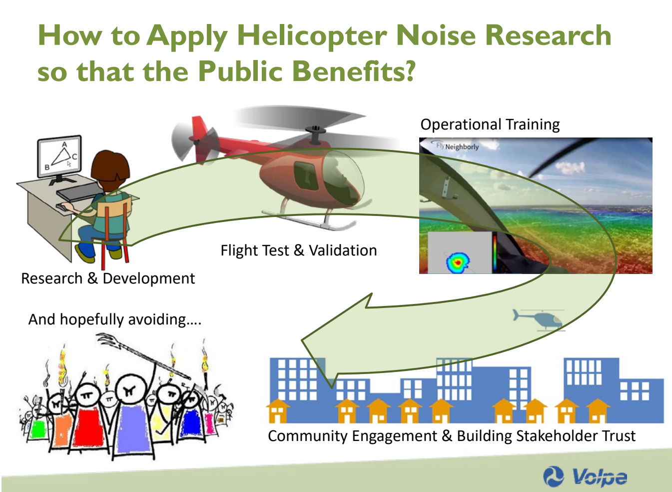
Project 6 — "Rotorcraft Noise Abatement Operating Conditions Modeling" — was conducted between 2014 and 2016 (reports are available on the ASCENT website). The project team used models to develop noise abatement procedures for helicopters, and then it created a flight test plan to study whether the model-based flight procedures were effective. The team also used the modeling tools to demonstrate the ability to gather noise data for conceptual vehicles with advanced technology that can be used in the FAA's Aviation Environmental Design Tool (AEDT).

AEDT is a software system "that dynamically models aircraft performance in space and time to produce fuel burn, emissions and noise. Full flight gate-to-gate analyses are possible for study sizes ranging from a single flight at an airport to scenarios at the regional, national, and global levels," the agency said.

At an AHS Fly Neighborly Roundtable at Forum 73, Rick Riley, an FAA environmental protection specialist, noted that AEDT will be used to answer challenges that include "needing to expand approach source noise data to have the flexibility of multiple flight path angles and speeds."

The FAA plans to release updated performance data in AEDT next year, while several papers on Project 6 have already been presented at AHS International conferences.

ASCENT's Project 38 — "Rotorcraft Noise Abatement Procedures Development" — began last year and is still ongoing. The project's objective "is to utilize computational and analytical modeling to develop noise abatement procedures for various helicopters for various phases of flight." These procedures will be compared to representative baseline operations using various noise metrics, along with the acoustic pressure time history and acoustics spectrum plots that will be used primarily to explain what is influencing the metrics.




A slide presented by Volpe at the Forum 73 Community Noise Roundtable summarizes the holistic approach needed to reduce helicopter noise and noise complaints. (Volpe graphic)

Part of the need for Project 38 stems from the fact that the original equipment manufacturers (OEMs) are no longer developing or updating the model-specific noise abatement procedures for their aircraft. As a result, to effectively control noise, operators need more detailed data and information about the noise produced from the operation of each rotorcraft model, with detailed and specific noise abatement procedures.

As part of Project 38, Penn State is developing a noise prediction system that uses the PSUHeloSim flight dynamics model to trim the aircraft for the desired flight path, coupled with Continuum Dynamics' CHARM model, which generates the main rotor and tail rotor forces and moments. PSU-WOPWOP then predicts the noise hemisphere.

The project team is investigating noise abatement flight procedures of rotorcraft through modeling, with physics-based modeling of noise, leveraging previous research performed for NASA and the DOD. The plan is to achieve comprehensive modeling of the many sources of rotor noise, with complete vehicle modeling during example flight procedures — such as flyovers, approaches, departures and turn maneuvers.

## Volpe Research

The Volpe National Transportation Systems Center is also deeply engaged in rotorcraft noise research. Volpe (named after John A. Volpe, Secretary of Transportation under President Nixon) is the DOT's "think tank" research center for all transportation modes. While Volpe is a division within the DOT, it is not congressionally funded through appropriations. Funding for specific programs comes from government agencies such as the FAA and NASA, academia, states or the private sector.

Volpe is now working with various agencies to find ways to get acoustics research into the hands of operators through programs such as Fly Neighborly and iFlyQuiet, which will "focus on updating the Fly Neighborly program and providing noise abatement procedures to be available to the pilots and operators impacting the community," Riley said.

Fly Neighborly is the helicopter pilot training program for noise abatement procedures administered by the Helicopter Association International (HAI). Originally started in 1982, Fly Neighborly techniques for noise abatement are taught as a training course for rotorcraft airmen and operators (the HAI Fly Neighborly/Environmental Committee updated the course and the accompanying white paper earlier this year). Volpe plans to assist with integrating Fly Neighborly into the FAA's advanced WINGS pilot proficiency award program; a course on the subject will be given at HAI's Heli-Expo trade show next year. iFlyQuiet (initially proposed by AHS and HAI) is a planned community engagement program funded by the FAA and conducted by Volpe.

The FAA also sponsors the US Transportation Research Board's Airport Cooperative Research Program (ACRP), an applied research program that "develops near-term, practical solutions to problems faced by airport operators." Riley said that the ARCP has completed a project to study acoustic and non-acoustic factors, compare rotary- and fixed-wing noise, and develop methods to compare helicopter noise exposure with surveyed community annoyance, with the final documents from this study published this year.

According to Volpe's Christopher Roof and Juliet Page, their helicopter noise research program is based on three guiding principles to determine how to effect change in the helicopter noise community: 1) the physics and modeling of systems must be validated; 2) guidance provided to operators must be readily available and understandable, practical to implement, flight tested, adaptable to site-specific needs, and incorporated into basic flight training; and 3) communication and knowledge will lead to trust and improved acceptance. They note that, "In the long term improved helicopter designs can help reduce noise. In the short term operational procedures must be relied upon."

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## Key Points to Fly Neighborly

- Fly at an altitude that is as high as practical.
- Avoid residential areas when possible.
- Fly over industrial areas and major roadways to mask the sound of helicopters.
- Avoid late night/early morning flights.
- Fly at an altitude that is as high as possible over scenic and recreational areas such as parks and beaches.
- Identify noise-sensitive areas and adjust routes to avoid them to the extent possible.
- Adhere to published noise abatement approach/ departure procedures when flying in and out of airports and heliports.

Fly Neighborly
HELICOPTER PILOT TRAINING PROGRAM

iFlyQuiet
COMMUNITY ENGAGEMENT PROGRAM

**Volpe is working to get the results of acoustics research into the hands of operators through programs such as Fly Neighborly and iFlyQuiet. (Volpe graphics)**

Making the material from the studies readily available and understandable to the operators will require involvement from the OEMs, particularly in the area of flight manuals, while the basic training in flight procedures will fall under FAA requirements, Page said. Organizations like HAI and AHS can help promote the adoption and use of Fly Neighborly procedures. "There is a lot of stress between the public and the regulatory agencies. The only way [the industry] is going to help solve the helicopter problem is to overcome some of these stress issues. It's a combination of communicating, validating facts and getting the operators on board to improve the dialogue."

She added that Volpe is looking to partner with some operators for its iFlyQuiet program to get a better understanding of the factors that affect adoption of the Fly Neighborly principles. In general, Volpe wants to better understand how operational procedures are conducted in actual flight conditions, how they are constrained by pilot workloads and airspaces; how closely established procedures are followed; what kinds of flight-to-flight variations exist; what factors cause deviations; and whether automated procedures and technology can be adopted to reduce noise.

Another step in getting public acceptance is dealing with the problem of "virtual noise." Virtual noise is not necessarily the decibel level of helicopters, Page said. "People don't have calibrated ears, so the fact that they are complaining is based on how much they are being annoyed. People's annoyance is often related to the 'value' of the operation and not just the measured noise level; for example, annoyance from a medevac or police operation could be lower than annoyance from other types of operations with a lower perceived community value, even if the measured noise level is the same. This difference is 'virtual noise.'"

Roof noted that "non-acoustic issues can be huge," and that the industry needs to build trust with the community, with engagement done at the grassroots  local level.

One possible grassroots approach is the use of pilot "ambassadors" who have been trained by organizations such as NASA, FAA and/ or HAI to educate communities on how the industry is working both to increase the value of helicopters to the public and to reduce helicopter noise — or at least make it less annoying.

### Noise for Pilots

Part of the problem lies simply in the non-technical issue of the pilots. Pilots have a totally different view, one that involves use of their time, money and workload. Noise abatement becomes a human-factors issue when pilots see its effects as a risk to their safety or employability — such as increased equipment costs, increased training in special equipment, and flight envelope changes that increase mission distances and durations.

Prof. Brentner with Penn State said that information needs to be made easy to understand — what makes a difference and why. "Pilots are capable of changing, but they will not if nobody cares. If [they] understand that they can make a difference and can reduce the noise, they will be willing to make those changes. We're not going to do anything that isn't safe. It has to be something that they can do that is comfortable for them to fly."

While the results of rotary-wing noise studies can be very detailed, pilots don't need the raw information. The researchers need to know all the differences that are determined "so the information can be boiled down to show what is important and what isn't," said Brentner. "If I don't understand which things do or do not make a difference, then I cannot give advice to the pilot. So a lot of the detailed studies are for the engineers who can take the research and eventually package it in a way that is useful to the pilots. The tests will provide empirical predictions, then we can actually go back and fly the cases that are somewhat in between, or we can develop procedures. We want to be sure that the things we tell the pilots will work, then we have to help them understand why."

**Helicopters provide vital services, but a rising crescendo of community complaints is posing a tangible threat to continued commercial helicopter operations. (Robinson Helicopter photo)**

The studies indicate which metrics should be used and how they should be used to determine the public's response to helicopter noise. This includes areas such as amplitude of helicopter noise and different frequency ranges, with varying opinions in the industry on how that data should be used. "The metrics are how we take the sound and analyze it. We come up with things like sound pressure levels, with … things such as amplitude of the sound and different frequency ranges — and there are different ways to weigh that," Brentner said.

## Real-Time NASA Research

So it is unclear as to which methods are the best and what really corresponds to the requirements. The problem lies in determining to what extent, and under which conditions, people will be annoyed by helicopter noise. With the majority of individuals working on the issues being engineers, the question arises as to how to obtain numbers that are precise and mathematical so that it can be determined exactly how people will respond to specific noise levels. This is a challenge of the virtual noise concept — people express annoyance even when they can't determine the noise levels of the helicopter.

Dr. Eric Greenwood with the Aeroacoustics Branch at NASA Langley Research Center noted that recent research has led to a better understanding of overall helicopter noise. The research has enabled identification of "many important factors that we can now account for with accuracy." These include accelerations/decelerations, maneuvers, ambient conditions, wind speeds and directions, control inputs, and vehicle configurations. But accounting for all of these factors to reduce a helicopter's noise footprint — all while trying to fly safely — might be too much for pilots. A key challenge in the research is to determine how pilots can make use of this information and still fly the aircraft.

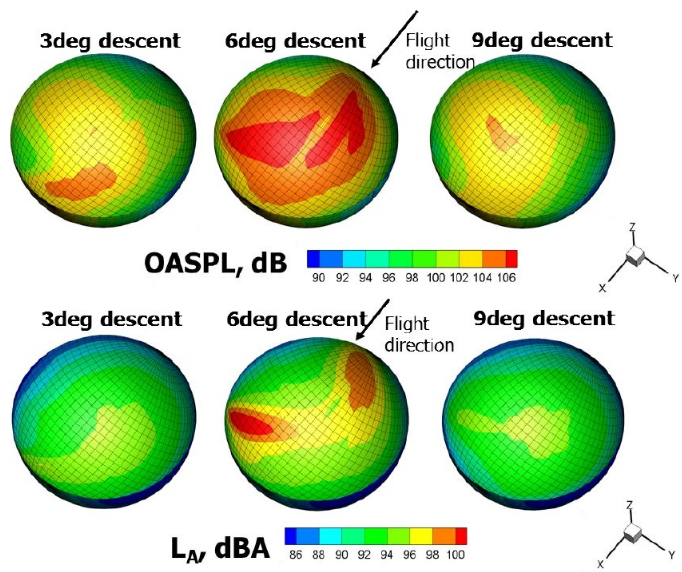
Now, however, accurate noise models can be fast enough to provide real-time noise feedback to the pilot, such as an overlay of an "annoyance footprint" on a moving map display (like a personal automobile GPS unit). Greenwood has developed the Fundamental Rotorcraft Acoustic Modeling from Experiments (FRAME) technique to "generalize measured data to a wide range of helicopter operation conditions."

By using a previously computed database of acoustic spheres, the acoustic impact of proposed helicopter operations can be rapidly predicted for use in mission planning. This develops a method to generate a realistic flight trajectory from a limited set of waypoints and is used to calculate the quasi-static operating condition and corresponding acoustic sphere for the vehicle throughout the maneuver.

This real-time noise modeling "may be a useful tool to reduce community impacts, as a training aid or for pilot community noise awareness," said Greenwood. However, he added that human factors research is necessary to determine the most effective ways to communicate community noise information. This could be done through heads-up displays, synthetic vision/augmented reality, haptic feedback (communication or recognition through touching) or integration with flight controls.

## Next Steps

In 2015, the FAA conducted a preliminary noise annoyance test in the Los Angeles basin, utilizing five volunteers and smartphones with a custom app to measure annoyance. The study determined that sound exposure level (SEL) was the best metric in evaluating helicopter annoyance.




**Above is a depiction of the noise hemisphere generated by a Bell 430 descending with no acceleration. It shows how blade-vortex interaction (BVI) peaks at around six degrees of descent, while a steeper or shallower descent angle reduces noise levels.(Graphic courtesy of Penn State)**

The FAA now has a 50/50 agreement with NASA, along with aircraft and flight testing provided by industry, for an upcoming Helicopter Noise Abatement Flight Test involving six different helicopter types. Testing is taking place between August and October 2017. The data will be used to validate Penn State's PSU-WOPWOP and NASA's FRAME models, with the ultimate goal of developing improved noise abatement procedures.

Details on the flight testing will be covered in a future issue of *Vertiflite*.

**About the Author**
Douglas Nelms is a retired US Army rotary-wing pilot and long-time aviation journalist, including serving as the managing editor of *Rotor & Wing* magazine. He is now a freelance writer specializing in the helicopter industry. He can be contacted at *dwnelms@msn.com*.