Peer into the Plume

The beauty of a rocket launch sometimes makes it a spectator event. Engines roar to life, billowing fire and smoke about the launch pad. The rocket lifts through the cloud and leaves behind a curving trail of smoke.

This "plume" of exhaust smoke may be pleasing to the eye, but is also can be hazardous to the environment. So, like Superman with his X-ray vision the Air Force is peering into the inner workings of the plume to protect the public and environment.

This new method of detecting toxic chemical clouds emitted from rocket launches and test firing is being developed under direction of Space Systems Division at Los Angeles AFB, Calif., and its companion services contractor Aerospace Corporation's Space and Environmental Technology Center.

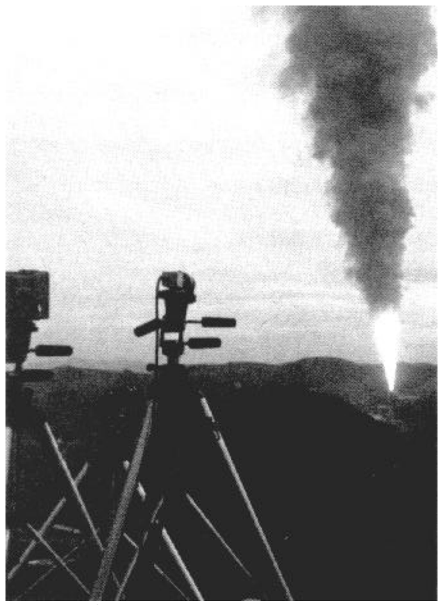
Led by center scientists Drs. Ken Herr, George Scherer, and Rick Heidner, the Toxic Plume Imaging program uses cameras with infrared light detectors. Rocket launches and test firings release toxic plumes -- the "smoke trail" -- into the atmosphere. Imaging detectors help evaluate the plume's size, its drift and location of its chemical contents, such as hydrazine or hydrogen chloride.

By setting up two cameras at 90 degree angles to each other, imaging provides a computerized three-dimensional video picture of individual chemicals within the cloud. Different filters are placed on the cameras to view wavelengths of infrared light from different toxic gases. The imaging allows scientists to check the accuracy of computer plume dispersion models and the location of air monitors.

"Modes that predict where toxic clouds go and their concentrations need the improvements we can provide with our techniques," Heidner said.

Plume dispersion models are based on factors such as wind speed and direction, temperature, humidity, ground surface roughness and type of gas. The models are usually tested by people on the ground who try to determine where the plume has traveled and its toxic concentrations. The infrared imaging helps fine-tune models by throwing off the cloud's cloak of invisibility.

Like Superman with his X-ray vision, the Air Force looks into the inner working of rocket exhaust to protect the public and environment while safeguarding the launch mission



Specially filtered video cameras capture visible, near infrared and infrared images of a Titan 34 D static test firing at a contractor's facility near San Jose, Calif.

"Up until recently, we used computer models to tell us where the toxic cloud ought to go from an activity such as a Vandenberg AFB Titan launch," Heidner said. "After the model has predicted safe launch conditions and the launch has occurred, someone takes a few samples of toxic chemicals and decides whether the model did a good job or not.

"No one wants to be responsible for underestimating hazards, sot he models tend to be very conservative. Unfortunately, that can result in the delay or shutdown of major operations costing the government millions of dollars when the operation may be perfectly safe."

A multidisciplinary team has been doing experiments by taking videos of non-toxic chemicals, such as sulfur hexafluoride, and of actual test firing toxic releases. Group members include Nhi Casey, Karen Foster, Carrol Gardner, Jeff Hall, Heidner, Herr, Tom Knudtson, David Levy, Mike Reese, Scherer and Don Stone.

"Tracer gas releases, such as the colorless, odorless, non-toxic molecule sulfur hexafluoride, can be imaged out to several miles," Herr said. "This tells us whether the plume dispersion model is giving reliable information. Compared to flying blind, we can now give the ground operations personnel a feeling of confidence on whether to proceed with a launch or the test."

The group's most intensive work now centers on developing the camera filter, which permits the molecules to be viewed and blocks out the majority of infrared in the background of daylight.

"That job is relatively easy for a large molecule such as sulfur hexafluoride where the molecular band is quite wide and conventional filters can be used," said team member Knudtson. "We've been developing a more sophisticated technology, scanning Fabry-Perot etalons, to detect the light from a molecule such as HCl (hydrogen chloride) which consists of many widely spaced, extremely narrow lines."

Supported by Bioastronautical Engineering and National Launch Systems of the Space Systems Division, and other Defense Department sponsors, the imaging project has potential for enormous payback. Expensive delays in launches and test firing due to weather changes could be prevented with this innovative process.

"Basically, you are seeing the result of a technology transfer of SSD/Aerospace expertise in infrared plume signature detection for rockets into the arena of environmental monitoring," Heidner said. "We've just scratched the surface of the power of advanced infrared optical methods coupled to modern image processing techniques. Our goal is to keep SSD operations safe and on schedule within the constraints of environmental regulations and responsibility."

by John Edwards • Space Systems Division environmental management