

## Miniature Blimps for Surveillance and Collection of Samples

These robots could follow complex three-dimensional trajectories through buildings.

NASA's Jet Propulsion Laboratory, Pasadena, California

Miniature blimps are under development as robots for use in exploring the thick, cold, nitrogen atmosphere of Saturn's moon, Titan. Similar blimps can also be used for surveillance and collection of biochemical samples in buildings, caves, subways, and other, similar



1-Meter and 2.3-Meter Radio-Controlled Blimps



Biochemical Collector Filled by Fan Engine

These **Miniature Blimps** are prototypes of radio-controlled, semiautonomous robots for use in preventing and detecting attacks on buildings and their occupants.

structures on Earth. The widely perceived need for means to thwart attacks on buildings and to mitigate the effects of such attacks has prompted consideration of the use of robots. Relative to "rover"-type (wheeled) robots that have been considered for such uses, miniature blimps offer the advantage of ability to move through the air in any direction and, hence, to perform tasks that are difficult or impossible for wheeled robots, including climbing stairs and looking through windows. In addition, miniature blimps are expected to have greater range and to cost less, relative to wheeled robots.

The upper part of the figure depicts two of the blimps, which have lengths of 2.3 and 1 m, and are commercially available as toys or advertising devices. The smaller blimp has a total mass of 200 g, maneuvers by use of fan motors, operates under radio control, and carries a video camera and transmitter. It is equipped with a JPL-fabricated biochemical collector in the form of a small cylinder filled with activated carbon and sandwiched by two open-cell filters. As shown in the lower part of the figure, the biochemical collector is mounted behind a fan motor, so that it automatically becomes filled with gas and/or biochemical dust when the motor is running. To kick up and collect surface dust, the blimp is made to land on its engine cowling and then its fan motors are turned on.

The larger blimp has a total mass of

1.2 kg. It can be filled in 30 seconds from the small bottle shown on the table in the figure. This blimp also operates under radio control and carries a video camera. This blimp has been equipped with an ultralight (170 g) automatic pilot manufactured commercially for radio-controlled small airplanes. This autopilot enables the control system of the blimp to utilize the Global Positioning System in following a trajectory through as many as 60 different waypoints. This autopilot also utilizes ultrasound for precise measurement and control of altitude when the blimp is <5 m above a surface.

For either blimp, the video signal could be utilized in conjunction with target tracking software running on a computer in a remote control station, such that the blimp could automatically approach a target chosen by a remote operator. Either blimp could easily pass through an open door, climb an open stairwell, or rise to look through a window. It could enter an elevator that was remotely operated or that had been manually set to open at a floor under surveillance. It could place small remote surveillance devices and/or relay devices at designated locations, including on ceilings.

*This work was done by Jack Jones of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1) NPO-30443*

## Hybrid Automotive Engine Using Ethanol-Burning Miller Cycle

This engine would operate with high fuel efficiency and generate little pollution.

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A proposed hybrid (internal-combustion/electric) automotive engine system would include as its internal-combustion subsystem, a modified Miller-cycle engine with regenerative air preheating and with autoignition like that of a Diesel engine. The fuel would be ethanol and would be burned lean to ensure com-

plete combustion. Although the proposed engine would have a relatively low power-to-weight ratio compared to most present engines, this would not be the problem encountered if this engine were used in a non-hybrid system since hybrid systems require significantly lower power and thus smaller engines than purely in-

ternal-combustion-engine-driven vehicles. The disadvantage would be offset by the advantages of high fuel efficiency, low emission of nitrogen oxides and particulate pollutants, and the fact that ethanol is a renewable fuel.

The original Miller-cycle engine, named after its inventor, was patented

in the 1940s and is the basis of engines used in some modern automobiles, but is not widely known. In somewhat oversimplified terms, the main difference between a Miller-cycle engine and a common (Otto-cycle) automobile engine is that the Miller-cycle engine has a longer expansion stroke while retaining the shorter compression stroke. This is accomplished by leaving the intake valve open for part of the compression stroke, whereas in the Otto-cycle engine, the intake valve is kept closed during the entire compression stroke. This greater expansion ratio makes it possible to extract more energy from the combustion process without expending more energy for compression. The net result is greater efficiency.

In the proposed engine, the regenerative preheating would be effected by running the intake air through a heat exchanger connected to the engine block. The regenerative preheating would offer two advantages: It would ensure reliable autoignition during operation at low ambient temperature and

would help to cool the engine, thereby reducing the remainder of the power needed for cooling and thereby further contributing to efficiency. An electrical-resistance air preheater might be needed to ensure autoignition at startup and during a short warmup period. Because of the autoignition, the engine could operate without either spark plugs or glow plugs.

Ethanol burns relatively cleanly and has been used as a motor fuel since the invention of internal-combustion engines. However, the energy content of ethanol per unit weight of ethanol is less than that of Diesel fuel or gasoline, and ethanol has a higher heat of vaporization. Because the Miller cycle offers an efficiency close to that of the Diesel cycle, burning ethanol in a Miller-cycle engine gives about as much usable output energy per unit volume of fuel as does burning gasoline in a conventional gasoline automotive engine.

Because of the combination of preheating, running lean, and the use of ethyl alcohol, the proposed engine

would generate less power per unit volume than does a conventional automotive gasoline engine. Consequently, for a given power level, the main body of the proposed engine would be bulkier.

However, because little or no exhaust cleanup would be needed, the increase in bulk of the engine could be partially offset by the decrease in bulk of the exhaust system. The regenerative preheating also greatly reduces the external engine cooling requirement, and would translate to reduced engine bulk. It may even be possible to accomplish the remaining cooling of the engine by use of air only, eliminating the bulk and power consumption of a water cooling system.

The combination of a Miller-cycle engine with regenerative air preheating, ethyl alcohol fuel, and hybrid operation could result in an automotive engine system that satisfies the need for a low pollution, high efficiency, and simple engine with a totally renewable fuel.

*This work was done by Leonard Weinstein of Langley Research Center. Further information is contained in a TSP (see page 1). LAR-16365*