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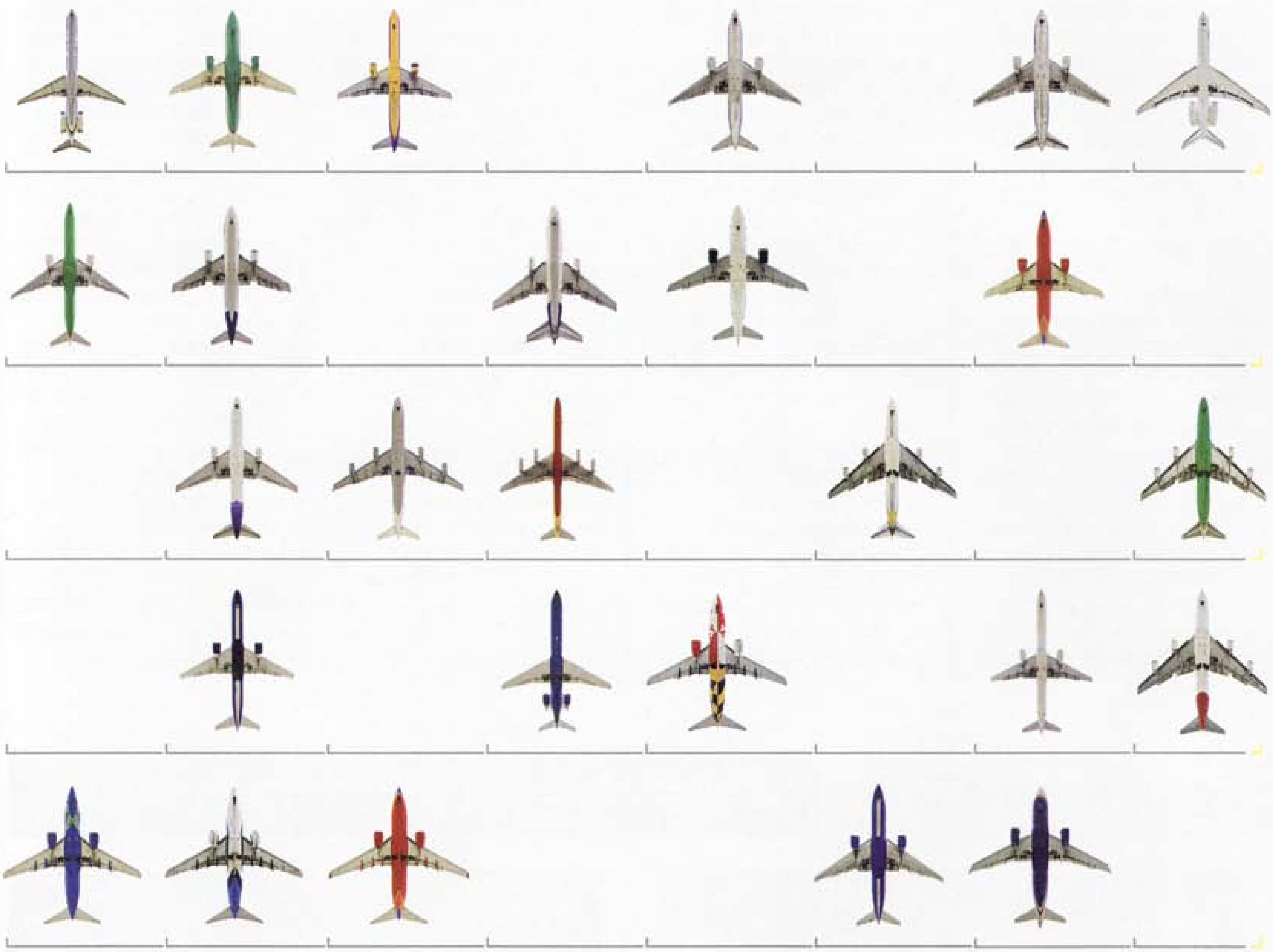
Nearly all US flight delays can be traced to the snarl of jets over New York City. How do you squeeze more efficiency out of an archaic air traffic control system? Redesign the sky. BY ANDREW BLUM



Two million flights pass through the New York area airspace each year; artist Aaron Koblin's *New York Flight Traces* captures the flight path of every plane that arrived at or departed Newark, LaGuardia, or JFK on August 13, 2008.

PHOTOGRAPHS BY JEFFREY MILSTEIN

I

INBOUND JFK. The turns start while you're still in the clouds. Engines howling, flaps down, the plane lurches and dives, jerky as a taxi in Midtown. Seatback upright and tray table locked, you're oblivious to the crowded flight paths around you. But the air above New York City is mapped: a dense and nuanced geography nearly as complicated as the city below.

More than 2 million flights pass over the city every year, most traveling to and from the metropolitan area's three busiest airports: John F. Kennedy, Newark, and LaGuardia. And all that traffic squeezes through a network of aerial routes first laid out for the mail planes of the 1920s. Aircraft are tracked by antiquated, ground-based radar and guided by verbal instructions issued over simplex radios, technology that predates the pocket calculator. The system is extremely safe—no commercial flight has been in a midair collision over the US in 22 years—but, because the Federal Aviation Administration treats each plane as if it were a 2,000-foot-tall, 6- by 6-mile block lumbering through the troposphere, New York is running out of air.

This is a nightmare for New York travelers; delays affect about a third of the area's flights. The problem also ripples out to create a bigger logjam: Because so many aircraft pass through New York's airspace, three-quarters of all holdups nationwide can be traced back to that tangled swath of East Coast sky.

Six years ago, Congress green-lit a plan to solve this problem. The Century of Aviation Reauthorization Act calls for a new system, dubbed NextGen, that uses GPS to create a sort of real-time social network in the skies. In theory, it should give pilots the data they need to route themselves—minus the huge safety cushions.

But NextGen needs some serious hardware: roughly $300,000 in new avionics equipment for every cockpit. That's a lot of peanuts for the struggling airlines. Add to the tab nearly 800 new federally funded ground stations to relay each plane's location and trajectory to every other plane in the sky and—by the time NextGen finally launches in 2025—the price tag could reach $42 billion.

In the meantime, the New York-area skies have seen a huge traffic bump over the past two decades—including a 48 percent increase between 1994 and 2004. So the FAA has set out to coax new efficiency from old technology.

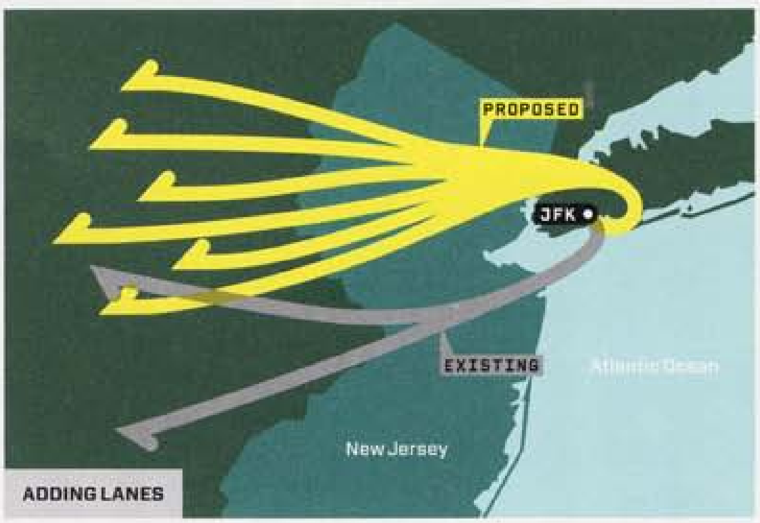
To help reorganize this airspace, the FAA called on Mitre, a Beltway R&D firm that works exclusively for the government. Mitre's scientists and mathematicians, in cooperation with some of the region's air traffic controllers, are completely rethinking the flow of aircraft in and out of New York City. Current flight patterns evolved like a rabbit warren, with additions tacked on to an existing architecture. As airports grew busier and airplanes started flying higher and faster, that architecture became increasingly inefficient. The plan, the unfortunately named New York/New Jersey/Philadelphia Metropolitan Area Airspace Redesign, aims to bring order to the air.

Think of it as a redrawn map of the roadways in the sky. While planes used to chug in and out of the city on a few packed roads, the redesign spreads out the aircraft by adding new arrival posts (exit ramps), departure gates (on-ramps), and takeoff headings (streets leading up to the intercity highways). But the biggest move will be making the space for all these additions. Mitre's proposal is to extend the boundaries of this airborne city into a 31,180-square-mile area that stretches from Philadelphia to Albany to Montauk.

The FAA started implementing the first part of the plan—the new takeoff headings—in December 2007 and should have the full strategy in place by 2012. By then the agencies hope to have reduced delays in New York by an average of three minutes per flight. And in a system as interconnected as the US air traffic network, those few minutes could quickly cascade into hours.

Unclogging the Skies

A new FAA plan—the New York/New Jersey/Philadelphia Metropolitan Area Airspace Redesign—aims to streamline the air traffic over New York. Here are two highlights.



Flights heading west out of New York have to squeeze onto two airborne highways over New Jersey before they merge with air traffic from the rest of the country. The redesign adds more lanes, allowing more planes to take off per hour.

The New York regional air traffic control center is the busiest in the world. The redesign integrates its authority with other regional centers so controllers can direct planes that are farther away, clearing the high-altitude flight paths for through-traffic.

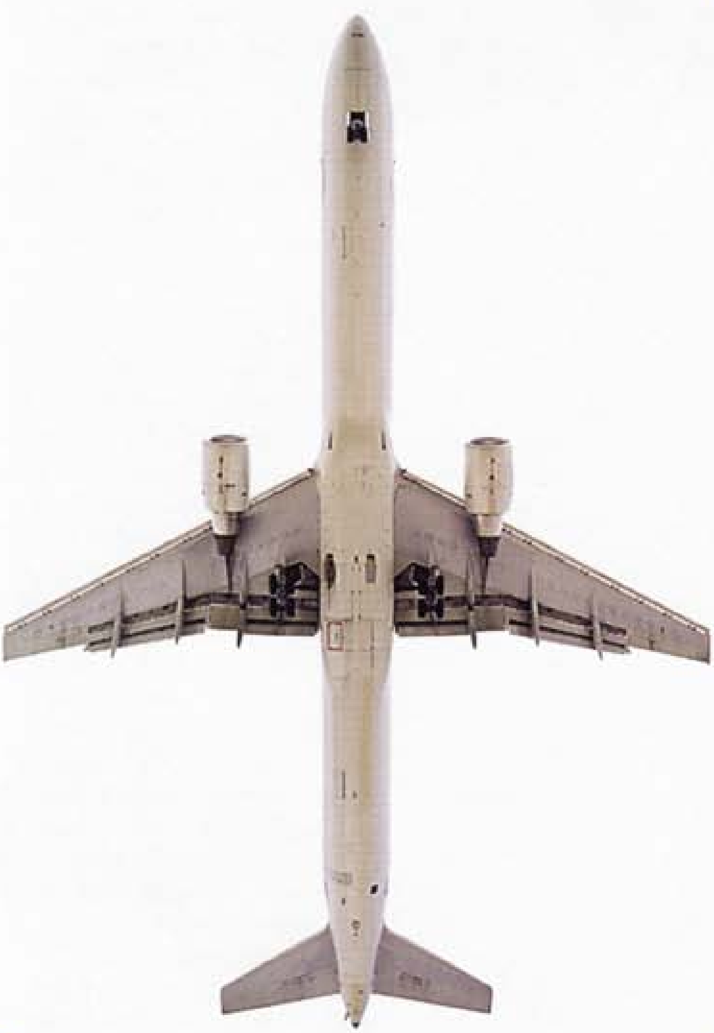
> The redesign creates a kind of airborne suburbia, paving the skies far out into what used to be the countryside.

THE NINE RUNWAYS at Kennedy, LaGuardia, and Newark—which together would form the nation's busiest airport—are roughly parallel to one another to accommodate prevailing wind conditions. The result is way too many planes flying in the same general direction. The controllers can override FAA safety regs when the skies are clear and calm, inching planes closer together and relying on the pilots' sharp eyes to avoid catastrophe. But when it rains and the pilots can't see each other, the multi-mile buffers return, the airspace overflows, and the line of traffic clogs the skies clear back to LAX. The redesign does not change the official safety separations—that's for NextGen—but it does try to use every last wisp of sky.

The first plan Mitre tested erased the current flight paths and placed the airports in an idealized box, where arrivals came in at the corners and departures went out over the sides. It didn't work. All the traffic clustered around one corner and jammed up.

So the team tried routing aircraft over the Atlantic. That didn't work either: Flight times were longer, the patterns were more complex, and the number of planes the airspace could accommodate decreased. "We don't have the luxury of saying all the arrivals are going down the Long Island Sound and all the departures are going out over the ocean," says Steve Kelley, the former New York controller overseeing the redesign for the FAA. "We'd handle about two airplanes an hour."

These test patterns, which worked poorly enough in ideal conditions, really fell apart when the simulators cranked up the intensity, adding bogeymen like inclement weather (of which the real New York has plenty). The team needed to factor in a controller's prerogative to make adjustments on the fly. The problem was a lot more complicated than just drawing new lines in the air. So, naturally, Mitre brought in its nuclear physicist.



Joe Hoffman came to Mitre in 1990 to work on command-and-control systems (what about them, precisely, he declines to say). When "nuclear war stopped being so popular," Hoffman says, he transferred to the wing of the building where the necessary security clearance isn't quite so high. As the redesign's chief strategic thinker, his first step was to figure out how to mathematically express the way planes move through New York's airspace. It wasn't so difficult: He'd been working with similar equations for years.

Airplanes in flight mimic (to a point) electrons whizzing around in their subatomic orbits. "The mathematics relate," he says. While a moving object in the terrestrial world can be tracked with four variables—latitude, longitude, speed, and time—an airplane soaring along a flight path adds a fifth—altitude. In Hoffman's sky—and in the math he uses to describe it—not all of these variables are equal; each one has to be weighted differently.

His calculations showed that some variables could be changed with fewer negative consequences than others. Planes have to keep a certain distance from one another, so latitude and longitude are rigid. Time, not surprisingly, is inelastic. The easiest variables to change are speed and altitude, but if you slow a plane down on the wrong road, you cause a traffic jam. The system needed more roads. Instead of lining up birds one behind another along the same trajectories, he needed to spread them out, maximizing the airspace.

To do this, Mitre recommended integrating the jurisdiction of the New York Tracon with other regional control centers—expanding the low-altitude zone in which all arriving and departing aircraft fly. The biggest backups in the current system happen when a flight transitions from the high-speed, long-distance "en route" highways to the slower, local "terminal" roads—the ones that the Tracon controls. The redesign creates a kind of airborne suburbia, paving the skies far out into what was the countryside. The idea is that the controllers can get planes off the intercity highways sooner, keeping them clear for through-traffic.

Ultimately, they'll be able to get more planes on the ground per hour by interlacing their runway approaches. And more widely spread patterns for outbound flights will prevent bottlenecks and allow more planes to take off every hour.

The aim of each of these tweaks is to shave off a few seconds here and there to ultimately hit that three-minute goal. Mitre sees it as a classic systems engineering scenario: Little changes snowball into big effects. But the question is, can the controllers handle the extra territory and fuller screens? Mitre put them in a giant simulation facility to find out.

FLIGHT DATA PROVIDED BY FLIGHTVIEW. AIRPLANE PHOTOGRAPHS FROM *AIRCRAFT: THE JET AS ART* BY JEFFREY MILSTEIN. MILSTEIN IS REPRESENTED BY BONNI BENRUBI GALLERY IN NY AND PAUL KOPEIKIN GALLERY IN WEST HOLLYWOOD. MAPS BY THE DEPARTMENT FOR INFORMATION DESIGN AT COPENHAGEN.

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MITRE HEADQUARTERS in McLean, Virginia, isn't far from the CIA. It shares a parking lot with Northrop Grumman and an architectural sensibility with Dunder Mifflin. The exterior is tan and glass and crenellated with cameras. The interior is a study in grays. When you check in, the receptionist will inquire, "Is this a classified meeting?" Nearby, a sign warns: NO UNENCRYPTED MITRE LAPTOPS BEYOND THIS POINT.

Founded in 1958 as an offshoot of MIT's Lincoln Laboratory, Mitre worked on an air defense network that was a model for Arpanet, the predecessor to the Internet. In the 1960s it figured out how to merge the nation's airports into a connected web that would become known as the National Airspace System. Since then, it has helped design flight patterns above Los Angeles and Chicago. But neither of these skyscapes was nearly as daunting as New York's.

Mitre's primary tool for testing whether its New York plan will work is the Air Traffic Management Laboratory. A sprawling windowless simulation facility, it has a full-size 737 cockpit, a mock airport tower, and an army of radar screens just like in a typical control tower. Technicians can simulate any event possible in the FAA's world—from a routine takeoff to a crash landing. Visitors—usually angry airline reps—watch the action piped into a conference room.

Hoffman stands inside the darkened lab. A half-dozen controllers gaze at pizza-box-sized monitors filled with pulsing green blips, imaginary planes flying around a fictitious New York City sky. These guys are the real thing: golf-shirted, bug-eyed FAA vets down from the city for a week of experiments and lonely beers in a strange town. With radio triggers gripped firmly in their left hands, they use their rights to punch at keypads, entering the verbal commands they've just issued to the pilots passing through their sectors.

But the pilots are not real cockpit jockeys. They're lab