A History of

Ground Controlled Approach (GCA)

By Tailspin45

For

Digital Dakota Works

You and your crew, still tired from yesterday's 13-hour flight from the Douglas plant in Oklahoma City, gather in the too-warm Gander, Newfoundland Met Office. It's mid-afternoon and you're planning to fly the new C-47 all night to England so the navigator, using celestial, can get star shots. With help from the briefer, you pore over the winds aloft forecast and scrutinize prog charts that predict the weather for your arrival in England.

After a pensive swig of coffee, you stub out your cigarette and confer with the navigator.

"So, with those winds aloft, even with 1600 gallons on board, it looks to me like we're going to have under two hours of fuel when we arrive at Cottesmore."

"That's what I figure, too, Skipper. I don't much like the destination weather forecast, either. Low fuel and low ceilings give me the willies."

"Could be worse," you say. "We'll have almost 14 hours to watch how the weather develops and it looks like Shannon might not be too bad as an alternate."

The copilot's Zippo clicks as he lights a Lucky Strike. "Assuming the forecast is right," he says.

You mount up, launch, and slog through the cold grey sky, straining the wing deicers and using up the alcohol that keeps ice off the props. The navigator's HOWGOZIT chart shows you're behind plan and using more fuel than estimated.

It's 6AM. Even after a brief nap in the back on a makeshift bunk, you're really beat. Eleven hours of vibration and noise and stress on top of the long haul from the States is taking its toll. With over three hours to go, you're more worried than ever because that two hours of extra fuel is now looking more like one.

Then you get the bad news--Shannon is zero-zero. Zero ceiling and zero visibility. Fog and mist are down to the ground. Vizibility is feet not miles. And damn near all of the British Isles--England, Ireland, and Scotland--is fogged in. So is France across The Channel.

There's no going back, and there's no place to go.

With crew morale in mind you say, "We don't need to rush. All we're going to do when we get there is fly around in a holding pattern waiting for things to improve. Pull her back to max conserve."

Power set to 29" and 1500 RPM, you stabilize at 105 knots. The very "over square" power setting is something Lindbergh out in the Pacific proved effective on long flights. Some quick figuring shows it will take 1+30 longer to get there; but burning just 70 gallons per hour, you'll have an extra hour of fuel onboard when you do arrive.

The wind and weather haven't cooperated, though, and now you've been in the air almost 16 hours. Over the destination field, despite your fuel conservation efforts, you have just minutes of gas left. Pucker-factor is approaching the over-pressure limit.

You discuss options. Going swimming isn't one of them, you all agree. Making a blind let down hasn't worked out for too many bombers and fighters, so that's out.

"Right. Will you accept a ground controlled descent?" a proper British voice crackles in your headphones. "Experimental system, it is, still being tested but results are rather encouraging."

You've heard about the system. Ground Control Approach, GCA, the Air Corps calls it. Controllers on the ground use precision radar to talk you down. It's your best option.

You brief your crew. Attitude controls airspeed, that's your job, along with staying on assigned headings. Power controls rate of descent, copilot will handle that and communications. The navigator, standing between you in the doorway, will watch for the runway and sing out when he sees the ground.

Your mouth is dry and your hands are wet. You smell hydraulic fluid, stale cigarette smoke, and sweat, maybe a whiff of fear. You wiggle around in your seat, re-adjust the height, and cinch down your safety belt.

A controller vectors you around to what they call the final approach course. Final approach? Don't like the sound of that.

"Approaching glidepath, do not acknowledge further transmissions. Turn right heading three two two...Begin descent...Slightly below glidepath, turn further right three two five...On glidepath, on course...Three miles from touch down. Winds three four zero at niner, you're cleared to land."

"Five hundred feet," says the copilot, "400 feet ... 300 feet ... 200 feet."

"At decision height, take over visually," says the controller.

"I don't see anything yet!" the Navigator says in a high squeaky voice.

A missed approach in this weather, with no fuel, is not an option.

Hold 90 knots, 500 foot per minute descent. On the assigned heading. Be smooth!

A bit darker, greenish instead of just gray. Starting to feel the ground but can't see it. Don't do anything stupid.

"Over landing threshold, on centerline," the voice says.

Can't see anything. A trickle of perspiration runs down your neck despite the chill.

A little power to slow your descent, your hand over the copilot's on the throttles. A little nose up to start a flare. Don't overdo it!

"I see runway lights! Hold what ya got!"

Touchdown!

Throttles back to idle. Keep her straight. Dance on the rudders. Watch the runway edge, *keep her straight*!

How far to the end? On the brakes. Easy, EASY! Adrenalin pumping.

Tail's down. We made it! Cowl flaps open, unlock the tailwheel. Don't touch anything else. Wouldn't do to put the gear up instead of the wing flaps.

"Contact tower. Welcome to England, Yank."

"Thank you for your help! *Very* nice to be here."

The blind landing problem

In the classic novel Night Flight, pilot and writer Antoine de Saint-Exupéry tells of the ambitious Argentine station supervisor who ignored worsening weather and insisted the airmail must go through. Flying between Patagonia and Buenos Aires, the French mail pilot and his radio operator are soon surrounded by storms. Unable to find a place to land, they don't die. They simply vanish.

Lindbergh, flying the St. Louis-Chicago airmail run in 1926 before his epic trans-Atlantic flight had a similar experience--twice. He didn't vanish, of course, but lost in stormy skies and low on fuel, he dropped a parachute flare carried for the purpose and hoped to see the ground so he could land in a field. Unsuccessful, he climbed over the side of the open cockpit and rode his parachute down.

Those experiences were by no means unusual. The U.S. Post Office Air Mail Service reported that in the year between July of 1925 and July of 1926, pilots made 750 forced landings, three-quarters (554) caused by bad weather.

Over the next decade, all manner of solutions were tried to solve what was popularly referred to as the "blind landing problem." They ranged from simple solutions such as lit balloons suspended as markers above airfields to advanced ideas such as high-power X-rays as guidance beams. The balloon method was popular with British researchers; fortunately the U.S. Army Signal Corps checked with radiation specialists before seriously exploring the X-ray proposal.

In any event, not all blind landing efforts were based on airmail needs. Military crews and airlines were looking for a safe round-the-clock all-weather solution, too.

The first step was the creation of a network of weather observation offices and a system to communicate weather reports. Then strings of bright beacons were built to form a transcontinental airway system to support night operations. Mail pilots flew "on the beam" from beacon to beacon. Sadly, most of the pioneers died doing it.

During the air war in Europe, weather was an enemy, too. WW2 crews on both sides who survived air battles were forced to return to runways obscured by weather. A post-WW2 USAAF report found that during the first seven months of 1944 one out of every five fatalities resulted from flying into or being caught by bad weather.

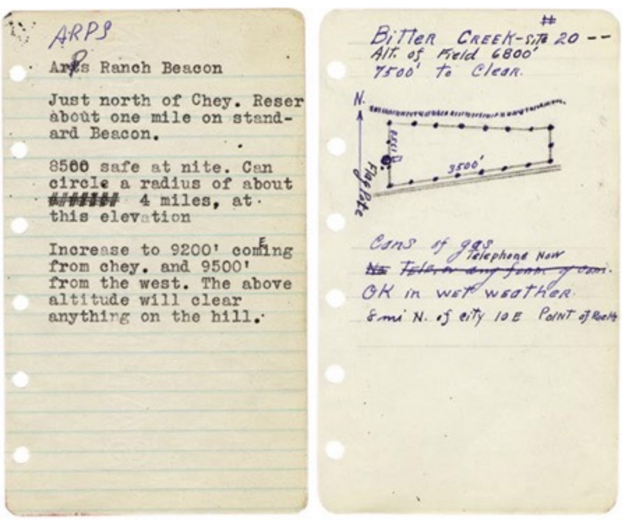
In one case, a flight of 35 aircraft, flown by RAF students and American instructors ran into bad weather during the return leg of a night cross-country training mission. Twelve planes out of the thirty-five crashed resulting in the death of 7 student pilots.

Instrument Landing Systems

As far back as 1888 Heinrich Hertz, who discovered electromagnetic waves, suggested radio frequency waves might, like visible light waves, reflect from metal surfaces. In 1933 Rudolf Kühnhold--known as the Father of Radar in Germany--began experimenting with microwaves and in 1935 was able to detect and range trees across a bay at a distance of 15 kilometers (9.3 miles). But in Germany, radar received less attention than in the U.S. or U.K., despite the country's head start.

In 1926 a new Aeronautics Branch of the U.S. Bureau of Standards' Radio Laboratory and the Bureau of Lighthouses (yes, really) had begun to replace the airways beacons with low-frequency radio ranges that broadcast signals pilots could hear in their headphones. Using the signals, pilots could fly blind from range to range across the country. But a blind landing system still hadn't been perfected.

Early attempts to use modified radio range signals failed because of instability, interference produced by weather, and fading because of changes in the upper atmosphere. Approach procedures were developed but they depended on visual checkpoints (turn left to a heading of 310 over the red barn) and were not useful in really bad weather.



In 1929, Jimmy Dolittle experimented with a line-up (localizer) system developed at Mitchell Field, and on September 29th he made the first deliberate blind landing there. No altitude or glideslope information was provided, however. He simply set up a slow rate of descent and flew until he hit the ground. Because Mitchell at the time was literally a big grass field, the method worked. But no obstacle clearance information was provided—his altimeter gave only barometric altitude not absolute (actual) altitude above the ground.

An acoustic height-finder was tried and was useful for slow-moving Zepplins, but the system went with dirigibles into technological oblivion.

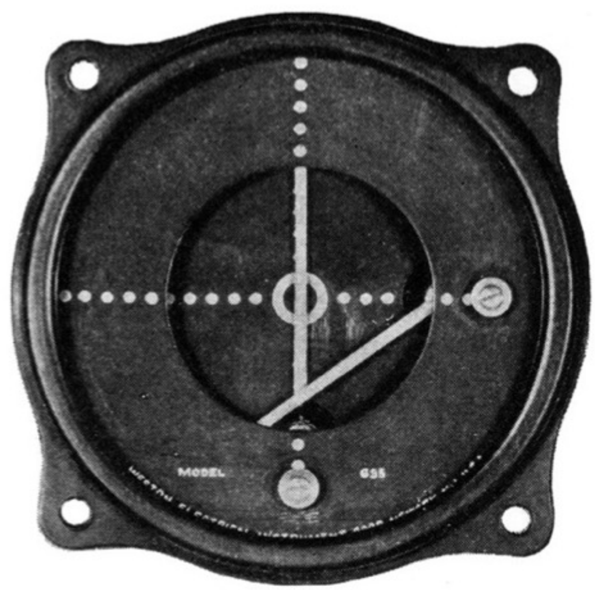
A system using a 'landing beam' (glidepath) attracted particular interest because it could be angled up to ensure the beam cleared all obstacles. Combined with Dolittle's localizer, a cross-pointer gauge was developed in 1930 that depicted localizer and glidepath information.

The system was tested at College Park, Maryland and Newark, New Jersey airports through 1934. The Secretary of the Navy wrote to the Secretary of Commerce to congratulate him for the "wonderful progress made" in blind landing after demonstrations during the summer of 1933. The German journal Zeitschrift für das Weltflugwesen commented that this was the best solution to the blind landing problem yet devised.

But, despite acclaim, the system remained experimental. A test pilot's ability to land sometimes did not mean he could do it every_time. As one test pilot put it, " (A safe landing) can be made occasionally, as I have already proved by my two 'blind landings' to date. But it takes almost perfect conditions to accomplish the feat."

All the instrument landing systems (ILS) that had been tested provided signals that operated one or more cockpit instruments. In essence, they were a primitive automated remote control with a pilot in the loop. Pilots interpreted the instruments' readings and maneuvered their aircraft accordingly, allowing them to fly independent of people on the ground.

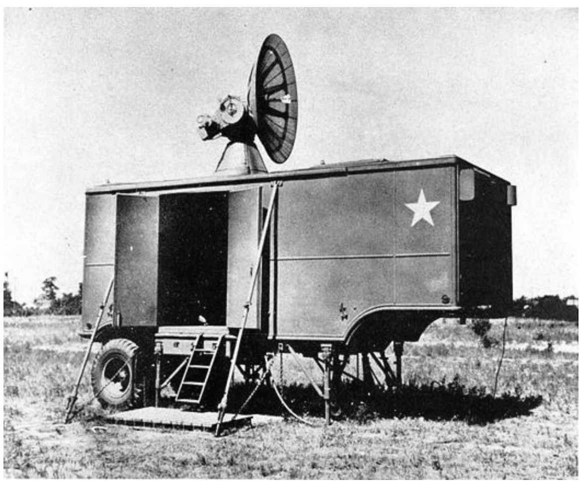
By 1940, every blind landing system was built on the assumption that it would include marker beacons, a localizer and glide path signal, and receivers in the plane. No other solution beside the instrument landing system was under serious consideration.



Ground Controlled Approach

But that was not the only way to build a landing system. The MIT Radiation Laboratory, in particular future Nobel laureate Luis Alvarez, challenged the pilot-control model with a new system that used a ground controlled approach.

Physicist Alvarez had earned a private pilot's license in 1933 and conceived of a blind landing aid after seeing a demonstration of a gun-laying radar. It was truck-mounted and automatically tracked an aircraft and fed range, azimuth, and elevation to an analog fire control computer that predicted the aircraft's future position.



Alvarez realized that if radar could track an aircraft accurately enough to hit it with an artillery shell, it should be able to track an aircraft accurately enough to help a pilot hit a runway.

Alvarez's concept was to use the gunnery radar to track an incoming plane and to use some modification of the analog gun director to provide an operator on the ground with range, bearing, and altitude information that he could then communicate to the plane's pilot via radio. The radar operator on the ground, in other words, would be able to talk a pilot down.

A ground controlled approach (GCA) also had the advantage that it could help small aircraft, which couldn't carry the receivers and gauges the instrument landing systems required. Pursuit ships and fighters, for example, hadn't been part of research efforts before 1941, since without radar fighters couldn't find targets in bad weather and therefore had no reason to be flying.

With the development of airborne radar, fighters could fight in poor weather but only as long as visibility was still good enough to land. Because all of the equipment for GCA was on the ground, it imposed no weight or drag penalties--they all had communication radios already--making GCA ideal for fighters and other small aircraft.

A Harvard geophysicist and private pilot built an optical version of Alvarez's GCA idea as a proof-of-concept experiment. Two modified theodolites and a range-only radar were combined and in March 1942, the team successfully "talked down" a Navy Grumman J2F "Duck."

The Navy invited Alvarez's group to Oceana Naval Air Station in Virginia to try their landing idea out with the anti-aircraft radar that had inspired Alvarez's idea in the first place. The Navy had no problem with the concept of aircraft control from the ground because they already used a talk-down system on aircraft carriers. The "talking," of course, was not by voice, but by paddles in the hands of a Landing Signals Officer (LSO) with no electronics involved in the process of "waving an aircraft aboard."

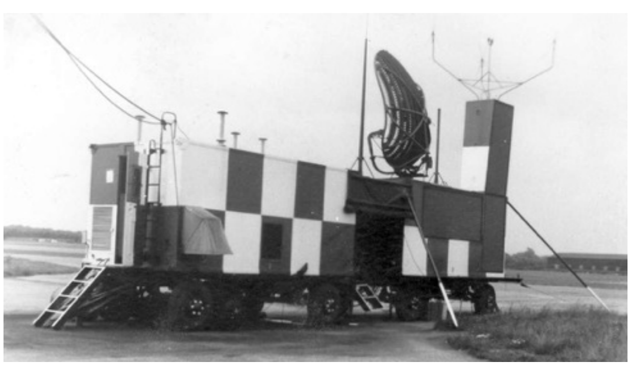
However, the project nearly ended at Oceana. The system, pointed at a low angle, produced an unexpected radar reflection under ground and one from the aircraft itself. With no way to distinguish the real airplane from its reflection, the automatic tracking system hunted between the real and virtual aircraft, making it useless.

The solution was to replace the single antenna of the gun-laying system with two narrow-beam antennae, one vertical and one horizontal, which mechanically scanned through narrow arcs. The result was highly precise tracking system. A third search radar was used by the GCA controllers to direct aircraft into the narrow precision beams.

First Steps

The Signal Corps selected Paramount Pictures to manufacture the first systems because esteemed two-time Academy Award winning inventor, electrical and radio engineer named Homer Tasker worked there. But the movie company didn't want to get into the electronics business and loaned Tasker to Gilfillan Brothers, a Los Angeles company that subsequently won the contract for the first ten units. By the end of March of 1942, the USAAF had fifty-seven on order. In late 1942, Gilfillan dispatched Tasker and three others to join Alvarez at MIT so they could begin learning the system from the experts.

The Mark I consisted of a gasoline-driven generator powering radars mounted in a trailer with the two antennae on its roof. A second trailer contained the radar screens and the voice radio sets that controllers used to communicate directions to pilots. Both trailers were parked fifty feet to the left side of the runway in use.



For the first production unit, Gilfillan's engineers put a generator, and air conditioning systems to keep the hundreds of vacuum tubes cool, in a covered truck that could also pull the trailer with the antennae.

The main innovation, however, was elimination of the mechanical scanning of the two precision antennae, which was a severe maintenance problem The inertia of the large devices quickly wore out and, sometimes, damaged the drive gears.

Hurry up and wait

Much of the GCA testing had been done at Quonset Point Naval Air Station in Rhode Island using Navy planes and pilots. The concept was therefore already well known to the Navy. The station Commanding Officer (CO) profusely praised the system, particularly after a January 1, 1943, incident in which a flight of 3 PBYs was caught in a snowstorm and became lost.

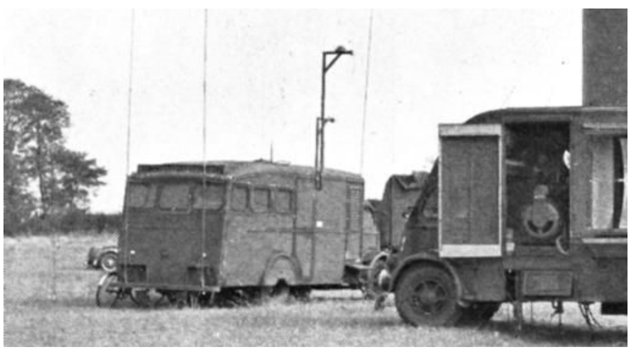
The CO called the GCA group from the control tower and asked if they could bring the planes home. The pilots didn't even know that a radar that could see them existed and were reluctant. But by talking them through various maneuvers before trying to get them to land, the controllers gained the pilots' trust and successful talked them down. The CO reported the feat to COMNAVAIRLANT at Quonset Point who ordered 80 GCA systems on the spot.

For some reason Alvarez apparently thought that he still needed to sell the system to military brass, despite the orders. The RAF Bomber Command was losing as many aircraft in landing accidents as it was over enemy territory, so Alvarez arranged to pack up the Mark I and ship it to Britain aboard a

GCA - Ground Controlled Approach

lend-lease British Escort Carrier HMS Smiter carrying new Corsairs and Avengers.

After a nerve-wracking three-week North Atlantic transit, evading U-boat packs, Alvarez's team set up the Mark I at Elsham Wold for more demonstrations.



As a side note: The British appointed a Technical Officer named Clarke to learn the GCA system. He caught on quickly, but was considered a bit odd because he would amuse himself by working on interplanetary navigation problems and was Secretary of the British Interplanetary Space Society which at the time might as well have called itself the Mad Hatter Society.

Alvarez's group trained the future Sir Arthur C. Clarke and his Women's Auxiliary Air Force controllers to maintain and operate Mark I, and they in turn trained other crews once Alvarez and his boffins left.

The Mark I moved to Davidstowe Moor in Cornwall, a coastal command base, after the Elsham Wold tests. It remained there as the centerpiece of the RAF's GCA school until mid-1944, when its antenna drive gearing failed for the last time. The Mark I was cannibalized for spares to use in the first three preproduction GCAs, which were given to the British because they had already-trained operators. The RAF thus started using GCA before the USAAF and the U.S. Navy.

A friend in need is a friend indeed

From the pilots' point of view, GCA was nearly miraculous. Controllers could see them when they couldn't see anything and the controllers could tell them where they were when they had no idea. Particularly important during the war was the human contact that GCA provided. Crews often returned from missions exhausted and sometimes with injuries. A reassuring voice to talk them down was something ILS could never do.

What's more, GCA's talk-down method didn't require special equipment in the aircraft and, even more importantly, it didn't require extensive pilot training. The instrument landing system required a lot of practice to become proficient. GCA only required pilots to respond accurately to voice commands.

Military pilots, and especially Navy pilots, took to GCA immediately. GCA's demand for teamwork between air and ground fit a model of behavior for which military pilots were already prepared.

Before World War II, pilots' authority and autonomy in the air was unquestioned. Only the pilots knew where they were and where they intended to go. The air traffic control system of the day had no way to communicate with aircraft at all, and no way to track them. It exerted no control over pilots and served more as a way to exchange information between airports about arrivals and departures. It was, simply, a flight-following system, not a control system.

ILS vs GCA

A vicious political battle took place after 1945 over the selection of a common landing aid for the United States. Some organizations supported GCA and others supported ILS.

The Civil Aeronautics Administration (CAA) insisted on deploying its "old-fashioned" ILS, developed in the '30s, with support from the airlines. Military and civilian aviation communities proclaimed GCA the best solution, but the CAA stood firm. CAA intransience resulted in media criticism and Congressional inquiries, especially after Alvarez was awarded the Collier Trophy in 1945 for developing GCA, "the greatest achievement in aviation in America."

In no small part the fight was caused by a Navy decision in late 1945 to abandon ILS in favor of GCA, while the USAAF publicly promoted GCA. (Oddly, the Air Force continued to buy and install ILS systems in the U.S. and overseas and most of their GCA sets stayed in storage, despite their rhetoric.)

The press fanned the flames of the controversy, too. It's virtually impossible to find positive references in print to ILS. A lot of ink was devoted to stories of "lives saved" by GCA, which is surprising given there were twice as many ILS as GCA approaches in the US in 1946.

The fundamental issue was how GCA and ILS worked, not how well. Private and most military fliers backed GCA, while the Air Line Pilots Association and the airlines supported the CAA and its ILS. Why? GCA was easier and cheaper for an "average" pilot to use, which is why airline pilots seemed so opposed to it. GCA proponents saw it as "every man's solution" that could be used by anyone with an airplane, which was true enough. The Air Line Pilots Association, though, disliked GCA because it was a threat to pilot autonomy and "dumbed-down" the profession.

The pilot-control model, on which ILS operated, favored skilled and experienced pilots who flew frequently, making it the obvious choice of professional pilots. The GCA model, on the other hand, supported the occasional pilot, leading to unswerving devotion from advocates of General Aviation.


Commercial Radar Planned On Coast

Equipment that can land planes every 30 seconds, regardless of weather, announced by Gilfillan.

Ground Control Approach radar equipment that can land an airplane every 30 seconds, regardless of weather conditions, is being developed for peacetime commercial aviation use by Gilfillan Bros., Inc., Los Angeles, it was announced last week.

The equipment, which has already been put to severe service tests at Army Air Force bases in the European and Pacific war theaters, was first developed in 1942 and put into service in 1943. It has been held secret until released recently by the War Department.

The two models sprung not from political differences between the inventors but from their design environment. The developers of the pilot-control model worked closely with professional pilots in a project driven largely by the demands of airlines for regular service. The ground-control model evolved from Luis Alvarez's experiences as a private pilot while he was working to solve a problem for drafted and hastily trained military pilots of World War II--a very different pilot than the post-war professional pilot.

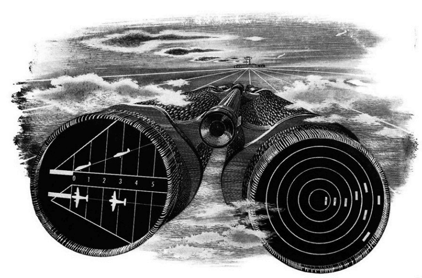
Political and funding squabbles, exacerbated by the Korean War, meant that the CAA had a total of ten precision approach radar (PAR) systems in 1950, and the number never grew larger. The ten-airport surveillance radar sets it had installed in 1950 remained through 1953, and the number of long-range surveillance radars remained fixed at two--both World War II sets on "loan" from the Air Force.

Congress dismantled the ineffectual CAA in 1958 and replaced it with the Federal Aviation Agency (FAA), responsible for pulling together post-war technologies into a modern air traffic system.

Nobody's perfect

On August 6, 1997, Korean Air flight 801 crashed near the top of Nimitz Hill, on Guam, almost plowing into the VOR installed there. The facility was used to navigate to the ILS approach path. Predictably, the press pounced on the "ancient" ILS installation, which, not so incidentally, had its height-finding glidepath transmitter out of service.

The airliner's crew was aware of the outage and knew the no-glideslope procedure, but for some reason they didn't follow it. Predictably, the NTSB ruled the accident the result of "pilot error." But as a GCA supporter wrote to Aviation Week and Space Technology, the accident would not have happened if GCA had been chosen as the blind landing system of choice back in the '40s.



GCA...Tower-Vision for Airports


Airlift Pilots log 54,630
GCA* Landings
Since the Airlift began one year ago, GCA has been in continuous operation—24 hours a day. By mid-May 1949, even by Airlift standards, GCA's record was enormous.
Of the 54,630 GCA landings, 17 were "saves"; 4,807 were below IFR: 31,028 were IFR. Only 17,804 were VFR. In all "Operation Vittles" there was not one GCAccident, not one minute of radar failure.
Chosen by the USAF as its exclusive landing aid, GCA justifies this confidence. In one emergency, 26 Airlift C-54's were GCA landed in 26 minutes, three times the normal rate.
Military authorities say Berlin's 2½ million people could not have been fed without GCA's help. As GCA's pioneer developer and manufacturer for the USAF, Gilfillan is proud of its share in the Airlift's success.
Gilfillan
LOS ANGELES
GCA
RCA International Division
Exclusive Export Distributors
*Ground Controlled Approach

But GCA wasn't infallible. Perhaps the most famous GCA failure came amid its greatest success, the Berlin Airlift of 1948 and 1949 when GCA controllers handled a total of more than 54,000 landings in 10 months.

On August 13, 1948, known now as Black Friday, a C-54 crashed and burned at Tempelhof and the aircraft behind it blew its tires trying to stop before hitting the wreck. Then a C-47 ground-looped after landing on another runway which was under construction.

As a result of Black Friday, stricter air traffic control procedures were put in place and all airlift aircraft had to follow instrument flight rules, regardless of weather conditions. When a Navy F-4 and a Hughes Air West DC-9 collided in 1971, all military flights also had to always follow instrument flight rules.

Blind landings realized

Years pass. Now you begin maneuvering your jet for the planned approach when the controller says a heavy marine layer has moved in. You know he's not talking about a 300-pound hooker near Quantico. Visibility, he says, has gone from 2 miles to less than an eighth of a mile.

No worries, you're prepared with special onboard systems, the required training, and the approach plate says the CAT IIIb approach is authorized down to virtually zero/zero conditions. It will be flown completely by the autopilot.

Stabilized on final, the auto-throttles make minute adjustments to your rate of descent. The pitch changes almost imperceptibly to maintain the programmed approach speed.

You hear, "Two hundred" at that radar altitude. Normally, this is where you have to see the approach lights, but you don't. No missed approach this time, you continue. "One hundred." Still nothing out the window. "Fifty "... nada. "Forty" ... zip. "Thirty" ... nothing.

The auto-throttles bring the engines to idle, the nose rises as the autopilot commands a flare. You feel the main gear touch the concrete as the nose lowers to the runway. Now you're just able to see the first couple of runway lights ahead of the airplane. Boards come out, reversers deploy, brakes are applied. Safely and right on time, you've arrived.

Now you have to get to work, release the brakes, taxi clear, and clean her up.

That's how you clould make an (almost) blind landing it in 1972, flying a CAT III approach.

The future is now

Today, Navy aircraft carriers and amphibious assault ships will continue to use GCA as a backup and have a talk-down approach available if all else fails. Ground-based GPS augmentation, coupled with synethetic vision systems, are being introduced that can provide a VFR depiction of

virtually any runway. The quest for blind landing has been realized.

The era of ground control approaches and the comforting phrases "approaching glidepath, begin descent" or "over landing threshold, on centerline" will no longer be heard in headsets...unless you have the Digital Dakota Works GCA add-on.

It's OK— we're landing on GCA

Gilfillan GCA Meets the Challenge— PAST... PRESENT... FUTURE

Gilfillan GCA has met the challenge of the air age. Its mastery over bad weather was dramatically proved by the Berlin Airlift. GCA received a large share of the credit for the success of Operation Vittles. ★ Today, GCA is on the job at 167 airports around the world. At GCAirports, schedules are regular, delays rare. ★ Gilfillan GCA—built with the *future* in mind—is the only navigational aid with the speed, accuracy and spacing safety features to cope with the supersonic problems of *tomorrow's* jet aircraft. ★ Air safety cannot wait. Gilfillan, in cooperation with the CAA, USAF and USN, is the prime factor in keeping air safety equipment in step with air travel.

GCA

Gilfillan

LOS ANGELES