# NASA Facts

National Aeronautics and
Space Administration

**Langley Research Center**
Hampton, Virginia 23681-0001

804 864-3293

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## World War II and the National Advisory Committee for Aeronautics:
# U.S. Aviation Research Helped Speed Victory

Well before the United States' formal entry into World War II on Dec. 8, 1941, the political, military and industrial leaders of the nation started what became a massive national mobilization effort. The nation's scientific organizations made vital contributions in several fields. In the area of aeronautical research, the National Advisory Committee for Aeronautics made many important contributions to the development and production of military aircraft that saw service during the war. The story of military aviation and the American aircraft industry during the war is well-known. The story of research conducted by the NACA has received less attention. This fact sheet highlights some aspects of the NACA's wartime work.

### "Research Midwife"- A New Approach to Aeronautical Research

The NACA was established in 1915 "to supervise and direct the scientific study of the problems of flight with a view to their practical solution." During the next 25 years, the NACA became one of the world's premier aeronautical research organizations. Still, in 1939 (the year Germany invaded Poland), there were only 500 employees and the organization had a modest budget of a little more than $4 million. Like almost every other government agency, the war transformed the NACA. It grew from one research facility—the Langley Memorial Aeronautical Laboratory in Hampton, Va.—to three. The new facilities were the Ames Aeronautical Laboratory in Mountain View, Calif., and the Aircraft Engine Research Laboratory in Cleveland, Ohio. Employment peaked at 6,077 employees in 1945 and the budget that same year was almost $41 million.

Equally significant as the changes created by the expansion of personnel and facilities was the change in the NACA's approach to research. Before the war, the NACA had conducted more basic research, mainly aerodynamics and flight research. Despite its charter to find "practical solutions," the NACA had held industry at arm's length. The urgent demands of war necessitated a different relationship. A unique partnership was formed by NACA researchers with industry designers and military planners. One journalist characterized the NACA's role in this partnership as "the research midwife at the birth of ... better American planes."

What the journalist was trying to capture was the NACA's new role in conducting applied development work for industry and the military. The fundamental research agenda of the 1920s and 30s proved a solid foundation for its new wartime responsibilities. The NACA mandate to find "practical solutions" assumed paramount importance in guiding the organization during the war. NACA engineers began using the laboratories (especially its growing wind tunnel complex) and technical expertise to develop new testing methods

which resulted in improvements in aircraft speed, range and maneuverability that ultimately helped turn the tide of the war in favor of the Allies.

## NACA Research: The Force Behind Our Air Supremacy

In January 1944, a leading aviation publication, *Aviation*, editorialized that the NACA was the "force behind our Air Supremacy" and that "the story of the NACA [was] the story of American aviation. Neither could well exist without the other. If either fails, the other cannot live." This was recognized later as exaggerated praise. In fact, the NACA was far behind Great Britain and Germany in recognizing the significance of jet propulsion, the single most important development in aviation during the war period.

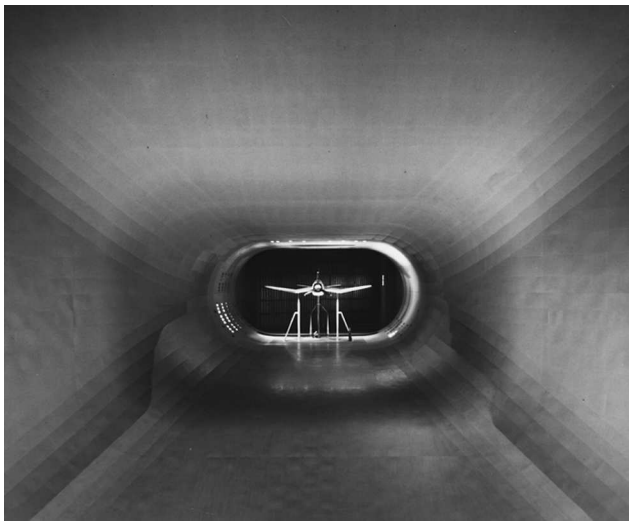
Nonetheless, the NACA did have many important accomplishments during the war and its employees were justifiably proud of their work. Air power was a critical factor in the nation's military success. Those who worked closely with the application of technology to the development and production of aircraft had a keen appreciation for the often "invisible" contributions made by the NACA. Further, the NACA organization served as a model for structuring other government scientific research agencies both during and after the war.

What follows is a description of a few of the major research projects including drag cleanup, deicing, engine development, low-drag wing, stability and control, compressibility, ditching and seaplane studies. To learn more about the NACA's wartime work, see the suggested reading list at the end of this fact sheet.

## Keep it Clean

The most important work done by the NACA during the war was "drag cleanup." Drag is the resistance to airflow. Every engineer or experimentalist since the beginnings of heavier-than-air flight has struggled to minimize it. Between 1938 and 1940, researchers at Langley pioneered a method using its cavernous Full-Scale Wind Tunnel to measure drag and make recommendations to the manufacturer as to how best to correct the problems. The military was so enthusiastic about the results of the "drag cleanup" process—which helped solve technical problems and was quick and inexpensive—that it had the NACA test virtually every new prototype.

Drag cleanup work continued throughout the war at Langley as well as at the Ames laboratory which opened a still larger full-scale tunnel of its own. The experimental work began by putting a full-size aircraft into one of the full-scale wind tunnels, taking off all antennas and other items sticking out from the aircraft body and, finally, covering the entire airplane surface with tape. Measurements were made of this "aerodynamically smooth" airplane. Gradually, the engineers would remove the tape strips and determine the drag created by every part of the airplane. The resulting report not only identified the problems but also made recommendations on how to correct them. The NACA also conducted an extensive program of flight research to confirm its drag cleanup recommendations and further assist industry and the military in the quest for maximum performance.



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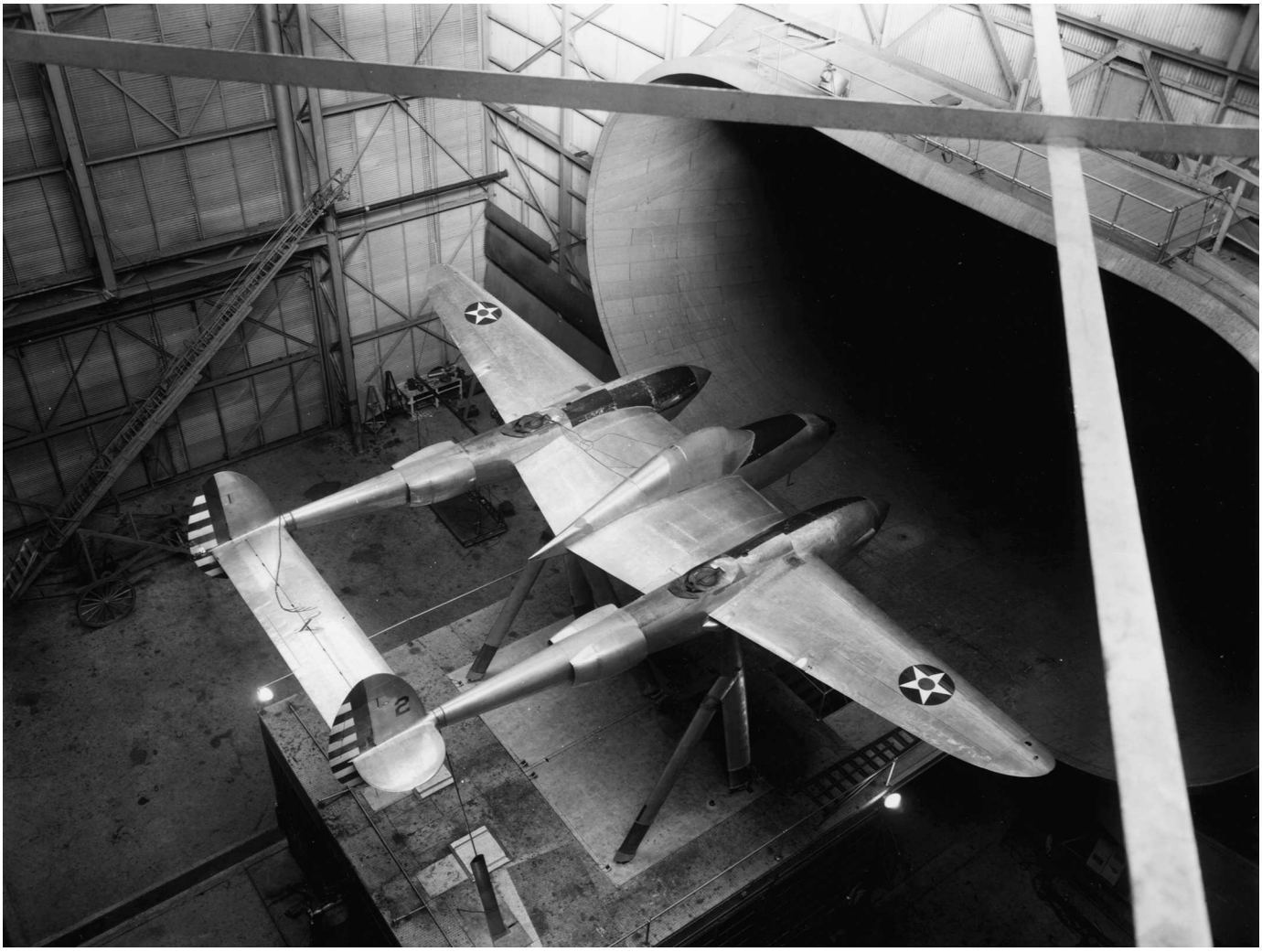
*This Douglas XSBD-2 model was the first aircraft to be tested in the NACA Ames 40 x 80-ft. Wind Tunnel, the largest wind tunnel in the world at the time. Drag reduction studies were performed on the airplane.*



*A Lockheed YP-38* Lightning *(the second prototype of the* Lightning *series) undergoes drag clean-up in the NACA Langley 30 x 60-ft. Full-Scale Tunnel.*

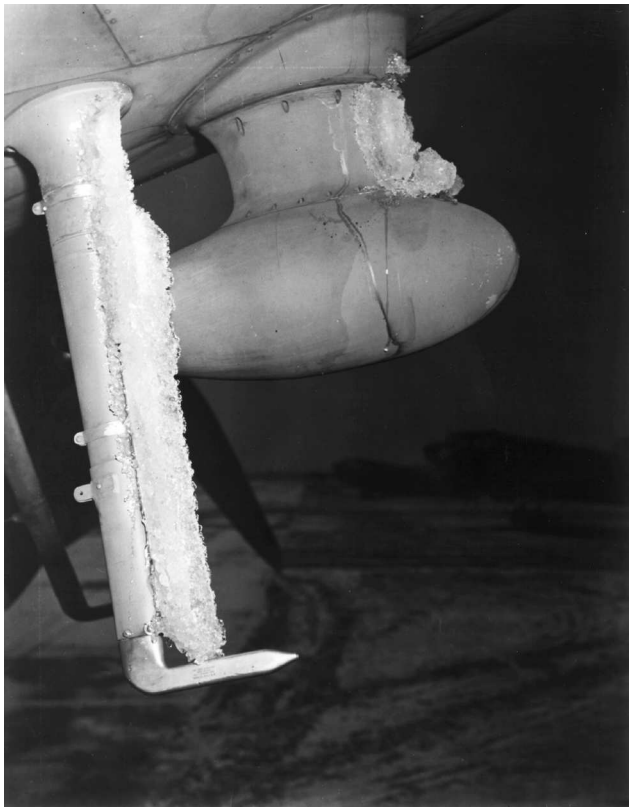
*LMAL-27008*

A good example of the impressive results produced by drag cleanup was the Bell P-39 *Airacobra*. The aircraft originally had a top speed of 340 mph. After undergoing two months of drag cleanup work, the plane emerged with a new maximum speed of 392 mph. Instead of an expensive and time-consuming complete redesign of the aircraft, the NACA's drag cleanup research showed that minor modifications would enable the P-39 to meet the Army's specifications.

## Hold the Ice

Ice is the bane of every pilot. It coats wings and propellers, reducing lift and increasing drag, often resulting in fatal crashes. Right from the start, the entire aviation community was unanimous in its desire to develop a system that would make flying safer. The NACA began its studies in the late 1920s at Langley, however, work was transferred to Ames as soon as the California lab was opened. The icing project was considered unique among NACA wartime efforts because it consisted of both research and extensive design of actual hardware used on airplanes.

The NACA developed a heat deicing system which piped air heated by hot engine exhaust along the leading edge of the wing. The Army asked the NACA to install a prototype of this system on two bombers, the Boeing B-17 *Flying Fortress* and the Consolidated B-24 *Liberator*; the Navy swiftly followed suit having the NACA put a prototype on the Consolidated PBY *Catalina*. Studying the results of these prototype systems as well as further test results from its own Curtiss



AAL-5010A

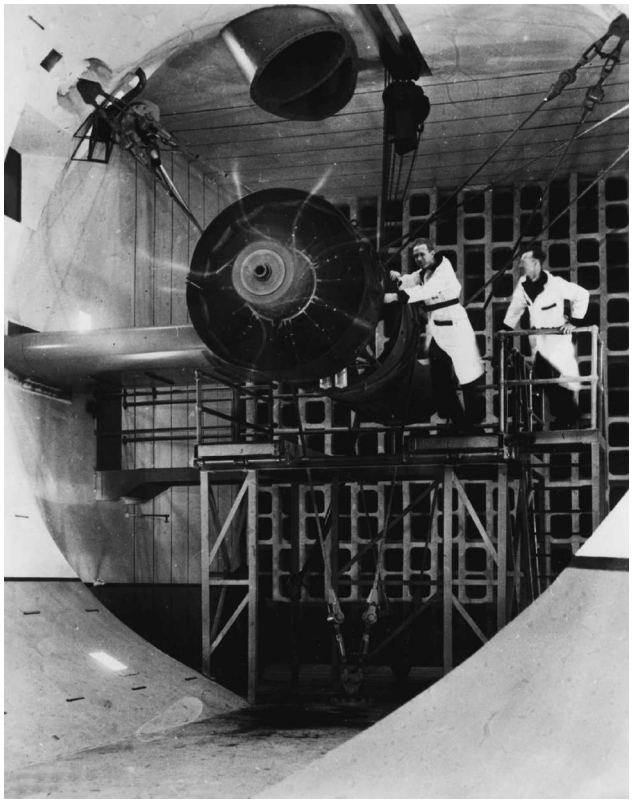
*Ice formation on the loop antenna and co-pilot's airspeed mast of a Curtiss C-46 Commando transport at Ames. The aircraft participated in icing flight research studies in 1944.*

C-46 "flying laboratory," the NACA perfected a deicing system used to save the lives of countless airmen flying in dangerous weather conditions. In 1946, Langley/Ames researcher Lewis Rodert and the NACA were awarded the Collier Trophy, aviation's highest award, for their deicing work.

## Supercharged Solutions

The NACA pioneered new methods of "troubleshooting" defects in new, higher powered piston engines. These efforts were conducted at the new Aircraft Engine Research Laboratory in Cleveland (now known as the Lewis Research Center) beginning in 1942. Engineers closely examined engines slated for rapid production and use in military aircraft. They developed new ways to solve complex combustion, heat exchange and supercharger problems. Engine manufacturers considered the supercharger their most pressing technical problem. The NACA began by studying existing corporate research programs; it swiftly introduced a single standard test procedure. Then researchers began developing the centrifugal supercharger. This work was extremely useful to manufacturers.

Engine research did not receive very much public attention. One project NACA engineers often highlighted was their work on the engines for the Boeing B-17 *Flying Fortress*. While testing the early B-17 prototypes, the Army had discovered that adding a turbo-supercharger would greatly improve the altitude and speed of the bomber. The Army ordered future B-17s be equipped with turbo-superchargers. Supercharger technology was not very well developed and Wright Aeronautical, makers of the R-1820 Cyclone engines used on the B-17, struggled with the requirements. This was precisely the kind of problem



AERL-1326

*On May 8, 1942, the Wright R-2600 Cyclone 14-cylinder engine became the first test subject to be evaluated in the Engine Propeller Research Building at the NACA Aircraft Engine Research Laboratory.*

the engine lab was intended to work on. Eventually, the turbo-supercharger problems were resolved and the B-17, a true high-altitude, high speed bomber, went on to become one of the military's most successful bombers. The turbosupercharger was also used with great success in the Boeing B-29 *Superfortress*. The Wright R-3350 Duplex Cyclone that powered the B-29 also underwent extensive testing in the NACA's new Altitude Wind Tunnel at the engine lab.

It should be noted that while the NACA engine research facility was used by General Electric to test the I-16 turbojet engine, NACA researchers had been virtually excluded from some aspects of wartime research on jet propulsion. Early in the war, the NACA had pursued some jet engine technologies, including an axial-flow compressor, that had a bright future but had too many problems to be overcome in the short term. In any event, by that time the United States was already behind Great Britain and Germany in developing a workable jet aircraft. Nonetheless, there was a dedicated group at the engine lab which seized every opportunity to work on the General Electric project thereby building the foundation for the NACA's postwar work on jet engine technology.

## Keep it Smooth

Airfoil research was a well-established hallmark of the NACA. A new series of airfoils announced in 1940 was the basis of the NACA's low-drag wing research which had a profound effect on the outcome of World War II. An airfoil is a typical cross-sectional shape of a wing. Airplane designers chose from hundreds of airfoils to get the maximum amount of lift-to-drag ratio. The aerodynamicist's dream was the laminar flow airfoil because it meant the layers of air moved completely smoothly over the surface of the wing. The new series developed by the NACA produced predominantly laminar flow when the airplane was at cruising speed.

Low-drag wings resulted in high speed at cruise conditions and longer range which is why the British (the original purchasers of the aircraft) requested that North American engineers use the NACA low-drag wing on the P-51. A prototype of the fighter tested at Langley showed tremendous capabilities and ignited enormous enthusiasm among engineers and test pilots alike. The *Mustang* went on to become a highly effective long-range escort support for heavy strategic bombers and outclassed most enemy fighter opposition in aerial combat. Back in the lab, low drag wing work continued as NACA engineers developed a second laminar flow airfoil series which would be incorporated into other aircraft such as the Bell P-63 *Kingcobra*, Douglas A-26 *Invader* and America's first jets, the Bell P-59 *Airacomet* and the Lockheed P-80 *Shooting Star*.

*LAL- 52638*

*This P-51B was used at NACA Langley to conduct in-flight investigations of wing sections, including the revolutionary near laminar-flow airfoil. The device located behind the white (test) section of the wing is an air pressure rake which registered details of airflow over the section.*

## Under Control

Wartime research on stability, control, and aircraft handling qualities included several projects. Three are described here. Stability means the tendency of an airplane to return to steady flight after a disturbance (such as a wind gust). The best way to determine an aircraft's stability was through flight testing. One important contribution made by the NACA in this area was its famous technical report, No. 755, "Requirements for Satisfactory Flying Qualities of Airplanes." Representing a decade of work, the NACA introduced to the industry a new set of quantitative measures to characterize the stability, control and handling qualities of an airplane. The military readily adopted the NACA findings and for the first time issued specific design

standards to its aircraft manufacturers. It is a classic example of the partnership between the military, aircraft industry and the NACA.

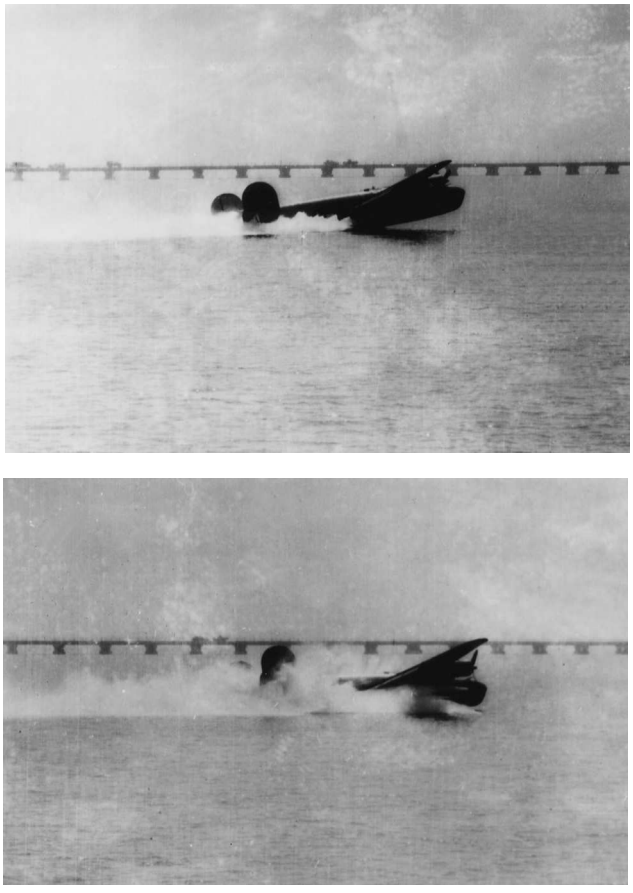
Another important area of work was spinning—the dangerous, uncontrolled downward spiral of an airplane. Both the Army and the Navy required that every fighter, light bomber, attack plane and trainer be tested in the NACA spin tunnels, using accurately scaled and dynamic models. More than 300 models were tested and aircraft designers used the results to help minimize spinning tendencies. This work also contributed to changes in airplane tail design, a factor instrumental in helping pilots recover from high-speed dives.

While flying various combat missions pilots of high-speed aircraft had been terrified by the unexplained loss of control which occurred when air flow over various portions of their aircraft exceeded the speed of sound (the airplane did not actually fly faster than the speed of sound). Suddenly without warning the airplane would plunge into a steep dive and the pilot's controls would be completely useless. This phenomenon surprised engineers both in industry and the NACA. The NACA quickly initiated studies of the problem. Air, researchers learned, is a compressible fluid and when airplanes approached the speed of sound it became so dense and the pressure so great that shock waves formed, changing the airflow over the surfaces of the wings.

Extensive testing of compressibility was conducted first on the Lockheed P-38 *Lightning* at Langley. Lockheed chose not to follow the recommendations because they would have required extensive design changes. In theory the NACA proposals would have solved the problem but Lockheed wanted a quick and inexpensive solution. A second research investigation was then undertaken at Ames. Ames researchers came up with three possible solutions. While they did some wind tunnel work, most of the Ames work involved flight tests duplicating the conditions encountered in combat. Although never crediting the NACA, Lockheed adopted the dive flaps proposal which added flaps on the wing's lower surface. While this was only a "quick fix" the dive recovery flaps did enable the pilot to overcome the effects of compressibility and retain control over the airplane if it went into a dive.

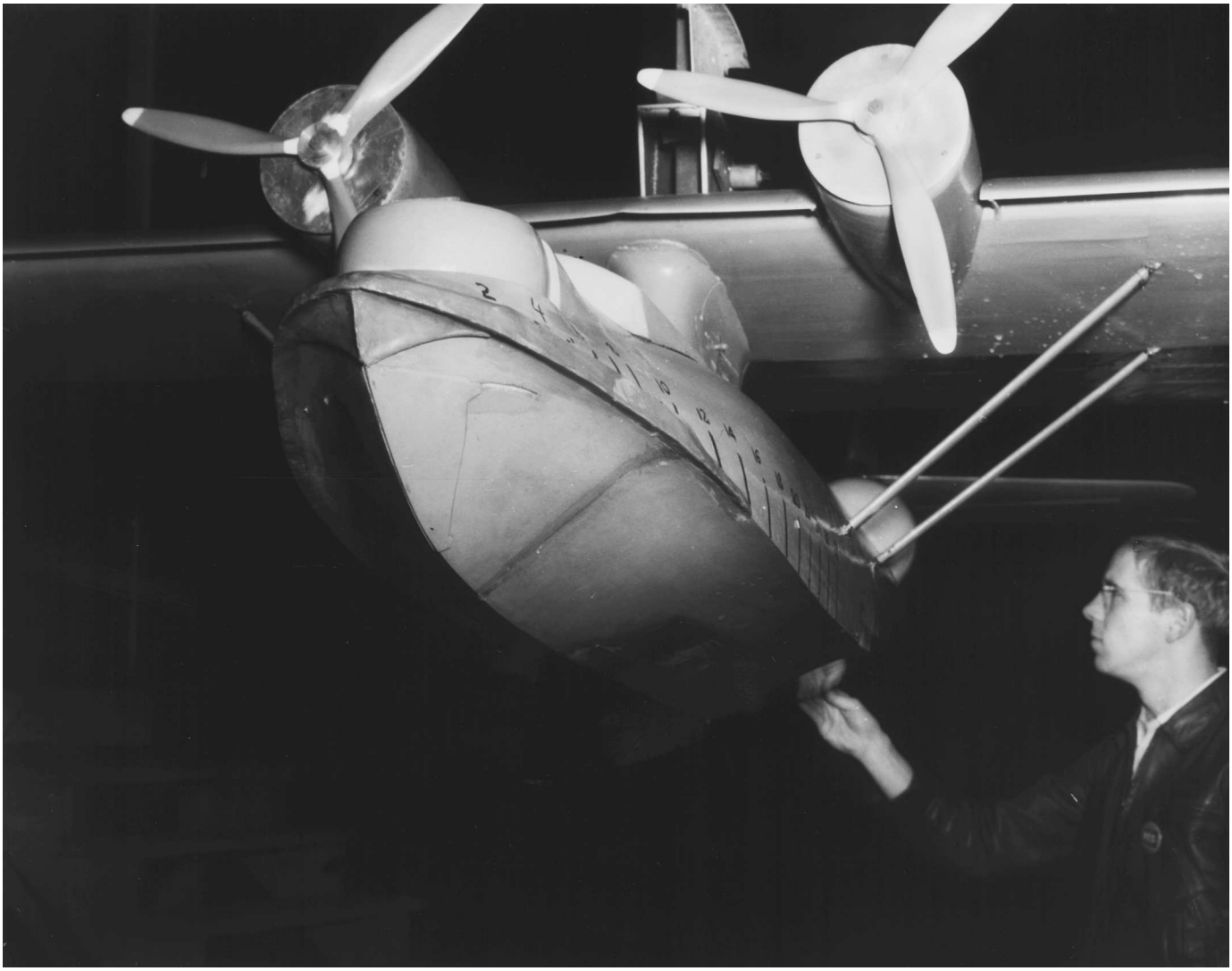
## Surviving Water Impacts

By 1943 military planners agonized over the mounting losses of aircrews experienced over vast ocean areas, particularly in the Pacific. They asked the NACA to assist in finding ways in which aircrews and aircraft might better withstand water impacts. An intensive program was initiated at Langley using its hydrodynamic and structures facilities plus full-scale aircraft. Most studies involved models but one of the more dramatic efforts was a joint project with the Army. Using an actual Consolidated B-24 *Liberator*, the NACA ditched the plane in the nearby James River. The force of the impact on the aircraft's bomb bay doors and other structural components was measured. The information obtained from the studies was sent to aircraft manufacturers as well as to air units in both the European and Pacific Theaters. The research helped to save the lives of countless aircrews.



*LMAL-40243*

*Sequential photos showing the ditching of a Consolidated B-24D* Liberator *in the James River.*



*A model of the Consolidated PBY* Catalina *flying-boat is prepared for tests in the NACA Langley hydrodynamic facilities.* *LMAL-31300*

## No More Porpoising

Before and during the war, NACA researchers studied problems involving seaplane hulls and floats using two unique tow tank facilities and an impact basin located at Langley. During takeoff and landing, the large seaplanes with their heavy hulls tended to bob up and down (the engineers called it "porpoising") or even worse, skip along the surface making the aircraft dangerously uncontrollable. The Navy, which used seaplanes for maritime patrol was keen on finding solutions to the problems of porpoising and skipping. Careful study showed that adding a "step"—really a notch—that broke the smooth surface of the hull would eliminate both problems. The step provided two separate surfaces—one for when the seaplane was plowing through the water (early in takeoff and during the final stages of landing) and one for when it was skimming along the surface when the plane was nearly airborne. The NACA also solved the problem of water being sprayed onto the propeller and wings by adding metal strips to the hull which deflected the spray.

## Suggested Reading:


*Dawson, Virginia P., *Engines and Innovation: Lewis Laboratory and American Propulsion Technology* (NASA SP-4306, 1991).

Gray, George W., *Frontiers of Flight: The Story of NACA Research. New York: Alfred A. Knopf, 1948*.

*Hansen, James R., *Engineer in Charge: A History of the Langley Aeronautical Laboratory, 1917-1958* (NASA SP-4305, 1987).

Hartman, Edwin P., *Adventures in Research: A History of Ames Research Center, 1940-1965* (NASA SP-4302, 1970).

*Muenger, Elizabeth A., *Searching the Horizon: A History of Ames Research Center, 1940-1976* (NASA SP-4304, 1985).

*Roland, Alex, *Model Research: The National Advisory Committee for Aeronautics, 1915-1958* (NASA SP-4103, 1985)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