

AIR ATTACK

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THINK TANK

Brainerd/Firehawk's
new tank for their
firefighting S70s

STORY BY **LEIGH NEIL** | PHOTOS BY **NED DAWSON**



First entering civilian use with Brainerd Helicopters almost twenty-four years ago and operated extensively on fire fighting missions, the Sikorsky S-70A Firehawk has relied primarily on Bambi buckets to carry out the work. Now, however, Brainerd's Firehawk Helicopters is in the final stages of development of an advanced inboard firefighting tank system for the robust and capable ex-military platform.



huck Brainerd, an army aviator and Vietnam veteran, founded Brainerd Helicopters Inc. in 1973. The always-progressive company

established the USA's first emergency helicopter service back in 1984 to carry a cardiac balloon pump onboard and began fire suppression operations for the US Forest Service, the Department of the Interior and the US Park service in 1987. In total, over 340 of Sikorsky's UH-60 Black Hawk family have been sold into the commercial market in one form or another over the past 5 years, but Brainerd obtained their first S-70C in 1995 to become the world's very first commercial operator of the military type. Brainerd immediately set up Firehawk Helicopters to operate the aircraft and commenced fire suppression operations with it in mid-1996. A second S-70C was added to the fleet in 2001 and in 2004 after partnering with Brown Helicopter Inc, Firehawk now operates ten S-70Cs, S-70As and UH-60 Blackhawks on various commercial work missions and in the fire fighting role.

Chuck's son Bart took over as the company president when the founder stood down from that role in 2015, and

he spoke to Air Attack about the fire fighting tank program, describing the system, explaining how it came about and outlining the progress to date. According to Brainerd, the US Forest Service decided in the early 2000s that it wanted all aerial firefighting to be carried out by tank-equipped aircraft and so in 2005 Firehawk began a project to develop a tank system for the Firehawk/Black Hawk airframe. Both of Firehawk's S-70s were equipped with the military's ESSS (external stores support system) so the tank design developed at that time used two tanks, one on each of the external stores stations and the resulting prototype system was rather heavy and complicated. While it was going through a challenging FAA certification process due to that agency's concerns with proof of composite engineering design standards, the Forest Service back-tracked in about 2008 when it realized that its needs were best served by the availability of both tanks and buckets, so Firehawk's project was quickly shelved. "My father was always a big proponent of buckets for the Black Hawk, so that was pretty much the end of the tank program," recalled Brainerd, "but when he stepped aside in 2015, I promptly re-launched a tank







program because I had a conceptual design in mind that I'd been slowly working on since about 2010. My father still owns the company so he asked lots of questions and watched what we were doing, but I think he saw some merit in the path we were taking."

Because of Brainerd's thorough understanding of the potential challenges of designing and certifying a new aircraft system, at the commencement of the new program he immediately put together a team of people to work in conjunction on the various aspects of a design. Participants included Brown Helicopter, FAA designated engineering and airworthiness representatives (DER and DAR) and the relevant Firehawk personnel. "I wanted a team on board with us to help make sure we made all the right decisions from the very start and we started off with a brainstorming session, talking about all the pros and cons of the different possible configurations," Brainerd related. "Something I had been focused on from the get-go was the way a bucket drops; the head pressure and drop pattern it has, and the way a bucket can punch

through the canopy, because I wanted to make sure that whatever we built could mimic those characteristics and that performance." It was a difficult task as Brainerd said that the Black Hawk does not lend itself very well to a tank, with its limited ground clearance and a fuselage that is designed to allow for a substantial amount of expansion or stretch when carrying heavy loads. He is aware of other tank designs currently under development and commented that the aircraft type's peculiarities made for each of the designs taking a unique approach to overcoming those challenges. "We knew from our original efforts that it would be some sort of internal/external concept though," he explained, "and my original concept was for split tanks in the cabin, with doors each side and space between them to allow for maintainability. The downside of that was the need to have the tanks bridged so that if a door failed you could still get rid of the water in that tank. Then Kenny Brown, the youngest guy in the room, asked why we couldn't just go out of one side." Brainerd remembers that the next couple of hours were spent



debating the pros and cons of going down that design path. On the positive side was the use of one tank and a single door, allowing a simpler design with reduced weight, while the major downside was a concern about CoG (center of gravity). “We’d done our homework and the Black Hawk has a really large CoG envelope. In fact, there’s not a published lateral CoG limit for the aircraft but there are published configurations for the military with their wing mounts and tanks, and their permitted lateral differential is quite large,” Brainerd stated.

Brainerd then went on to explain that a major asset to the development program was having Alejandro (Alex) Anduze on the team. Alex’s background made him uniquely qualified to assist in such a project, as he is an ex-Sikorsky test pilot and knows just what the real numbers and limitations of the Black Hawk are. Originally starting with Sikorsky as a fight-test engineer,

Anduze then decided he wanted to fly and trained as a Black Hawk pilot with the US Army reserve. He is a veteran of overseas service in Iraq and also became a maintenance test pilot for the Army so when he returned to Sikorsky full-time, the helicopter manufacturer sent him to National Test Pilot School in Mojave and he became a full-blown experimental test pilot. “He has a diverse and unique set of skills,” commented Brainerd, “combining his engineering experience with piloting skills and he’s been integral to this program from its inception, in terms of both flying it and of making sure we’re doing everything correctly and safely. That’s critical for us because we’re taking this aircraft to the edge of its envelope. We’ve dived it to 193kts, done water drops at 193kts and we’ve flown it all the way out to maximum auto-rotation, which is 153kts. You’re dropping out of the sky pretty fast then, over four thousand feet a minute,

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and we've even had to drop water in that envelope for the FAA, to ensure that none goes into the tail and that there is no adverse behavior in that particular environment. Interestingly, the snorkel is very stable above 150kts and shows the most oscillation between about 120 and 130kts, although even then it's certainly not to the degree that would be a concern." The most crucial thing to prove with the new tank was that it would perform as required and, while the team was sure there would be sufficient head pressure, to ascertain if they could achieve the desired drop pattern a proof-of-concept prototype was commenced in spring of 2017, with flight testing commencing in fall of the same year.

Maintainability of the tank-equipped aircraft was always a priority of the development program and Brainerd commented that the company had developed a good understanding of the maintenance requirements and the

specific demands of keeping the Black Hawks airworthy on a daily basis. "Our mechanics have a hard enough job as it is, so we didn't want to impose a system that added even a half-hour extra work to their day, just to deal with that particular system," Brainerd remarked. "Originally we had hoped to be able to have it classed as cargo, rather than a fully STC complied system but we have to tap into AC power for the snorkel and a bit of 28V DC to charge the batteries, so it has to be treated as an aircraft modification and certified accordingly." Brainerd pointed out that having the DER and DAR included in the whole design and build process has been extremely helpful in providing good information to the FAA, as those representatives have had the opportunity to observe the entire procedure from concept, through all the build stages and on to the flying test example. They have also been valuable in providing advice from experience on

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things that have been challenging, or even the downfall of other tank designs. “The big thing they have been adamant about all the way through is that we have to test, test, test. Then, when we go to the FAA for the first time with an application, we can give them hard data and not just a theoretical concept,” he said.

To get the desired head pressure, the 925 gallon (3,500 liter) Brainerd tank has a ramped internal design, wide at the top and narrowing towards the bottom all the way to the gate, so that the water column is as tall as possible

and the majority of the volume is held in the upper level of the tank. Head pressure is a function of height so according to Brainerd a ‘vee’ design would be the optimum internal tank profile, but the single-side design of his system makes the ramped version the next best option. The end concept for the tank is for it to eventually be ambidextrous, but the original version discharges from the left side of the aircraft. He explained that the command pilots in their machines fly from the left seat for maximum visibility on long-line work and the like, so it was common



sense to initially configure the tank for a left-side gate. The tank payload discharges just behind the left-hand main wheel and Brainerd explained that the design intentionally uses the wheel as an aerodynamic 'buffer' to break up the airflow ahead of the discharge stream and minimize disruption to the flow pattern. The system's fifteen-foot long snorkel takes around fifty seconds to fill the tank if just the pump is in the water, with that fill-time dropping to just under forty seconds if an extra five or six feet of snorkel hose are submerged. Discharge of a full tank takes about four

and a half seconds and Brainerd said that the tank's location almost directly at the CoG means that very little effect is noticed when dropping water. "You see a little more roll at the hover than you do in forward flight, but it's a progressive change and not violent or sudden," he described. "The worst-case scenario is when you have only a couple of hundred gallons in the tank because then it's all on the left side, but even then you only have about one and a half degrees left-wheel-low if you're in the hover."

Discussing the construction of the



tank, Brainerd advised, “We have gone with as many off the shelf components as we could. The pump is the same three-phase electric pump that LA County uses on their Firehawks and the snorkel material is a commercially available product. Even the tank itself is assembled from commercially available composite panels by Leading Edge Composites and as part of the certification process, the FAA is currently assessing quality control on

the assembly and joining methods used in building the tank. Leading Edge has brought their deep composite experience to the program helping us to build a lighter tank while still exceeding the FAA’s strength criteria. We also stepped up with Trotter Controls, who had debuted their third generation fire gate system earlier this year during the Australian fire season. Their new gate has done away with the hydraulics entirely and is now fully electrical.”



The door system used is that fitted to the Air Tractor 802 fixed-wing and is a little larger and heavier than that which is necessary for the demands of the Firehawk design, but it still weighs in more than two hundred pounds lighter than the original Air Tractor hydraulic door system. Brainerd's design goal is to eventually get the weight of a complete empty unit down to seven hundred pounds or less, but the initial example's use of standard componentry

will bring it in at a probable weight somewhere between 850-900lbs. "There are things that we can invest in, such as a gate and gearbox design that's sized for our doors, but that would take at least a year and time is of the essence now, so that's something for future development once the system is up and running and has proven itself. Bear in mind that this is version one of the tank. In my mind I'm already working on version three



and meanwhile we've still got to build version two, which will tell us some things to include on version three. We've already got a few key pieces of the tank that we intend to refine, especially where we can remove weight from the system. The nice thing is that everything is modular. The alloy gate has a mating plate to the composite tank so you can un-bolt and replace the entire gate system for maintenance, repair or replacement."

Brainerd says that the new design is exceeding his expectations and that his original concerns about a variable door-control mechanism interfering with the flow pattern have proved to be unfounded. "Trotter Controls supply the door control system, the computer and software, the whole nine yards and I was able to watch the gentleman on the test stand greatly improve the performance of the doors by directly controlling how quickly and how much the doors open, and he was able to dramatically improve the flow pattern." The tank is an integrated unit that incorporates all the control mechanism, computer control system and batteries. It attaches to the aircraft on rails using four existing tie-down

points in the cabin and an additional upper restraining rack system designed to comply with the engineers' demand for greater restraint in the 'tipping' plane. The restraint system uses pivoting arms, allowing the system to flex and eliminate adding stress to the cabin-structure as the aircraft stretches or contracts under different loadings. For maintenance purposes, by removing eight pit-pins the tank can be disconnected and slid approximately two thirds of the way out on the attachment rails, to the limit of the restraining security cables. "By doing that you can get in to inspect the filters and filter buttons, all the things you need to do as part of a daily inspection on the aircraft," Brainerd described. To remove the tank entirely, a new piece of ground equipment is being designed and using that equipment, three or four people can remove the tank completely in about ten minutes. A highly advantageous feature of the Brainerd tank system is that the cargo hook is retained and unaffected, so the ability to transition back to underbelly hook work is retained, requiring only a few minutes to reconfigure the machine for urgent lifts. The tank would



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necessarily be retained in the aircraft in those circumstances but that would incur a payload hit of only around ten percent of maximum payload. The snorkel design is angled out from the side of the aircraft before it drops vertically, the profile leaving it clear of the discharge flow and preventing it rubbing against any part of the aircraft structure, while the tank itself is baffled against water surge in all three dimensions. When ferrying or otherwise equipped but not firefighting, the snorkel is clipped to a D-ring in the rear of the cabin area to allow taxiing on the landing gear and Brainerd explained that an intended future improvement is to fit an electric release in the cockpit, enabling the pilots to release the snorkel and commence uploading water without landing.

Progress has been steady and

consistent so far and Brainerd told Air Attack that he hoped for the new system to be certified and operational later this year. "I was really hoping we'd have the certification about now, in May 2019, but like any certification project there are unforeseen challenges and questions, and we're going through our fair share of them right now. The FAA currently wants us to show that we have sufficient protection against lightning, particularly with regard to satisfactory electrical continuity for the grounding of the snorkel and they have designated a lightning-specific DER to assess it. We've finished the initial FAA flight test card so we've now started on what I'd call the conforming prototype. We've flown through the complete flight envelope and the FAA has now come back with a list of additional tests that we need to do. We have to conduct



