DR. JON YAGLA
1965 - Present

Introduction	<u>MUSIC</u> Welcome to the Dahlgren Centennial Celebration – A Century of Innovation. We hope that this and our many other products, events and offerings will showcase what Dahlgren has accomplished during its last 100 years. Throughout our history, we've interviewed some of the most prominent minds, leaders and innovators that have been here, and we're opening up the vault to share them with you this year. Today we are honored to listen to the story of Dr. Jon Yagla, whose work spans from 1965 to the present. Dr. Yagla has had an extensive career at Dahlgren, particularly in weapons development. His podcast will focus on his work on the conical shock tube, launchers, and blast testing. Let's listen to Dr. Yagla…
Yagla	My first assignment was to the Conical Shock Tube Project. That was the new project. We were going to build a nuclear blast simulator, and my first assignment there was to develop a calibration program. In other words, when we get it built, how you're going to test it to see what it can do compared to what it was supposed to do. You're supposed to be able to simulate a nuclear blast from a 20 kiloton nuclear weapon, so… I worked out a plan where we just start with progressively larger and larger charges in the firing chamber, and measure the blast pressure as it went down the tube to see how it compared with the nuclear blast and how it compared with the predictions that went into designing it. And then my other job was to design an instrumentation system for the shock tube, and again that would be using the latest and greatest computer equipment of that time. Digital computers would be available for that kind of work in about three or four years, so it would take a couple of years to buy all this stuff. We had instrumentation companies come in, show us what they had available now and what was under development and when we would be able to get… For example, analog-to-digital converter, you don't think anything of that now. Boy, that was a big deal then! Because all our signals were analog: strength, pressure, temperature, everything we measured. And to do anything with the computer, the first step is to digitize it somehow. You've got all this stuff

	recorded on analog magnetic tape, how're you going to get it off tape and into a digital-type format so you can apply your calibrations and get an output. And another thing was getting the output. That was no simple thing either! I mean, in those days, you could get a table printed out of your data and you could plot it yourself on graph paper, or you could maybe program a pen plotter to plot it out, which wasn't a heck of a lot better. You had to tell the pen to pick the pen up or otherwise it would draw a line where it's going over here to another point. You say you plot this and this, and you know x versus y, and you get it back, and there's all these tracks going around, and there's your plot in there too, and you've got to tell it to pick the pen up and put the pen down. So anyway, it was a period of a whole lot of change. Computers were a big part of it. Those were my first two jobs.
Staton	How long did the Conical Shock Tube job last?
Yagla	Well, that lasted until about 1974. And I would say—
Staton	We were still doing testing in '74?
Yagla	At the very end. Right. I like to look at it as it completed its mission because in the time period it was built, the nuclear threat was very real. We could've been at war any time. It was really scary for everybody involved, and somebody could just accidentally have started a war, and we have things set up to automatically fight back, and it could very well lead to a lot of destruction. The Navy even envisioned nuclear warfare at sea. We had nuclear weapons and ASROC [Anti-Submarine Rocket], and practically all the surface combatants at that time. We had a marine detail on that ship guarding those nukes and the ASROC magazine… And we had a nuclear capability for Standard Missile, and a lot of the Tomahawk stuff was just starting development back then. We had to design the ships for a nuclear blast, and it was a certain pressure that the equipment had to be designed for. And so we would set up equipment items in the shock tube and see if they could resist that blast and then go back to work on them. The Navy didn't get nearly as serious, I don't think, as the other services about nuclear warfare. It was something that was possible, but they didn't ever want to spend a whole lot of money on it. They preferred to "qualify by analysis," as they called it. The testing was expensive, and if some engineers would go in there and convince them that the piece of equipment would survive the blast by analysis, that would be good for most of the stuff that went on the ships… We didn't get as much testing of that type as was envisioned. But the biggest

	project we got was to test the equipment for Safeguard anti-ballistic missile defense system. It was the system that was designed to knock down Soviet-launched interceptors coming mainly over the North Pole. It had radars that would detect these missiles and then—coming in and then missiles that would fire at them. There was a long range one called Spartan, and a short-range one called Sprint. And we actually tested those missiles in the shock tube because the scenario they envisioned, one of these missiles would come into the search radars and they would see it and that would be about the time they'd be ejecting multiple reentry vehicles that would have independent weapons on them. And so our missiles would have to attack these one at a time and knock them down. And as a consequence of that, there would be all these fireballs and nuclear blasts in the air, and these targets—they're not spreading out very quickly, so the second missile might have to fly through the blast of the first missile. And so we set those scenarios up out there in the shock tube where we suspended the missile, and we attacked it with the nuclear blast, and we measured its response. And that was the biggest test that we did. And also that Safeguard system had the radar buildings that were out in the fields that would have the radars and process that data. And they wanted to make sure that they were nuclear hardened so they couldn't be defeated early in the engagement. So we had models of these buildings, testing the models of the building in the shock tube. That's what we did in the shock tube. The costs of operating it continued to go up, and the likelihood of the nuclear warfare went down, and that was the end of it. I was the one responsible at that time, and I closed it down for the Navy. And we sent out to letters to everybody--
Staton	Nobody objected.
Yagla	Nobody was interested. Yeah, right. "We don't have business. We're going to close it down at such and such a date." And that's what we did.
Staton	How long was it before it was dismantled?
Yagla	Probably twenty more years. Yeah. It wasn't really hurting anything. It could've easily been reconstituted if we needed it. There wasn't really any point in tearing it down. I mean, we weren't going to make anything by it. Maybe free up some real estate. The price of the scrap metal wasn't all that significant. I don't know if the government made any money on it or not. Might have had to give it away to get it out of the way. It was sad. Some of it was real high strength steel. Very good steel.

Harmon	Well, there were gun barrels. How many gun barrels?
Yagla	4 gun barrels
Harmon	4?
Yagla	Yeah. 16-
Harman	16 inch guns?
Yagla	16 inch guns. There were over a thousand pounds of TNT. And they set that off in the confined space of those gun barrels, tremendous pressure, and it just goes down the tube.
Harman	Did the shock tube hold up on the first shot? First time they ever…?
Yagla	Yeah it did, but there were problems with it that weren't anticipated by anybody. It was plenty strong in internal pressure. A cylinder is a really good pressure vessel. But one thing a cylinder isn't—it's a good pressure vessel when the pressure is on the inside. When the pressure is on the outside, it's very bad. It will buckle; it's called instability. And the most serious thing that you have that would be in a submarine when it goes down to test depth and it just gets crushed like a soda can.
Staton	Yeah.
Yagla	The physics of the gun blast going down the tube—it's internal pressure, and when the shock wave gets to the open end and leaves, the physics pressure condition there is—the pressure is one atmosphere at the boundary, that's the pressure of the atmosphere. Now there's pressure going in there was like fifteen or twenty psi. So now this pressure condition says I've got to get down to fifteen psi, which is ambient pressure, and what it does is that it undershoots that and goes down to as much of below it as it was above it is what it's trying to do. It's a reflection. Electrical waves do the same thing. If an electrical wave or a sound wave goes out there and hits that hard wall, the pressure would double on the wall and something will reflect back. If it goes into a medium that's transparent, it would be the opposite thing, and an expansion wave will come back and the acoustics in this gas dynamic thing. There was big suction because all this gas that's in there wants to get out now and has got a lot of forward momentum, and it just keeps going out, and the pressure drop drop drops. And so the atmosphere crushed it. It crushed about 800 feet of the shock tube. It just crushed it! So that had to be repaired. We had to get new sections made, and then we put stiffeners on the sections, and that's an easy cure for buckling instability in a cylinder, you just put a stiffening ring on it, and so every,

	say every diameter or so, you just put a ring on it. It doesn't have to be hardly anything at all. I think it was just a quarter inch or 3/8 inch thick plate, maybe four or five inches tall. And we just welded them on the whole length, and we never had any more trouble with it. I was able to calculate very exactly what the pressure was inside, when the wave reflected from the opening and then you could just go to a mechanical engineering handbook and look up the stability criteria for cylinders under external pressure, figure out why it did that and how to fix it. And we had a lot of nuclear blast work going on at Dahlgren at that time. Missile blast and gun blasts. These are very important things to designing ships. And for people who have to man the weapons, to make sure they're safe. Like a missile blast—it'll burn anything up! And you have to protect your ship from that. You have to make sure the missile blast doesn't impinge on many of those things on the ship; it'll just burn them right up. And so we had that work that needed to be done in the Navy. And then gun blasts have been a problem a ship ever since they put guns on ships. It's caused damage in the very first days of that in the 1800s.
Staton	Gun blasts.
Yagla	Gun blasts on ships. You need to be careful where you put the chicken coops; they'd crush the eggs. Well, it'd scare the chickens! And they couldn't lay eggs until they got over it, I guess. I don't know what happened. I don't think it crushed the eggs. Well, it might. Yeah, it could. So anyway, the equipment has to be designed to withstand the gun blast. So we would bring equipment here to Dahlgren, and set it up near the guns and test, and we would do calculations to see what the pressure would be. We had—a big job we still do is designing the firing zones for ships, to make sure the guns and the missiles don't come too close to the structures. And each of the fire control systems or the gun itself will have provisions in there so that you can't fire the gun when it's in… Danger. There's areas where you can't point the gun; you can't make the gun go over too close to something. We figure all that out at Dahlgren. The stuff that I learned for nuclear blasts immediately became useful in that. And then the other thing we do with blasts is we were in charge of the Navy Structural Test Firing program. Each ship that gets delivered to the Navy has to go through a structural test fire. And for the first-of-class of a ship, or a ship that's received any new weapons, or a ship that's been through a major

	overhaul, it has to have a structural test fire. air blasts— --From weapons firing. From gun blasts to missile blasts. So we would design those tests and then carry them out on ships. We'd send a test team out with lots of instrumentation [to] actually measure the blast, and invariably there'd be problems that arose from trying to do these tests with the equipment, with the guns themselves… It would just be just the essentials of the propulsion system, the actual tactical rocket motor. But it didn't really have to push any expensive electronics, seekers, gyros, all that stuff. So they actually used telephone poles. A piece of a telephone pole would be good enough for the front end of the missile for a Blast Test—other ones are more sophisticated [mailroom bell rings]. …But a tactical rocket motor and a telephone pole would do it… And that would make a Blast Test Vehicle. Because missiles have always been expensive--
Staton	Oh yeah.
Yagla	--Go out and do a blast test with a million dollar missile, I mean, that's a pretty serious expense. So, in the past when we had to do that kind of data gathering, we would get missiles at the end of their useful life. And the fleet could shoot them at something; they get the experience of firing, and we get the data. So sometimes that worked out…
Staton	So yeah, I think of you in the launcher area.
Yagla	See, we had the expertise to work through these blasts problems. And how we got in the launcher business was—we were knowledgeable in all the physics, the equations for the blast. And the Navy decided they'd be interested in developing a [mailroom bell rings] vertical launching system. And so right away I was involved in that because that system would have to survive its own blast.
Staton	Yeah.
Yagla	It was a really hard decision to make at that point in time. We don't think much of it now. The ships all have a Mark 41 Vertical Launch System, yeah so what, well you had go back to the mid to late 1970s, early 1980s when all the missiles were on external, rotating arms that were pointed at the target. They were in a box that would be pointed at the target, some sort of canister on the deck. Now you say we're going to fire this missile from inside the ship. Fire this missile with a thousand pounds of propellant, a big warhead on it. A lot of people said

	this on the face of it, said you know, "You're crazy, you'll blow the ship up. You'll blow the ship up!" They were sure we would blow the ship up. So it took a lot of engineering and a lot of salesmanship to convince the community at large that this could be done safely. That's what we did. We worked on that awhile.
Harmon	Did they use the [USS] *Norton Sound* for VLS?
Yagla	Yeah the very first launcher we put on the *Norton Sound*. We started out with a ship called… P-H-M… No… SES-100B. It was a surface effect ship, and it was maybe a hundred ton ship. And we put a vertical launcher on the back. It wasn't below deck yet. But just the idea of firing a missile vertically and have it attack some target out here at a horizontal distance being a whole lot greater than its altitude just to deal with the—that was a big step, so that you could, from this moving ship, you could fire a missile vertically and then you could point it out there to there to intercept and get it to go in a pretty small basket there for acquisition and make the intercepts, so the first tests were done on the SES-100B ship with just a single launch, vertical launch off the fantail of that ship while it was underway. And then the next step was to try to build this stuff so it would fit below deck, and that's where the Norton Sound came in. That was the next set of— I wasn't involved on the *Norton Sound* at all. [I did] some of the design work and all that, but to actually go there and fire a missile or make a measurement, I didn't ever do that personally. So you've got this tremendous flow of propellant out of the rocket nozzle into the ships, so you've got to confine it. Catch that and a box called a plenum, 8 missiles over a plenum. So the exhaust goes down in this box, and the box is coated with ablative type material that was designed for chemical industry applications—heat shields on reentry vehicles and that sort of thing. Ablative-type materials. And then that plenum would be pressurized and then all the exhaust would flow through the duct to the surf—to the deck of the ship to flow through the duct-- The service life of the launcher [phone rings] depends on whenever it's had a casualty or not. It has this thing that we designed for called a restrained firing. That was the thing they were scared of, not the fly-out. What do you do if you give it the Command to fire, and the missile fires, but for whatever reason it doesn't leave to the launcher? Then you hold it there in your belly the whole burn time. That's what we had to demonstrate, that this gas management system would last through a restrained firing.

	And another facet of that—once we turn the corner and said, alright well maybe it is feasible to launch these missiles from inside the ship, we have a Vertical Launching System. And then the next round of it was do we really have to have this restrained firing requirement? Isn't that really unlikely? Couldn't we save a lot of money by not worrying about that? Easily the most expensive part of that launcher for a missile bases is the thermal protection system, and—well, maybe not the most expensive, but it's right up there… big part of it… So anyway, we had systems safety, and they engineered safety things and interlocks. They really did make it very unlikely that there would be a restrained firing. But we went along building confidence in this for fifteen or twenty years, ok, guess what-- Missile didn't move. Happened on a battleship. That was a restrained firing. It wasn't a vertical launching system. That kind of showed—restrained firing. And then quite a few more years went by and we had a Tomahawk that didn't launch, and it burned propulsively in the VLS, and the gas was safely ducted out of the ship. And there weren't any casualties. It did just fine. Another thing that happened prior to the box launcher restrained firing, again the same thing—couldn't we save a lot of money? Well they wanted to save a lot of money when they put the Armored Box Launcher on the…Spruance-class destroyers. I think it was eight of those destroyers, or sixteen of them or something, got Armored Box Launchers, right on forward, right by the 5 inch gun forward. And they were doing a test out at Port Hueneme [California], and they were going to actually fire a missile out of the Armored Box Launcher out over the water out there at Point Magu [California]. And they had all the data processing equipment for the launch, at least simulations there. It looked like good equipment to me. But they had it all set up in this space behind the bulkhead of the ship between the launcher and this equipment room. It was called the Data Processing Center on that ship. And I got a naval message handed to me at one in the morning that said, "Test T11 rescheduled." And I said, "What's Test T11?" I didn't even know about Test T11, but anyway, T11 was a fire—Tomahawk-like shape with this booster motor, the Tomahawk booster motor out over the water. Well, when they fired that, it didn't move! Again, it was an unexpected thing like we were talking about before. What if you pressurize that rocket motor internally with 2000 psi? Well, it grows radially. Gets bigger! Now it's like a friction break, and it can't get out! That's many millions and millions and hundreds of millions of dollars spent to get to that point. And it's something so stupid. And now looking back it's obvious somebody should've thought of that but that's what comes to get you in the development business. You don't at first see everything.

	This same launcher, and in parallel with this test actually [mailroom bell rings] being installed on a ship, down in San Diego. I mean, the launcher was in place, and they wondered what would happen if you had a restrained firing on the ship. Well, the same thing would happen. So we had an emergency job to design a thermal protection system for that ship. It was the USS *Merrill*
Conclusion	Thank you for listening to this week's Dahlgren Centennial Podcast, and hopefully you have learned another interesting aspect of what our people accomplish for the Navy and for our nation. We will continue sharing how Dahlgren is a one-of-a-kind location where innovation is heralded as the hallmark of each individual. <u>PAUSE</u> Tune in next week to hear from Leon Lysher whose significant work at Dahlgren spanned from the late 1950s to 1986. His podcast will focus on his contributions to electronic warfare. Thank you for celebrating this century of innovation with us at Dahlgren. <u>MUSIC</u>