

This report comes from Gary Kerr, a member of the Smithsonian's National Air and Space Museum's special advisory committee for the restoration and preservation of the Star Trek starship Enterprise studio model. In it, he recounts some of his efforts over the past year to document missing parts and secure the hardware needed for the restoration of the model. This was originally published August 2016. See more at: airandspace.si.edu/startrek

Adventures in Sci-Fi Archaeology

The Literal Nut & Bolts of Restoring the Starship Enterprise

It was a dark and stormy night...

Well, actually it was a dark and rainy day, and I was driving all over the metro area in search of some hardware I needed to repair an old starship. Not just any starship, mind you, but the original – the USS *Enterprise*. How did I find myself in this situation? It started almost 50 years ago, with the premiere of a new TV show called “Star Trek.”

From the moment I watched the first episode, I was hooked, and this began a lifelong love affair with the *Enterprise* and all things *Star Trek*. I memorized the episodes and bought all the plastic kits, tech manuals, and commercially available blueprints. I started drawing my own blueprints while in high school, and made a couple pilgrimages to the Smithsonian's National Air and Space Museum to see the *Enterprise* studio model in person, hanging high overhead. In 1991, I leapt at the chance to get a hands-on experience with the 11-foot studio model when it was at Ed Miarecki's shop, just before the formal restoration began. A friend, Richard Shafer, and I made measurements and took a number of photos of the model, but little did we realize how important those photos and measurements would become.

In 1996, veteran Hollywood model maker and *Star Trek* fan, Gregory Jein, phoned me and said he needed blueprints of the *Enterprise* so he could build a model of the ship for the *Star Trek - Deep Space Nine* episode, “Trials & Tribble-ations.” No accurate plans were commercially available, so I used the photos and measurements that I'd made of the model in 1991 to draw a set of half-scale plans for Greg. That brought me to the attention of *Star Trek* graphic designer and historian, Mike Okuda, and the rest, as they say, is history. In the intervening years, I've switched from drawing plans with mylar and ink to using AutoCAD, and I've been refining my blueprints of the ship with each new *Enterprise*-related project.

In November 2014, I received an invitation to become a member of the Smithsonian Institution's Special Advisory Committee for the restoration of the 11-foot *Enterprise* studio model, and naturally I accepted. Our goal was to restore the model to its 1967

configuration, a state that nobody, other than a handful of stagehands and others, has ever seen in person. First, a quick history of the *Enterprise* model.

In the early 1960s, an ex-pilot, former LA cop, and writer named Gene Roddenberry was trying to get his proposed science fiction TV show off the ground. Roddenberry wanted the design of his ship, initially christened "USS Yorktown," to be different from the flying saucers and flame-belching rockets commonly seen in TV shows and movies of the time. The responsibility for translating Roddenberry's ideas to a set of construction blueprints eventually fell on Walter M. "Matt" Jefferies, who served as set designer and art director for the original series. At the time, nobody knew what a "starship" was supposed to look like, but Jefferies finalized the iconic design that would serve as the template for countless starships that followed over the next half-century.

The 11-foot *Enterprise* model was built from wood, plastic, and sheet metal at Volmer Jensen's Production Models Shop, under the supervision of Richard C. Datin, and it was delivered to the Howard Anderson Studio on December 29, 1964. Over the next year or so, Datin tweaked the design of the model several times until Roddenberry and Jefferies were satisfied with the look of the ship. Fans have designated the early stages in the ship's design as the Rollout, 1st Pilot, and 2nd Pilot versions, with the final design being called the Production version.

The show was canceled after three seasons, and the *Enterprise* model was disassembled and stored in crates for several years. The model finally saw daylight again at the 1972 Space Week exhibition at Golden West College in Huntington Beach, California, but the Christmas bulbs inside the nacelle domes were burned out, and the deflector dish had broken off and gone missing. After the exhibition, the model was placed into storage for another couple years, and then the model was donated to the Smithsonian Institution, arriving at the Museum in April 1974. By this time, even more parts of the model had vanished, most noticeably the nacelle domes and most of the lighting mechanism inside the domes. During subsequent restorations of the model in 1974, 1984, and 1992, other original parts disappeared, and less-than perfect replacements took their place. The model was repainted several times, and the original paint job and weathering on the model, with the exception of the upper portion of the saucer section, were obliterated. Even worse, gravity and age began to take their toll on the model, and by the time the current restoration began, the aging glue that held parts of the model together was starting to fail, and the *Enterprise* was in danger of literally coming apart at the seams.

The members of our restoration team had their first in-person meeting at the Steven F. Udvar-Hazy Center in Chantilly, Virginia, in May 2015. After the meeting, the Smithsonian's conservators continued their research into the physical conservation of the model, and both Museum personnel and various restoration team members began the hunt for additional references in earnest. Since I had already done the most research on the model's design history, I served as a "sci-fi archaeologist." I delved into the history of this half-century-old artifact and began cataloging all the cosmetic changes that would be required to restore the model to its appearance *circa* 1967. I had

a number of big advantages that earlier restorers didn't have, such as Blu-rays, screen captions, and high resolution photos of the model, plus Museum staff to conduct interviews and beat the bushes in search of previously unseen reference materials. Computer technology that we take for granted nowadays, such as email, the Internet, and computer-aided drafting, have been invaluable to the current restoration, yet they were in their infancy during the previous restoration in 1992.

To begin my study of the model I pored over all my written materials and photographic sources, and compiled a detailed chronology of all the changes to the model's design and paint scheme over the years. The design of the *Enterprise* is deceptively complex, and much of the research involved playing a game of "spot the differences" between photos taken at different times. Even photos that I'd seen a hundred times before sometimes yielded clues that have been overlooked for all these years, especially when we acquired higher-res versions of the photos. We also obtained previously unpublished photos thanks to the sleuthing efforts of Mike and Denise Okuda and others. I quickly learned that I needed to unlearn – or at least take with a large grain of salt – many of the "facts" that I *thought* I knew about the model, and I decided to go wherever the evidence led me.

This entry will concentrate on a few of my initial research efforts last year and earlier this year. The research phase for the cosmetic restoration of the model fell into three main categories: replacing decorative hardware items, such as nuts & bolts; fabricating larger parts that had disappeared over the years; and replicating the original markings.

Fun with Fonts

I decided to tackle the ship's markings first. The original lettering on the upper saucer would remain untouched, but I'd have to draw the artwork for everything else—the registry numbers on the nacelles and under the saucer, the red side banners for the nacelles and the side of the secondary hull, small technical markings for the saucer and secondary hull, belly markings on the secondary hull, and a few sundry items.

I started with recreating the 1.75" high "NCC-1701" registry numbers. Redrawing the alpha-numeric characters was made simpler by the fact that I had a fairly high resolution scan of an original decal sheet, plus tracings of the markings made in 1991 and 1999. When I overlaid a 1/32" grid onto the original decal sheet in AutoCAD, I could see exactly how Matt Jefferies, or somebody under his direction, had drawn the artwork for the font by hand in the old days before computers, and I was able to redraw the characters with a precision to six decimal places. I was also able to see how human error may have crept into the drafting of the original lettering, as I'll explain in a moment.

A rare 1967 photo of the left side of the model showed something unusual about the numbers "1" and "7" in the registry number on the left-hand nacelle, and it dawned on me that I was looking at the slightly different font that was unique to the Pilot versions.

Instead of using decals, the Production Models Shop had originally painted all the lettering on the model, including the registry number on the left nacelle, in the Pilot version font. When Roddenberry made the decision to add lights to the model, wires protruding from the left side of the model made it impossible to show the left side onscreen.

During the model's conversion into the Production version the painted-on lettering, with the exception of the miniscule "frame numbers" and the registry number on the port-side nacelle, was removed and replaced with decals. The budget for the show was always extremely tight, so when they made the decision to show only the right side of the model, the left-side registry number, in its Pilot version font, was ignored. This is a good example of *Star Trek's* real prime directive: "If it doesn't show up onscreen, then ignore it."

In theory, the "left" side of the ship could be shown by applying reversed decals to the right side of the model and flopping the negative, but as far as I know, this was never done. Before anyone brings up the reversed shot of the 2nd Pilot version of the *Enterprise* in "Mirror, Mirror," I should mention that in that episode, reversed registry lettering was drawn on a piece of gray paper, and the paper was wallpapered over the painted registry numbers on the nacelle of the 2nd Pilot model. If you have a high resolution screen caption of that scene, you can actually see the lower edge of the paper.

Interestingly, I found that the original draftsman seems to have had a slight problem with the letter "N." The lettering on the model appears to have been largely based on Amarillo USAF font, with a few tweaks. In my admittedly conjectural reconstruction of events, I suspect that the draftsman drew the "N" incorrectly in the original Pilot font and tried to correct it for the Production version, and, instead, made a different error. Whether or not this was an error, it's still part of the model's design history and is something that had to be duplicated. Here are the details.

I had high resolution reference photos from the model's 1964 rollout, generously supplied by Melvin Keys, the only surviving member of the team that built the *Enterprise*. In Autocad, I overlaid the Pilot lettering onto a scaled ortho view of the starboard nacelle, and something about the letter "N" looked a little odd: it was slightly wider than the other painted-on block letters. Upon closer examination, it turned out that two-thirds of the "N" had been drawn correctly, following the same pattern as the other letters, but the rightmost of the two vertical bars (or "stems," in font-talk) had been moved 1/16" too far to the right on the 1.75" tall letter. The "N" remained unchanged until the model's conversion into the Production version. When the artwork was being tweaked for the Production version decals, the draftsman moved the right-hand stem back to where it should be, giving the "N" the same width as the other block lettering. He seemingly tried to beef up the slanted middle part of the "N" to better match the Amarillo USAF version of the letter, but he didn't connect the right dots and ended up with a center section whose sides weren't quite parallel. This created an asymmetrical "N," with a definite up and down. We'll never know whether this was done by accident or

design, and I'm not criticizing the draftsman at all. Rather, I'm pointing out how much easier computers have made the lives of draftsmen.

The asymmetrical nature of the "N" allowed me to determine that some of the "N" decals had been applied right-side up on the model, while others were upside-down. I mentioned all this to Margaret Weitekamp, the leader of our merry band of "Treksperfs," and she decided that for the sake of fidelity to the original model, we should duplicate the original design, literally to the letter. By carefully studying the registry numbers on our high resolution photos, I was able to duplicate the orientations of the topsy-turvy N's.

Rick Sternbach, *Star Trek* spaceship designer, illustrator, and expert on decals, got in on the fun with fonts, too. The 11-foot model had some tiny technical markings, in the form of decals that were probably meant for auto models. And by tiny, I mean less than 1/16" tall! I shared my references with Rick, and he identified the font and determined the correct font size. In AutoCAD I overlaid the fonts onto my blurry scans of the original decals and adjusted the spacing between each of the characters, as well as the spacing between lines. Rick, on the other hand, joked that he preferred to use the automatic letter spacing selected by "our computer overlords." Regardless of which method was used, the results were identical to the unaided human eye.

I also had to recreate the red banners on the sides of the nacelles and secondary hull, plus the ship's belly markings. I had tracings of these markings that we'd made in 1991, but again, I preferred to consult original sources, whenever possible. For some odd reason, recreating the side banner on the secondary hull gave me fits, but eventually I reconciled the 1991 tracings with high resolution photos of the original markings. When the dimensions of the various parts of the design started coming out in even fractions of inches, I felt that I had finally arrived at the same method of drawing the banner that Matt Jefferies had used. I sent Rick the artwork for the lettering and other markings, and then he worked his magic on them and converted them into a format suitable for either making decals or for cutting vinyl paint stencils. Rick also had a test batch of decals of the tiny technical markings printed so we could get a better idea of what we'd be working with. While Rick was busy ordering decals and paint friskets, I turned to the next issue, recreating the lost parts of the model.

Cooking Up a New Dish

Determining the parts of the model that needed to be replaced with more accurate recreations was pretty simple, since, as I explained earlier, nearly all the original parts that weren't nailed down had vanished years ago. Sometimes the incorrectly restored parts weren't so obvious. For example, the upper saucer had supposedly remained untouched during previous restorations, but this proved to not be the case, as I discovered while comparing some "then and now" photos of the model.

Three rectangular holes and one circular opening in the upper saucer provided access

to the light bulbs illuminating windows in the side of the saucer section. During the entire time the model has been displayed at the Smithsonian the rectangular openings were covered with translucent white plastic panels, while near the bow, a frosted piece of clear acrylic covered the round opening (which fans refer to as the "bow light"). A high resolution 1966 photo revealed that both the original three panels and the bow light were made from the same frosted clear plastic (sandblasted clear acrylic); however, a 1974 photo taken during the model's arrival at the Museum revealed that the three rectangular panels were missing, while the bow light was still present. I concluded that the three missing rectangular panels had been incorrectly replaced with milky, white panels during the initial restoration in 1974, so we needed to fabricate new, frosted panels.

There was another error on the "virgin" upper saucer. There's a removable piece of wood on the aft end of the upper saucer that we call the "bolt cover" because it hides the bolts that attach the saucer to the "neck" of the secondary hull. A ridged spine made of layers of plastic runs down the middle of the bolt cover, and the front end of the spine has been rather stubby and rounded-off for as long as the 11-footer has been displayed at the Museum. One of my 1974 photos revealed that the front corner of the spine was chipped when the Museum got the model in 1974, and when I examined other photos from the 1960s, they confirmed that the ridged spine had originally been longer, with a squared-off front end. It appears that rather than correctly repair the chipped corner on the spine, the 1974 restorers had chopped off the front of the spine and rounded it off, which meant that the Museum conservators had to restore the front end of the spine to its original shape.

Recreating the design of the upper and lower saucer domes was relatively simple. By scaling my high resolution photos in AutoCAD to match my castings of the original bridge and lower sensor dome housing, I could accurately determine both the radius of curvature and the diameters of the domes.

The ship's deflector dish had broken off and vanished sometime before 1972, so I also had to recreate this very visible part of the model. The Pilot version of the dish was 10" in diameter, and Richard Datin trimmed it down to a diameter of 7" during the model's conversion into the Production version during the spring of 1966.

I had drawn my most refined plans of the ship's deflector dish for the 1:350 scale plastic *Enterprise* kit that Polar Lights released several years ago. My plan was partly based on some older reference material and on studio plans of the original dish, which Richard Datin had scanned for me. The basic size/shape of the dish was verified with a 3D overlay created by Petri Blomqvist, a friend and digital artist in Helsinki, Finland. During the first in-person meeting of the restoration team members this past May, John Goodson, a longtime model maker for Industrial Light and Magic, had brought with him a 3D printed plastic model of the deflector dish. The dish was based on my plans for the Polar Lights kit and had been enlarged approximately fourfold to match the scale of the 11-footer.

While the deflector looked correct in most aspects, it was obvious that the dish was too thick. The studio plans showed a dish that was thicker in the center and gradually became thinner toward its outer edges. I had retained this design for the Polar Lights kit so the dish would be thick enough to be cast in styrene. Datin had stated in an interview that the dish for the 11-footer had been heat-formed from acrylic sheet plastic, and this process would have resulted in a proportionally thinner dish with a near uniform thickness. This meant that I had to go back to the digital drawing board.

I repeated the design process of the original dish by first drawing the larger-diameter Pilot version dish and then trimming off its outer edges. I matched the basic curvature of the dish in our high resolution photos and then redrew the dish with a uniform thickness of 1/8" thick, to match the original. This time around I had multiple high resolution images of the original dish to use as references, so I scaled the photos and started measuring the diameters of the two engraved and one raised ring on the face of the dish. I got good agreement on the diameters of the three rings from my multiple sources, so I marked them on a cutaway profile of the dish. At first I was concerned because none of the diameters were in the even fractions of inches that model builders normally prefer, so I put myself in Datin's shoes and asked myself how he would have added the rings to the dish. After some thought, I had my "eureka moment" and found that if you put one end of a compass in the center of the dish, the other end of the compass at the outer edge of each ring, then that yielded a nice, even dimension. Datin had probably started with even dimensions and had transferred them to the curved dish with a compass. Problem solved.

I measured the diameter of each part of the central spike in the dish from my scaled photos, and these dimensions came out in even fractions of an inch because the wooden spike had simply been lathed. Nearly all my references photos were taken at varying oblique angles, which precluded my making accurate estimates of the spike's length, and the dish blocked my view of the spike's base in the few reasonably clear side views that I had. All was not lost, since I had a side view of the Pilot model that had adequate resolution. On the Pilot versions of the *Enterprise* model the spike on the deflector dish and the two spires on the nacelle domes were identical, except Datin had sanded the doughnut-shaped part near the base of each nacelle spire into a diamond shape to differentiate the nacelle spires slightly from the deflector spike. I simply scaled the side view and measured the length of each part of the spire. I combined those measurements with a scaled, high resolution side view of the dish to draw a side profile of the deflector spike. The original spike had been lathed from wood, but the spike for the restored model was machined from aluminum, for its archival qualities. The new dish was computer-milled, according to my plans, from acrylic. The plastic dish shattered during the first attempt, but the second attempt was successful.

Grommets and Washers and Nuts - Oh My!

Another goal of mine was to identify some of the hardware that was used to detail the *Enterprise* model, so Greg Jein recommended that I consult with Gene Golus, an

engineer and Original Series prop expert. Gene told me not to overthink things, and reminded me that starships of the 1960s were not high-tech affairs, and that they sometimes utilized mundane pieces of hardware. A case in point: the blinking light on the side of the hangar bay.

When I first saw the 11-footer up close in 1991, all that remained of the light was a 5/16" diameter hole in the side of the model, with a slight, 9/16" diameter indentation in the wood around the hole. When I examined the interior of the model at the restoration lab, all I could see was the 5/16" hole with no screw holes or anything else in the vicinity to indicate where a light socket had been secured. I had always assumed that the side light was the same type of automotive blinker bulb that was used elsewhere on the model, and that the bulb was set in a silver bezel; however, when I examined a high resolution, oblique view of the light, I couldn't see a protruding light bulb. Furthermore, color photos from the 1960s revealed that the bezel was actually a dark brownish color, but was not as dark as the black registry markings. I checked a series of backstage photos that showed the model being prepped for filming, and sometimes the dark bezel was there and sometimes it wasn't. This suggested that whatever the bezel was, it was easily removable.

At first I assumed that the non-protruding light was flush with the bezel, like a lighted doorbell, but Gene Golus pointed out that there was nothing inside the bezel, except a bright reflection. Gene suggested that the "light" was nothing more than a metal grommet or eyelet, and suddenly everything made sense. During the day-long search for hardware that I mentioned at the beginning of this article, I found a perfect eyelet at a nationwide craft store: dark bronze in color, with a 9/16" outside diameter and a quarter-inch wide stem that would fit into the hole in the hull and hold the eyelet in place. During a later visit to the Museum, I found that the eyelet fit like a glove.

The design of the model's windows and portholes explained the lack of evidence of mounting holes for the blinking side light inside the hull. Both the windows and portholes were fashioned from varying lengths of rectangular or round acrylic rods that were inserted into holes in the hull. I could picture a length of acrylic rod inserted into the hole for the side light from inside the hull. Fasten a blinking bulb near the end of the rod, and the rod would act like a king-size fiber optic cable and transmit the light to the outside. As a matter of fact, the 2nd Pilot version of the 11-footer had a blinking bulb inside the dome over the hangar bay doors, so Richard Datin may have repurposed that bulb to power the new light on the side of the ship.

Another question that needed answering was how were the nacelle domes held onto the nacelles? By now, most *Star Trek* fans are aware that three tabs held each dome in place, but for the restoration I had to replicate the tabs exactly as they were in the 1960s. Thanks to my old notes, some additional measurements I made during a recent trip to the Museum, and some follow-up measurements made by conservators Malcolm Collum and Ariel O'Connor, I knew the exact size of the cutouts for the clear acrylic tabs and could easily scale the dimensions of the tabs from our new, high resolution photos.

Our color photos suggested that the tabs had been frosted and tinted orange, and our eyewitness from 1972 confirmed this.

Next question: How were the tabs held in place? Each recess around the perimeter of the front of the nacelle had an original screw hole, with a small nail hole on either side of the screw hole. The nail holes were leftovers from a previous restoration, but the screw holes appeared to be original. Ariel confirmed that the holes were made for 4-40 threads.

Some years previously, I had examined some high resolution publicity photos of the Production version model, and it appeared that each tab was held in place by a single round-head machine screw and a simple hex nut. It was hard to be certain, because even if you are examining a high resolution photo, a quarter-inch wide detail part on an 11-foot spaceship model won't be crystal-clear. Nevertheless, I thought that I had the answer, but then our new color photos added a wrinkle; some of the nuts had been partially unscrewed while somebody was performing maintenance on the model, and while the threads were silver, as I expected, the nut and head of the screw appeared to be one piece and were a bright golden color. In addition, the head of the screw appeared to be more convex than that of a regular machine screw. So much for the machine screw and hex nut theory. What had Richard Datin used 50 years ago?

Shortly thereafter, I found myself wandering the hardware aisle of a nearby big-box home improvement store, looking for a likely suspect, and then I saw the answer to my question, a brass acorn cap nut. It was the correct gold color, the correct tall shape, and once you've screwed a silver-colored length of thread into it, then VOILA - you've got a starship nacelle tab holder-onner! Or whatever you want to call it. I'll let Mike Okuda or Rick Sternbach come up with a more technical-sounding name. Trouble was, all the cap nuts and threads at the big-box store were too large, but during my day-long, waterlogged search for hardware, I finally found a local mom and pop hardware store that carried the correct size.

Lastly, I had to find replacements for the tiny red and green running lights atop the nacelles, just aft of the domes, but I found myself in the same situation as with the nacelle tabs: While I may have high resolution photos of an 11-foot model, a quarter-inch object will still look blurry. The lights were never illuminated, as evidenced by a lack of wiring channels in the wooden nacelle. Since I couldn't make any reliable estimates of the exact size of the lights in the blurry reference photos, I decided to make a couple cardboard mock-ups of the front ends of the nacelles and "eyeball" the correct size of the lights.

Gene Golus came through again with the observation that instrument panel lights that small were uncommon in the 1960s, so the "lights" could have been made from something else, even something as rudimentary as finish washers and furniture tacks. I found several combinations of tacks and washers that looked good, but were too large. I finally sourced some appropriately small hardware online, but what color should I choose for the "bezel" – brass or chrome? Since I'd spotted a few pixels of yellow in our

one color reference photo, and because most of the other fittings on the model were brass, I went with brass. Brass fittings are apparently going to be fashionable again in the 23rd century!

This little essay covers some of the issues that I've been dealing with over the past year, but there are still a number of topics that I haven't addressed: determining the original color scheme of the model; the fabrication, painting and installation of new nacelle grills and the faux nacelle recess; and recreating the internal lighting mechanism of the nacelles and hull. There is much to tell about these topics, but they are best left for another day.

Kerr out.